building performance congress

# Can energy savings from operations promoting energy efficient behaviors in office buildings be accounted for ?

## Abstract

When looking for solutions to mitigate the growth of energy consumption in the commercial buildings sector, research works often focus on the energy performance of buildings. Indeed, many studies established how large the technical improvement potential was in this sector. But cost-effective energy savings can also be achieved in a complementary way by an improved energy management promoting energy efficient behaviors, because energy consumptions depend on both energy performance of buildings and equipments, and end-users behaviors.

Past experiences tend to show that if awareness operations were widely disseminated, a significant amount of energy savings could be realized. It is likely that more and more organizations engage such operations. Unfortunately, their real impacts remain rather unknown and uncertain, mainly because they are not perceived as a serious option. Consequently they are implemented in very heterogeneous ways. Thus, their results may vary a lot too.

This paper first reminds success factors analyzed in previous works, before presenting monitoring guidelines to ensure that energy savings can be accounted for.

This methodological approach could be an entry to consider the inclusion of behavioral actions in schemes accounting for energy savings, such as white certificates. The option to include awareness operations in an energy management service appears to create good conditions ensuring the quality of the operations and therefore an accounting system reliable enough for certified energy savings.

Admitting this new kind of energy service in white certificates schemes would on the one side provide a clear recognition of behavioral actions, and on the other side promote quality standards ensuring more homogeneity and effectiveness among this kind of operation.

## Keywords

Energy efficiency, behavior, awareness, evaluation, energy savings accounting, office buildings, white certificates, energy management service.

## Introduction

As the announcement of the IEECB'08 conference highlighted, "*the commercial buildings sector is one of the fastest growing energy consuming sectors*". This sector is thus one of the priority targets of any energy efficiency policy. In fact, the Energy Efficiency Action Plan published by the European Commission in 2006 stated "*the largest cost-effective savings potential lies in the residential (households) and commercial buildings sector (tertiary sector), where the full potential is now estimated to be around 27% and 30% of energy use, respectively*" (European Commission 2006 p.5).

When addressing this energy savings potential, the primary focus is most often on technical solutions. Main reasons for such prioritizing are first that these solutions are assumed to represent the major part of the potential, and second that corresponding savings are assumed to be reliable. A technical solution implies a concrete investment and implementation, which directly improves the energy performance and thus provides savings. The link between action and savings is not so clear when dealing with behavioral actions[1].

However, behavioral solutions are not to be neglected, because they do represent an interesting cost-effective potential (Broc, Combes et al. 2006, Henryson, Håkansson et al. 2000, Junnila 2007, McMakin, Malone et al. 2002). And the more energy efficient buildings or technologies will be, the more influence the behavior of their users will have (Bourgeois, Reinhart et al. 2006, Gjerstad, Antonsen et al. 2007, Throne-Holst 2005). Changing behaviors is though a complicated challenge. Therefore improving our know-how in this area is a key issue to reach this savings potential (Uitdenbogerd, Egmond et al. 2007). That's why at least three projects related to changing energy behaviors have recently been or are currently supported by the Intelligent Energy Europe program (the BEHAVE project[2], the Energy Trophy project[3], and the Intelligent Metering project[4]).

These projects have brought or will provide useful information and experience for exchanging best practices and better designing new programs (Bruel 2007, Webber, Conway et al. 2007). However, such good practices will still have to be disseminated at a larger scale, if behavioral actions (and their corresponding savings potential) are to be included in international policies, such as the Energy Service Directive[5].

This paper considers the concrete case of improved energy management promoting energy efficient behavior in office buildings, and how good practices could be significantly encouraged. First, barriers to their development are analyzed based on literature and current context for energy efficiency policies. This highlights the need to make behavioral energy savings more reliable by improving their evaluation. Monitoring guidelines are subsequently proposed. Finally, the admission of behavioral actions in savings accounting system such as white certificates scheme is discussed.

## Barriers to the dissemination of energy efficient behaviors in office buildings

### Energy efficient behaviors have been less studied at work than at home, but available feedback provides useful lessons still.

