Towards a Behavioral Indicator for the Evaluation of Energy Conservation at Work

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Abstract

The purpose of this paper is to present a new behavioral indicator, which is still at an experimental stage, and the results of two experiments making use of it. This indicator could be used to complement traditional impact evaluations of energy efficiency programs.

In the framework of its Environmental Management System, the State of Geneva planned to save 2 GWh in 2013 due to five projects of energy efficiency optimization, a part of which focused on the promotion of energy-efficient behavior at work. This was done in collaboration with a demand-side management program, éco21, implemented by the local utility. To evaluate its efficiency, a behavioral indicator, the *Environmental Awareness Indicator,* based on psychological studies, was designed and tested to complement quantitative results in kWh obtained by the instrumentation of several buildings.

First, changes in the energy consumption before and after two energy conservation promotional weeks (called « Energy Weeks ») were measured. Consumption was also measured six months after one of the promotional weeks. Our investigations show that a well-organized Energy Week for a fairly large organization (around 400 employees) has a potential of 20% energy savings immediately after the event, decreasing to a value between 3% and 12% after six months.

Second, we made use of the above mentioned indicator to analyse the qualitative behavioral evolution of the two populations studied. The indicator shows that after the Energy Week there is a general shift towards behavioral change, at all stages of the change model, with an increase (13% and 19%) of employees moving towards action. The usefulness of such an indicator is therefore twofold: it permits behavioral monitoring and enables to adapt the implementation of change actions to the behavioral stage of the target.

Context

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In the framework of its Environmental Management System, the State of Geneva (Switzerland) planned to save 2 GWh in 2013 due to five projects of energy efficiency optimization, a part of which focused on the promotion of energy-efficient behavior at work. This was done in collaboration with *Ambition Négawatt,* an action plan of the demand-side management program, éco21, implemented by SIG (*Services Industriels de Genève*), the local utility. Ambition Négawatt specifically concerns large consumers (i.e., companies that have an electrical consumption of at least 1 GWh per year) and provides financial incentives to organizations that wish to organize information and behavioral change workshops or to implement energy-efficient technologies.[1] One of the

1 The organizations that wish to join the program must have an Energy Manager. Ambition Négawatt developed, for these Energy Managers, a week-long training course dealing with different aspects of energy efficiency and conservation; it also introduced the International Performance Measurement and Verification Protocol (IPMVP) as the reference for all the technical changes, and organizes IPMVP training sessions twice a year. During several years, Ambition Négawatt entirely paid for the engineers and consultants' IPMVP training.

different items offered by the Ambition Négawatt action plan is the concept of *Energy Week*, a week-long energy-saving event set up for an organization (or part of one, i.e., the employees of a specific building).

The State of Geneva, among other actions, organized Energy Week for two administrative buildings: the "*Hôtel des Finances*" building with 1,000 employees (mostly tax service employees) and the "*Grand-Pré*" building with 400 information technology (IT) service employees. The data gathered from these two case studies are analyzed in this paper.

Monitoring and evaluation

The University of Geneva has been monitoring and evaluating the éco21 program from its very beginning in 2009. For this purpose, the evaluators have been trying to isolate the electricity savings generated by the information and behavioral change workshops. The difficulty is accentuated by the nature of the Ambition Négawatt action plan:

- It is not easy to distinguish the savings due to the behavioral change actions from the global consumption of the large consumers, because the first represents only a small part of the total energy consumption; further, the energy consumption is usually read on a central meter (in addition, this part varies depending on the type of organization, e.g., pharmaceutical company vs. administration);
- The fact that Ambition Négawatt offers support for both equipment and behavioral changes makes it challenging to evaluate the savings solely attributable to the latter.

For these reasons, the evaluators expressed the need to make extraordinary consumption measurements, performed in a systematic way; thus, for Grand-Pré, éco21 commissioned an energy consultancy company (Exenco) to measure consumption in appropriate locations in the building (the methodology is described below).

Consumption measurement methodologies

Grand-Pré

The methodology, developed by the University of Geneva[2] and implemented by Exenco, consisted, firstly, in analysing data from the electric meter (using Webnergie, an energy monitoring application providing data information every 15 minutes) and, secondly, in conducting extraordinary measurements in selected parts of the building, including the following:

- The electric consumption of specific appliances (i.e., those on which the personnel have an influence, such as the manual control of lighting);
- The use of the staircases (by counting the number of times the doors to the stairways were opened) in order to infer the use of the lifts; and
- The indoor temperature of the building.