Programs for improving the energy-related behavior of households have been widely reviewed (Abrahamse, Steg et al. 2005, Uitdenbogerd, Egmond et al. 2007). On the contrary, when dealing with energy behavior at work, literature is quite poor. An analysis of available experience feedback in commercial buildings was presented at the previous IEECB conference in 2006 (Broc, Combes et al. 2006). This review showed that a 5 to 10% energy savings potential can be assumed to be realistic, even if the results from past experiences were not always clearly defined. It also emphasized the following barriers to energy efficient behaviors in office buildings:

- lack of concrete knowledge on how to use energy efficiently and on environmental impacts linked to energy consumption;
- difficulties to quantify the resulting impacts, and then to give a feedback and for benchmarking;
- difficulties to change behavior;
- difficulties to involve the building users because they don't directly benefit from the achieved savings;
- technical problems preventing good practices to be applied (e.g. radiator without thermostat).

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[1] In this paper, "behavioral actions" means good practices applied by the end-use consumers (i.e. the building users in our case). We do not consider in this paper other behavioral aspects (e.g. behavior of decision-makers), which may represent another research field (see for example (Cooremans 2007)).

[2] see www.energy-behave.net

[3] see www.energytrophy.org

[4] see www.intelmeter.com

[5] European Directive 2006/32/EC on energy end-use efficiency and energy services.

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Experience feedback (e.g. Henze 2001, McClelland and Cook 1983, OEEC 2003, Pyrko and Norén 1998, Weber 1999) also highlighted the following success factors:
- to get an outspoken and consistent support of the upper management;
- to provide concrete examples of good practices and successful operations;
- to use the several available internal communication means of the company or public body;
- to propose to building users to use a part of the savings for something they choose (sharing of the savings, improvement of the building, donation to charitable organizations);
- to organize monitoring and regular communication of operation achievements.

The conclusions of this previous study were therefore that behavioral actions in office buildings represent an interesting potential for energy savings, and that available experience feedback provided key factors to ensure the success of future operations. A new study (Junnila 2007) proved a theoretical savings potential for behavioral actions up to 20% of the specific electricity consumption (mainly related to lighting and office equipments). The authors highlight this result should be considered with caution, but this study does confirm how promising behavioral actions are.

However, the past review of existing projects (Broc, Combes et al. 2006) also illustrated that the experience sharing and the development of good practices remain restricted to a circle of "initiated" stakeholders. The proposition for a larger dissemination was finally to work on more reliable evaluation methods so that behavioral actions can be included in energy savings accounting systems.

**Energy savings from efficient behaviors at work can not be reached widely if they are not considered a "serious" option.**

Available literature and experiences (e.g. Henryson, Håkansson et al. 2000, Pyrko and Norén 1998) present analysis of the barriers to efficient behaviors, once it is decided to implement an intervention. Thus, these papers focus on the barriers preventing the employees to apply efficient behaviors. But they did not consider what preclude the (private or public) organizations to improve their energy management, especially by including "good-quality" operations to promote energy efficient behaviors at work.

One explanation is the implicit assumption that there is no financial barrier for behavioral actions, as they are supposed to be almost costless, contrary to technical actions. So the main remaining barrier, when dealing with energy savings, is the lack of information, which is more treated at the employee than at the organization level.

Indeed, it is likely that many organizations have done operations promoting energy efficient (or environment-friendly) behaviors. Many factors tend to support such initiatives, like strategies for sustainable development in the organizations (Nousiainen and Junnila 2005). However if behavioral actions can seem a common practice, it does not mean that good practices and success factors related to the operations promoting these actions are widespread.

On the contrary, such operations are often engaged because they are cheap, which make them considered straightforward to implement. It is thus thought that this kind of operation can be led "spontaneously", without setting requirements based on available experience feedback. Consequently the operations promoting energy efficient behavior can vary from random uncoordinated short-term initiatives to well planned long-term strategies. Results then fluctuate in the same proportion.

As a result, behavioral actions at work are not regarded as a serious option to improve energy efficiency in the commercial buildings. So there is a paradox: behavioral actions are assumed to be cost-effective, but they are not really included in the official schemes for saving energy.

This situation can be improved if the following conditions are fulfilled:

- operations promoting efficient behaviors should be built as a real investment, even if their costs are low, which means they should be implemented in a professional way:

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- a person (or group of persons) should be clearly in charge of the operation, i.e. supervising it, and so be trained for this particular responsibility;
- the actions package used in the operation should be defined according to lessons from available experience feedback, especially taking account of the highlighted success factors; this could be ensured by using proven and standardized actions package;
- the means (money and time) used for the operations should be clearly accounted, first to show that they are "real" (and not just a kind of hobby) and second to better know their real costs;

- a minimum monitoring should be used to confirm the causality between behavioral actions and energy savings results.

This paper presents a proposal for such monitoring guidelines.

## Evaluating energy savings from efficient behaviors at the office

The monitoring guidelines proposed in this paper was built on a first case study presented at the previous IEECB conference (Broc, Combes et al. 2006), other similar proposals (e.g. monitoring systems used for the Energy Trophy[6] or in (Fludia 2005)) and methodological reference and works (such as (Broc, Bourges et al. 2007, IPMVP 2002)).

To be comprehensive, an evaluation method would include two main components: an energy consumption monitoring, and a participants' survey (to confirm the link between actions and energy savings). This paper deals with the monitoring. Requirements for the survey part may be found in the sociology literature (e.g. Javeau 1992).

**Three possible levels of monitoring**

According to the office building, opportunities for monitoring energy consumption may differ. So our proposal include three levels of monitoring, mainly based on three of the options defined in the IPMVP (2002) and on works on energy signature (e.g. (Rabl, Rialhe 1992)). Moreover, these three levels of monitoring correspond to three levels of expected feedback information.

Whatever the monitoring level, the evaluation has to be planned before the operation begins. This especially applies for the data collection: what (list of required data), how (sources and templates), by whom (planning and dedicated time). This is essential to ensure data availability and reliability for the final evaluation. Early evaluation planning also minimizes evaluation costs.

The three proposed levels are presented hereafter, including the following details:
- definition of the initial consumption level;
- data to be registered;
- method used to analyze the data;
- results expected from the evaluation;
- qualitative assessment of evaluation costs.

Besides, based on existing literature (Henryson, Håkansson et al. 2000), we make the conservative assumption that the effects of the operation only last as long as awareness actions are implemented. But the monitoring period may be extended after the operation to check whether some effects last afterwards.

*Level 1: monthly metering and operating report*

This level can be compared to the option C of the IPMVP (monitoring of the global consumption).

[6] see www.energytrophy.org/eu-deliverables-1st-period

**The initial consumption level** is defined using historical metering data (e.g. the monthly data of the five years previous to the operation) and details about building and energy uses (e.g. building age and last renovation works, number of employees, work schedules, heating and cooling systems, etc.). This first data collection is also the occasion to know who the contact persons related to the energy management of the building are (who could be both, internal and external contacts in case of subcontractors).

**The data to be registered** (related to the energy consumption) are mainly the monthly metering and the information of the operating report (dated information recorded by the energy manager along the operation):
- planning of the awareness actions;
- other significant changes related to the equipments and energy uses compared to the initial situation (e.g. change in the heating settings, substitutions of luminaries, etc.);
- start and end of the heating (and eventually cooling) period;
- breakdowns, users claims, or other significant incidents;
- renovation or other building works;
- significant changes in the number of employees and work schedule;
- particular events (doors open day, strikes, etc.).

**The method used to analyze the data** is based on the principles of energy signature models, in order to detect significant variations from a statistical point of view. The parameters used in the model are monthly consumption (per energy carrier), HDD (Heating Degree Days), heating period, use (or not) and period of cooling. Other registered information is then used to explain detected variations, or may be included as additional parameters in the model when relevant (e.g. the number of employees when significant variations occur during the operation period). More details about analyzing energy consumption data may be found in (Claridge 1998).