These measurements were performed during three two-week periods: The first period, called the *baseline period*, occurred just before the Energy Week; the second period took place just after the Energy Week; and the third period occurred six months after the Energy Week.

The immediate impact of the Energy Week on behavioral change – and on energy savings – and the long-term effects were evaluated by comparing the consumption of these different periods. Corrections have been made to take into account the contexts of the measurement periods (i.e., occupancy rates of the buildings and meteorological conditions).

2 See also Cabrera et al. 2012.

Hôtel des Finances

For Hôtel des Finances, there was no systematic use of extraordinary meters (as for Grand-Pré) and, therefore, the data providing the load information solely came from the central electric meter (Webnergie, an energy monitoring application giving data information every 15 minutes). The simple comparison of the consumption of the Energy Week[3] with that of the baseline period was not meaningful, since the weather conditions of both periods were very different. Therefore, three methodologies were used to estimate the electrical savings obtained.

1) Temperature correction: The temperature of the baseline period was corrected to correspond to that of the Energy Week period.
2) Construction of a pseudo-baseline week: The energy consumption of the Energy Week was aggregated into day periods and then the latter were compared to days of 2013 and 2012 having similar average daily temperatures (comparing Mondays with Mondays, etc.), thus resulting in the construction of a pseudo-baseline week with similar temperature conditions (using the Webnergie database).
3) Analysis using a model: A statistical model reproducing the load curve was designed, and then the model was used to predict the consumption of the Energy Week (taking into account the specific temperature conditions of the Energy Week). The load data of years 2012 and 2013 were used to estimate the parameters of the model.

The Energy Week and its results at Grand-Pré and Hôtel des Finances

The program of an Energy Week is composed of a variety of items, such as technical workshops, a demonstration office equipped with data loggers to measure energy consumption, explanatory posters on energy conservation, the presentation of load curves, the distribution of explanatory cards on energy savings, discussion-conferences on energy efficiency, a charter (i.e., a commitment to save energy) to be accepted or refused by the employees, the projection of the film "*Le thé ou l'électricité*" (on the installation of electricity in a Moroccan village), a discussion wall for skeptics, launching and closing ceremonies etc. These activities were chosen to conform to the four different modes of thinking: analytical, sequential, interpersonal and imaginative thinking[4] (Herrmann 1989).

Before the Energy Week, a Green Team composed of 10 to 15 voluntary members per building were trained over two to three days on energy conservation issues and environmental communication. The final program of the Energy Week was prepared with the assistance of the Green Team, adapting it to the actual working environment. The role of the Green Team was to inform and encourage the staff members and, in the long run, to maintain the conservation actions.

The measurement of the electrical consumption of the Grand-Pré building showed (Figure 1) that, after the Energy Week, electricity consumption was 19% lower than that of the baseline period. After six months, the savings were reduced and were between 3% and 12%. The uncertainty was large due to the changes in the occupancy of the building (an increase of more than 100 employees).

3 The energy savings were calculated by comparing the consumption of the Energy Week with the baseline period (i.e., NOT the two week period just after the Energy Week, like it was done for Grand-Pré).

4 In the HBDI framework, *analytical* refers primarily to logical and factual thinking, *sequential* to safekeeping and structured thinking, *interpersonal* to emotional and sensory thinking, and *imaginative* to holistic and intuitive thinking.

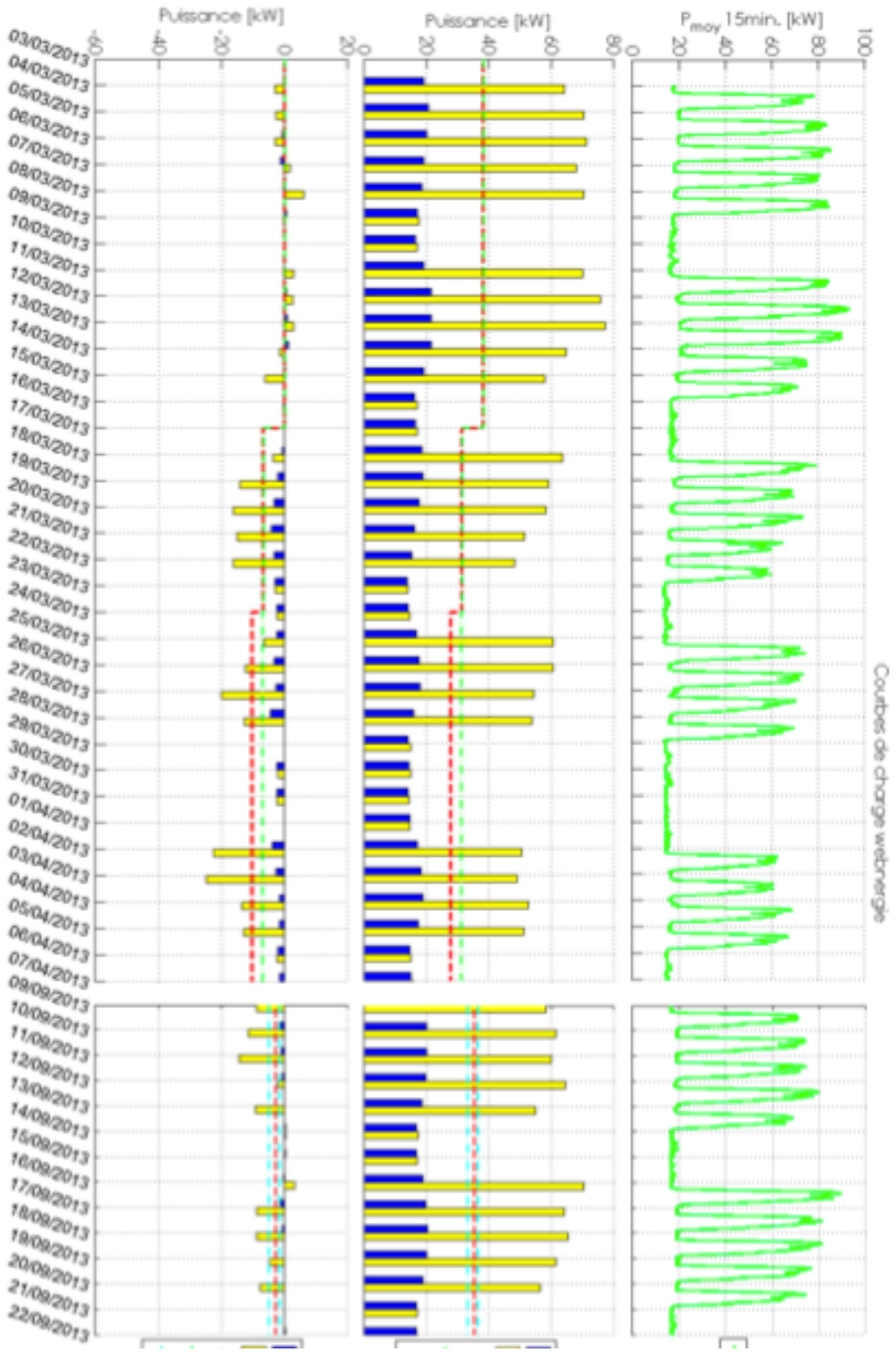


Figure 1. Evolution of the consumption of the Grand-Pré building: load curve (to the right); average load night vs. day (middle); departure of the load from the baseline period (to the left)

For the Hôtel des Finances, the energy savings were between 4% and 8%. The persistence of the savings has not yet been evaluated for this building.

To complement these results, which do not provide information on human factors such as changes in environmental awareness and barriers to change, an environmental indicator was developed, as discussed in the next section.

Theoretical framework of the Environmental Awareness Indicator

The *Environmental Awareness Indicator* (EAI) was conceived using the transtheoretical model, a change theory that was initially developed by Prochaska *et al.* (1979, 1982, 1992) for the prevention of smoking addiction and is currently used in studies of environmental practices. This particular theory was chosen because it presents the change process in stages and pertains to an approach using a process of continuous improvement. The interest and objective of such an indicator is to be able to refine our understanding of behavioral change and individual environmental awareness, beyond the coarse analysis based on electric meter readings. Conceived by Flora Madic (State of Geneva) and Lara Mang-Joubert (Oxalys, Lyon), the EAI is an indicator that provides information for an impact evaluation of environmental communication, and monitoring and refining future awareness actions, as described below.