This method provides an estimate of gross savings, and energy savings results can be considered statistically significant only if their amplitude is higher than the noise observed in historical data. 10% of the monitored consumption can be used as a default threshold, based on IPMVP requirements (IPMVP 2002 p.37). If this condition is not fulfilled, then a level 2 or 3 monitoring would be necessary to prove energy savings, when detailed explanations are necessary. However, in most cases, level 1 monitoring will be sufficient, as the main objective is to assess the evolutions of energy consumption to know whether the implemented energy management provides real improvements.

**Expected results** from this level 1 monitoring are:
- a gross assessment of the energy savings, taking account of information registered in the operating report;
- corrected (from weather conditions) monthly consumption data and progress information to provide a feedback to the participants (which is a key factor to get lasting effects);
- the creation and regular maintaining of a database which can be used to better manage energy at the building level;
- the comparison of the results with other similar operations (e.g. with other sites of the same company).

The main **evaluation costs** for this level are linked to human resources:
- time used to define the initial state;
- time used to regularly collect the data;
- expert time required for the data analysis.

Moreover, in case the concerned buildings are already operated under an energy management system[7], they would be almost no additional cost. Indeed, these monitoring activities are the basic components of an energy management process (see e.g. Henze 2001).

[7] In this paper, “energy management system” means there is a clear process in place to manage energy in the buildings. This process includes the definition of tasks and responsabilities, but does not necessarily require the use of a dedicated software.

In conclusion, level 1 is the “routine” monitoring recommended to provide the required feedback both in the control loop of the energy management system, and to inform the end-users.

*Level 2: level 1 + load curves analysis*

The proposed level 2 is similar to the evaluation method used for a past operation in the city hall of Rueil-Malmaison, France (Fludia 2005) or for the Energy Trophy contest. It may also correspond to a level 1 monitoring completed by an energy audit.

Level 2 monitoring includes level 1 requirements. Hereafter are only presented the additional requirements, specific to level 2.

For the **definition of the initial consumption level**, additional requirements are:
- to perform a load curves analysis during a typical week before the operation to detect the consumption level during special "idle" periods such as lunch breaks, nights and week-ends;
- to review whether large equipments load curves (such as cooling system) can explain a significant part of the idle periods consumption;
- to check the energy-related practice before the operation (e.g. control by housekeeping personnel of the equipments and lights let on at night);
- to have a detailed interview with the energy manager (and/or subcontractors) about the heating/cooling systems and the feedback from the building users about their comfort.

The additional **data to be registered** along the operation are the same information as used to define the initial consumption level, in order to compare pre- and post-data.

The complementary **method used to analyze the data** consists in load curves analysis, especially applied to idle periods, using registered information to explain possible changes.

Expected additional **results** from this level 2 monitoring are:
- a more detailed assessment of the energy savings related to the operation, and then more detailed and concrete information to provide feedback to the participants;
- a better knowledge of the sequences of building use;
- an identification of the main causes of punctual variations of energy demand.

Main **additional evaluation costs** are linked to the load curve analysis, which require additional expert time. Moreover, the usual energy meter of the office building may not enable to get the data for a load curve analysis. In that case, a specific meter system will be required (for buying or rent).

Level 2 may be used for an enhanced energy management, not continuously but periodically, e.g. before planning a pluri-annual energy savings strategy, in order to detect priority targets.

*Level 3: level 2 + direct measurements*

This level can be compared to the options A or B of the IPMVP (partial or detailed measurements). It also corresponds to a level 2 monitoring completed by direct measurements (such as (ENERTECH 2005)).

For the **definition of the initial consumption level**, the additional requirements are to use sub-meters to measure the energy consumption of specific end-uses (e.g. electric circuit for lighting) or areas of the buildings (e.g. to isolate one particular floor).

The additional **data to be registered** along the operation are the sub-metered data and detailed information about the specific metered end-uses and/or areas in the operating report.

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The **data analysis** is then a comparison of the before and after energy consumption (and/or load curves), using the information of the operating report and of the participants survey to explain the observed variations.

The **result expected** from this level 3 monitoring is mainly a more accurate quantification of the energy savings related to the operation.

The main additional evaluation costs are related to the specific metering equipments, which could quickly become expensive. However, large office buildings may already have sub-meters, which may be used for such monitoring.

Due to the high related costs, level 3 has a more restricted scope than levels 1 and 2. It may be used for large or special buildings, or for experimental case studies to ascertain the average energy savings which may be expected from a specific actions package.

## Why and how to include behavioral actions in a white certificates scheme

White certificates are defined by the Energy Services Directive[8] (art.3(s)) as "*certificates issued by independent certifying bodies confirming the energy savings claims of market actors as a consequence of energy efficiency improvement measures*".

A white certificates scheme (WCS) is designed to bring the following advantages (among others[9]):
- to create recognition and (virtual) value for energy savings actions;
- to provide a common definition of standardized energy savings actions;
- to provide a common accounting of the energy savings resulting from the standardized actions.

Applying these advantages to behavioral actions would help address the barriers to their development:
- their recognition would make them considered a serious option;
- their standardization would ensure their quality;
- their accounting would provide a reference for their evaluation.

However, certain conditions are required so that a given action can be standardized and then included in the WCS. These conditions are not clearly officially defined, as this inclusion most often results from a negotiation between the concerned stakeholders. We analyzed the current accepted and rejected kinds of actions in the case of the French WCS to better know these conditions:
1. the action has to be considered mature enough, meaning:
    - enough experience feedback, studies, statistics, know-how, etc. are available;
    - and/or proven and recognized values of unitary energy savings and costs are available;
    - and/or this action represents a significant interest among stakeholders (especially for the regulator) because the corresponding energy savings potential is high enough, but is not efficiently tackled yet;
    - and/or a certification system ensures the quality of the action;
2. a standard value of unitary energy savings (i.e. savings per action) has to be agreed upon;
3. the action has to be proven by a concrete investment (usually the proof is a bill).

In concrete terms, two components are to be defined and accepted so that an action can be "standardizable": its principle and the calculation method for its unitary savings value.

**Possible options for the principle of behavioral actions**

[8] Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services.
[9] For more details about white certificates, see for example (Bertoldi, Huld 2006).

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The main issue for the principle of the behavioral actions is how to ensure their quality. The solution may be to include in the standardized package of the operation a certified training for the operation manager. This solution was already used to include in the French WCS an eco-driving action related to training of bus drivers. Similarly, the person responsible of the operation promoting efficient behaviors in an office building may receive a training, which can be assumed to ensure the quality of the actions engaged. Moreover, this training will bring the required investment proof.

Another option would be to include the awareness operation in an energy management service. An energy company or ESCo (Energy Services Company) may then propose to help its client implementing an awareness operation among other energy advice or services. This professional support can then be assumed to ensure the quality of the actions. If the client pays for this support, this would also provide the required investment proof.

The latter option would provide regularly an external support to the operation, which is a guarantee for the actions to last over time. However, if the proposed service is too intrusive (i.e. not requiring enough efforts from the building managers and occupants), it could decrease the level of involvement of the occupants. On contrary, the training option would create good conditions for a strong internal involvement, but would not provide any support afterwards, making the operation success more relying on the internal "good will".

Besides, the review of experiences made in (Broc, Combes et al. 2006) highlighted that behavioral actions were typically not implemented alone, but together with a general improvement (or set up) of the internal energy management. This argues in favor of the latter option.

**Possible options for the calculation method**

The following options can be considered:

- behavioral actions alone:
    - global approach: the unitary savings value is an average standardized amount of kWh, based on the following data:
        - average consumption per m² or employee for the concerned end-use for office buildings in France;
        - average size of office buildings in France;
        - average expected gain (%) for an operation promoting efficient behaviors;
    - approach per end-use: the unitary savings value is an average standardized amount of kWh, based on the following data:
        - average consumption per m² or employee for the concerned end-use for office buildings in France;
        - average size of office buildings in France;
        - average expected gain (%) for the efficient behaviors promoted;
- behavioral actions together with other standardized actions:
    - "bonus" approach: the unitary savings value is an average standardized amount of kWh, based on the following data:
        - the unitary savings value of the other standardized action related to the behavioral actions;
        - average expected additional gain (%) for the behavioral action considered.