In concrete terms, a multiple choice questionnaire was designed with three sections: (1) an introduction explaining the goals; (2) a set of open-ended questions allowing participants to express themselves freely, and, most importantly, (3) a set of closed-ended questions with choices based on the stages of change given in the transtheoretical model. Each closed-ended question concerns a specific energy saving action (to be done at work).[5] For each item, five options are given as possible answers, as shown in Table 1:

Table 1. Stages of change and corresponding elements in the questionnaire

Stage in the transtheoretical model	Meaning of stage	Corresponding feeling	Structuring element in the questionnaire	Result on action
Precontemplation	People, at this stage, do not see the reason for change. They do not feel concerned.	It is useless for me to change.	No, impossible…	I do not do the energy saving action
Contemplation	Consider change, but are not ready to give up the advantages or comfort of their present situation. They compare pros and cons.	I could change if I saw the point.	Maybe if …	
Preparation	Ready to change, want to change in the near future, but do not know what to do or how to do it. They seek practical information.	Yes, I am going to change.	Probably, but how	
Action	They experiment the new action, the new behavior.	I am changing.	-	-
Maintenance	Change is on its way, but requires an effort. Risk of relapse. They need encouragement from the group.	I have changed, but it remains an effort.	Yes but …	I do the energy saving action
Termination	Natural behavior	Of course, I do it, it is natural.	Yes, of course …	

The exact same questionnaire was sent twice by email to each employee (see Table 2), first before the Energy Week (Q1) and then after the Energy Week (Q2). The questionnaire asked about four energy saving actions that were discussed during the Energy Week. These are concrete and easy actions that solely depend on individual decisions:

- To turn the screen of the computer off during pauses;
- To turn the computer off at night;
- To turn the office lights off before leaving in the evening; and
- To lower the brightness of the computer screen to 50%.

5 To avoid having too many options, the action stage was not included in the questionnaire.

The stages of change are expressed in the following manner:

- I refuse to do the energy saving action (Precontemplation);
- I think I possibly ought to do the energy saving action (Contemplation);
- I am going to do the energy saving action (Preparation);
- I remember to do the energy saving action (Maintenance); and
- I do the energy saving action naturally (Termination).

The questionnaire was designed to avoid two types of bias in the answers:

- The *desirability effect*: the person answering the questionnaire gives what he/she thinks is the expected answer, even though it might not correspond to reality. To help minimize this effect, the employees were informed of the expectations of the Environmental Management System department: "to understand as well as possible the barriers to and drivers for eco-friendly behavior at work". Hence, the aim was to focus the desirability effect on the accuracy of the answers rather than on the execution of the energy saving action.
- A particular case of *mental contamination* (Wilson and Brekke, 1994): several questions, one after another, on the same subject make the person answering the questionnaire want to be coherent.

In order to avoid automatic or less thoughtful answers, the questionnaire contains a variety of questions on the energy saving actions. The formulation of the possible answers - specifically adapted to the working context - was designed to avoid feelings of guilt, therefore, helping the participants to answer more freely. The more the questions concerned a specific action, the more the given answers were realistic.

The exploratory closed-ended questions (pertaining to the chosen energy saving action) and two secondary questions - aimed at avoiding mental contamination and creating detachment - are asked alternately. Finally, the suggested answers do not have a specific order nor do they follow the sequence of the stages of change, carefully avoiding hinting at a value ranking of the answers (see Table 2).

Table 2. The questionnaires

The questionnaire Q1

Dear colleagues of Hôtel des Finances,
The Administration of Geneva has been involved for a long time in environmental conservation. To develop daily better practices at work, the Environmental Management System (EMS) is organizing awareness campaigns in the large buildings of the State. For this reason, the EMS needs to better understand your difficulties and motivations as regards eco-friendly practices at work. Your feedback is important for us to adapt the offered activities, in particular during the Energy Week.
Thank you for answering the following questionnaire that will be treated anonymously.
The SME department relies on your participation.
Do not hesitate to answer sincerely.

1- In your opinion, what is the annual electricity consumption of the Hôtel des Finances?