Available experience feedback provides benchmarks for the first option (behavioral actions alone + global approach) (see e.g. Broc, Combes et al. 2006). Another argument in favor of this option is that behavioral actions are more efficient when they target all possible fields of improvements (McClelland and Cook 1983).

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However the potential study led by Junnila (2007) reports results by end-uses (mainly lighting and office equipments).

In past experiences, evaluation of energy savings was most often based on a monitoring closed to level 1 monitoring proposed in this paper. This level 1 could then provide benchmarks values to define the average gain, using conservative assumptions. Moreover, level 1 monitoring could be included in an energy management service, so that new values would be available to update this average gain with more experience feedback after a first period.

Level 2 and 3 monitoring could be used on a limited experimental case studies, if more accurate analysis appeared necessary (especially if the first average gain seems too conservative to practitioners).

**First elements of decision**

From the available experience feedback and the analysis presented in this paper, one option can already be highlighted: the inclusion of awareness actions in an energy management service.

It would ensure the quality of the actions implemented due to the professional support environment, and the corresponding energy management system would provide "naturally" the data required for level 1 monitoring proposed in this paper. Moreover, it would also create favorable conditions so that awareness operations are managed on a longer term, providing a background for lasting effects, meaning persistent energy savings.

Looking back at the conditions required for a kind of actions to be included in the standardized frame of the French White Certificates Scheme, it appears possible to define the contents of behavioral actions so that these conditions be fulfilled:
1. "maturity" of the action: even if the knowledge about behavioral actions is still to be improved, significant experience exists, and a recent study (Junnila 2007) confirmed how interesting their potential may be;
2. standard value of unitary energy savings: even if available experience feedback is not sufficient to define a statistically representative average value, it provides benchmarks to define a conservative standard value, which the stakeholders may agree upon;
3. investment/result proof: it could be either the contract between the company receiving and the company providing the energy management service, or a specific certification (like for ISO14000).

## Conclusions and discussions

Operations promoting energy efficient behaviors in office buildings may represent an interesting energy savings potential. At the same time, it is likely that more and more organizations engage such actions, e.g. within their sustainable development strategies. Unfortunately, the real impacts of such operations remain rather unknown and uncertain.

The first main explanation is that behavioral actions are not perceived as a serious option for improving energy efficiency in office buildings. Their quality may therefore differ a lot from uncoordinated and random short-term initiatives to well planned and sophisticated longer term strategies. Consequently the results may vary a lot too.

The second main explanation is the lack of clear and consensual method to evaluate the corresponding results.

Working on including such actions in a white certificates scheme can then be a way to address both issues:
- by defining standardized components for this kind operation, it would insure their quality and homogeneity;

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- by including standardized monitoring practices in the operation, it would provide the basic frame for consistently evaluating new operations, which would then give new energy savings values.

Moreover, it would give to such operations an external value (even if virtual). And this would help making them regarded as a serious option. It could therefore initiate a virtuous circle, inducing a general improvement in the practice of behavioral actions.

Two scenarios may be imagined for including such behavioral actions in a white certificates scheme.

In the first one, hereafter called "cautious scenario", available information about behavioral actions would be assessed as insufficient and their inclusion as standardized actions would be delayed until experimental case studies provide more accurate information. This could take time, due to the difficulty to find good experience fields and then to the time necessary to perform case studies. But it would minimize the risk of overestimating energy savings from this kind of actions.

In the second one, hereafter called "voluntary scenario", present conditions described above would be considered sufficient to accept such behavioral actions as standardized in the white certificates scheme. Their energy savings ratio would be defined assuming conservative assumptions, to avoid overestimations (and thus probably leading to underestimations in a first period). This official recognition would be a valuable sign to support the development of a market for the corresponding energy management service, and would accelerate the dissemination of promoted good practices, especially for small and medium enterprises, which are likely not to have any real energy management so far.

In this "voluntary scenario", the white certificates scheme would play its expected role of supporting the development of energy services and of accelerating the dissemination of energy savings actions, especially to scattered targets, such as small and medium enterprises.

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