- ☐ *I don't know, but is it important for action?*
- ☐ *150 MWh, that is, the electricity consumption of 40 homes in Geneva.*
- ☐ *No idea, besides, it does not interest me.*
- ☐ *The consumption of Hôtel des Finances is identical to that of the other buildings of the Administration.*
- ☐ *1500 MWh, that is the annual electricity consumption of 400 homes in Geneva, can you believe it!*

2- Do you talk of the environment with your colleagues?

- ☐ *Yes, sometimes, at coffee break, it is something to joke about. We indeed noticed the campaign « I, State employee, sort my PET »!* [Play on words in French]
- ☐ *No, never. In my department, nobody pays attention to this subject.*
- ☐ *Why? In my department, eco-friendly practices are natural to everyone.*

☐ *Yes, often, we try to motivate each other.*
☐ *I would like to, but I don't dare mention the topic.*

3- Do you turn your screen off during pauses?
☐ *No. It takes more energy to turn it back on, doesn't it?*
☐ *Yes, at the touch of a fingertip, it only takes half a second!*
☐ *No, because the savings are ridiculously small. Above all, other means of energy production ought to be implemented.*
☐ *I agree to turn my screen off, but what is the minimum length of time for this to be useful?*
☐ *Yes, during pauses and at night. One just has to think of it each time…*

4- Do you lower your screen brightness to 50%?
☐ *Yes, I don't even notice the difference between 50% and 80%.*
☐ *Impossible, otherwise I can't see.*
☐ *It can be done? How?*
☐ *Yes, even though it is difficult to read certain files.*
☐ *I do not know how my computer was programmed.*

5- Do you turn your computer off in the evening?
☐ *I am going to turn it off at night and during the week-ends.*
☐ *I turn it off every evening, but I find it takes a while to turn it back on the next day.*
☐ *No, because I need my files and desktop just as I left them the day before.*
☐ *It is not necessary, because it goes anyway into sleep mode.*
☐ *I turn it off for long pauses and every evening.*

6- Do you turn the office lights off if you are the last to leave?
☐ *Yes, because the switch is near my door.*
☐ *No, it is the concierge who turns the lights off.*
☐ *Yes, I turn all the lights off when I leave.*
☐ *Don't they switch off on their own?*
☐ *If I were sure to be the last, I would.*

7- And at home, do you save energy?
☐ *I would like to, but what is really efficient?*
☐ *Yes, I pay attention to the lights, electric devices on standby, the heating, computers… and to what my spouse and children do…*
☐ *No, because it does not reduce the bill.*
☐ *It is useless, because my flat is poorly insulated.*
☐ *Of course, I always have, don't you?*

8- Today, for you, what makes these eco-friendly practices difficult to do at work?
Open field

9-What would help you to perform these eco-friendly practices more often?
Open field

In order to analyze the answers of the various questionnaires (present and forthcoming), your email address is needed. The results will be treated anonymously. Our email address: champs@etat.ge.ch
Thank you for your answers, and see you in January at the Hôtel des Finances Energy Week.
To learn more on the Environmental Management System of the State of Geneva: www.ge.ch/sme

Introduction to the questionnaire Q2

Energy Week: "your efforts, your habits"?
Many of you have taken part in the Hôtel des Finances Energy Week. Thank you and bravo!
Beyond the watts, we would like to know if the eco-friendly actions have become natural for you or remain an effort?
You are all invited to answer the following questionnaire, even if some of you have already answered the first questionnaire in December, because although the questions are identical, your answers might be different.
After the Energy Week what are your choices or new choices? Click here (1 minute):
The EMS needs you to improve the integration of eco-friendly practices at work
The comparison of the answers given before and after the Energy Week will be communicated to you anonymously.
We deeply thank you, dear colleagues. The EMS

Behavioral indicator data (Q1 and Q2)

The answers to both questionnaires were given on a voluntary basis; the response rate of the questionnaire was small, approximately 15 to 20%; therefore, the findings in this paper must be interpreted with caution. Explanations for the low rate of answers are:

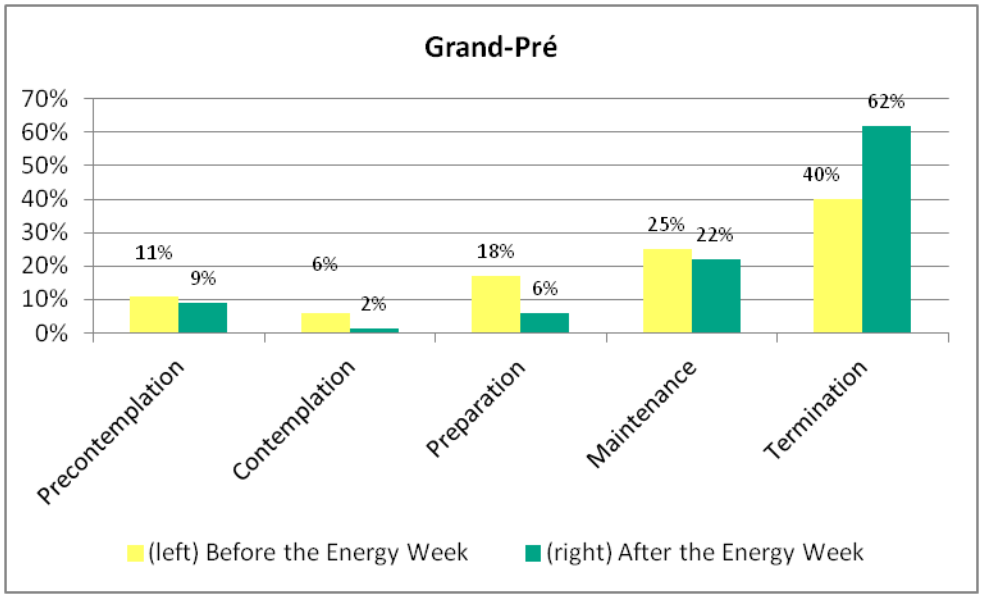
- For Grand-Pré, just before the beginning of the action, the top management informed the temporary employees (half of the entire staff) that their participation in the Energy Week could not be considered as working hours.
- For Hôtel des Finances, the major part of the tax employees do not have internet access at work (for confidentiality reasons), hence could not answer the questionnaire that was sent by e-mail during their working hours.

The decrease in the number of answers to the second questionnaire can be explained by the fact that the same questionnaire was intentionally sent out twice; therefore, many of the employees which had answered the first questionnaire thought it was not necessary to answer the second one. In the future, the fact that there are two identical questionnaires to be answered (before and after the Energy Week) will be clearly spelled out.

Table 3. Results of the questionnaires

	Number of employees	Number of answers		% of employees doing the eco-friendly actions		Increase of employees shifting towards action
		Q1	Q2	before the Energy Week	after the Energy Week	
Grand-Pré	400	86	34	65%	84%	19%
Hôtel des Finances	1000	141	119	65%	78%	13%

The results in Figure 2 show the global dynamics according to the transtheoretical model. A general shift towards change at all stages of the change process can be observed: an increase of 13% of employees in the action stages of the model at Hôtel des Finances and an increase of 19% at Grand-Pré.



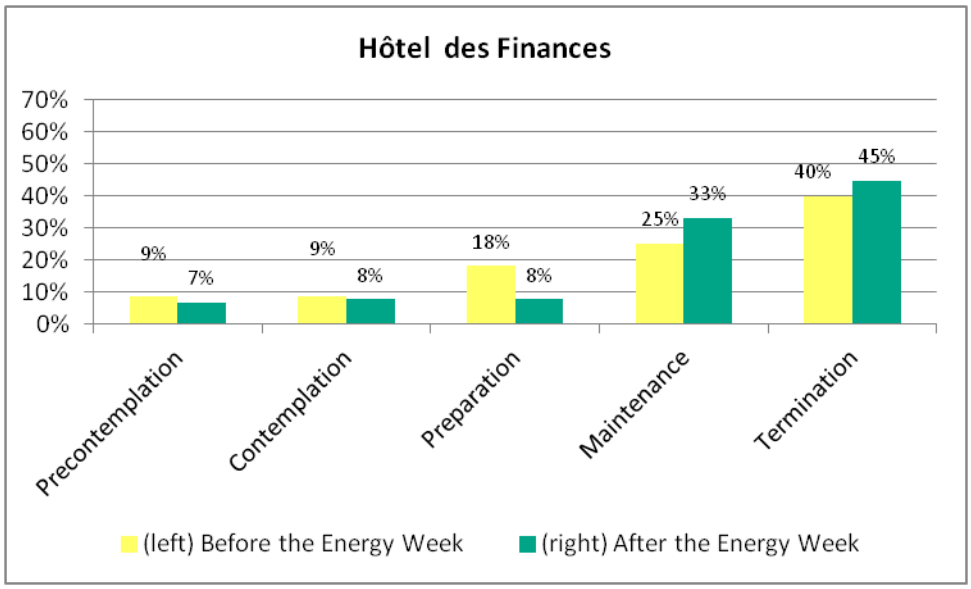


Figure 2. The global dynamics of change for Grand-Pré and Hôtel des Finances, according to the transtheoretical model.

For Grand-Pré, there is a discrepancy between the above given results and the measurements obtained six months after the Energy Week. Indeed, let us recall that, after six months, the savings were reduced and were between 3% and 12%. This result is only compatible with the 62% of employees at the Termination stage if one adopts the most optimistic hypotheses. This strongly suggests that our indicator needs to be refined. The problems might be of theoretical nature (inadequacy of the transtheoretical model for our purpose) or of practical nature (such as difficulties to obtain sincere answers to the questionnaire).

Two months after the Energy Week, individual interviews were made at the Hôtel des Finances to identify the drivers of change. None of the 16 persons interviewed mentioned environmental issues. However, all of them stressed the importance of group dynamics and human relations such as the enthusiasm and environmental commitment of the Green Team. Several activities gave rise to a sense of belonging to the group, in particular the *Flash Mob Négawatt* (the employees were asked to turn off the electrical appliances of their office and to go to the main conference room plunged into darkness for the occasion; they were then invited for a lunch made of

local organic food) and the awarding of "smiley sticky notes" (posted on the turned off computers and later collected by the employees). However, the demonstration activities and information exhibits were less successful, even though a majority of the interviewed employees asked for a regular posting of the electrical consumption of the building to evaluate the global effectiveness of their efforts. The interviews also showed that there was a demand for the Green Team to continue its motivation actions.

In sum, group dynamics, a shared culture and the construction of a collective story, are powerful levers for behavioral change. Another questionnaire, different from Q1 and Q2, is planned to be distributed in order to confirm and refine the results obtained so far.

A tool for behavioral monitoring

Beyond measurement and observation, the EAI constitutes a tool for monitoring environmental issues. The indicator leads the employees to reflect upon their daily behavior at work. Thus, it guides change by making every participant an observer of his own mental blocks within the group dynamics. Furthermore, because the EAI pays much attention to individual expectations, it helps in creating an atmosphere of confidence and respect. Finally, the distribution of the target population among the different stages of change helps the Energy Management System department to define a communication strategy, as shown in Table 4.

Table 4. The stages of change and corresponding communication messages

STAGE OF CHANGEMENT	**BEHAVIORAL MONITORING**	
	Message type	**Environmental promotion**
Precontemplation	Information	Inform on issues to initiate awareness
Contemplation	Information	Try to convince by giving reasons for change
Preparation	Practical guide	To make action easier
Maintenance	Encouragement	Encourage the continuation of engaged efforts
Termination	Enhancement	Exemplarity, spreading the good practices

For Grand-Pré, the answers to Q2 place the population at the stages of Maintenance (22%) and mostly Termination (60%). A forthcoming campaign could stress the exemplariness of those performing the energy saving actions, such as the accounting of their experience to their colleagues and the sharing of their knowledge during other Energy Weeks organized within the organization.

As for the Hôtel des Finances, the population is mainly at the stages of Maintenance (33%) and Termination (45%). Here, the message could be an encouragement to pursue the engaged efforts, for example, by giving awards.

Conclusion

The EAI is a tool for the evaluation of the behavioral effects of energy conservation programs. For the time being, there is a discrepancy between the results given by the EAI and those obtained from the data loggers and electric meter readings. Although the response rate was quite low, this strongly suggests that the indicator needs refining. Nevertheless, it seems to us that the EAI has a

real potential for the evaluation of energy conservation measures: firstly, it provides an evaluation of the behavioral effects of energy saving actions beyond the measurement of watts; secondly, it can be used as a guide for the choice of communication strategies aimed at specific target populations.

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