Evaluation of Energy Efficiency program in Geneva

Evaluation methodologies for two subprograms using bottom-up approach

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Abstract
éco21 is an energy efficiency program addressing the electricity sector in Geneva-Switzerland (population[1] ~460000 and yearly electricity consumption[2] ~2850 GWh/year, CERN excepted). The program was launched in 2007 and was redesigned in the middle of 2009. At the very beginning of the new program, the University of Geneva was requested to develop the evaluation methodology for the program and do the corresponding monitoring and evaluation.

After a brief presentation of the program *éco21* and the framework of its monitoring and evaluation, we address the evaluation methodologies pertaining to two of the subprograms (Low Income Household Energy Efficiency and Building Communal Areas) and the results of the very first evaluation experiences.

For these two subprograms, different options of enhanced engineering estimations – that are to be used with a sample of projects – will enable to refine simple engineering estimations. The aim is to drop the enhanced engineering methods later in favor of the (improved) simple engineering estimations that are more time and cost effective. Billing analysis will be used systematically to double check the estimates and to evaluate the lifetime of the actions.

Introduction

<u>Description of the program *éco21*</u>
éco21, an energy efficiency program addressing the electricity sector in Geneva-Switzerland, was launched in 2007 with a budget of 21 million CHF (approx. 15 million EUR)[3]. The activities of the program concerned lighting systems of common areas in residential buildings and energy efficiency campaigns targeting mainly small customers.

In the middle of 2009, the program was redesigned and expanded to all of the electricity users in Geneva. The budget allocated to the program is now 57 million CHF (approx. 40 million

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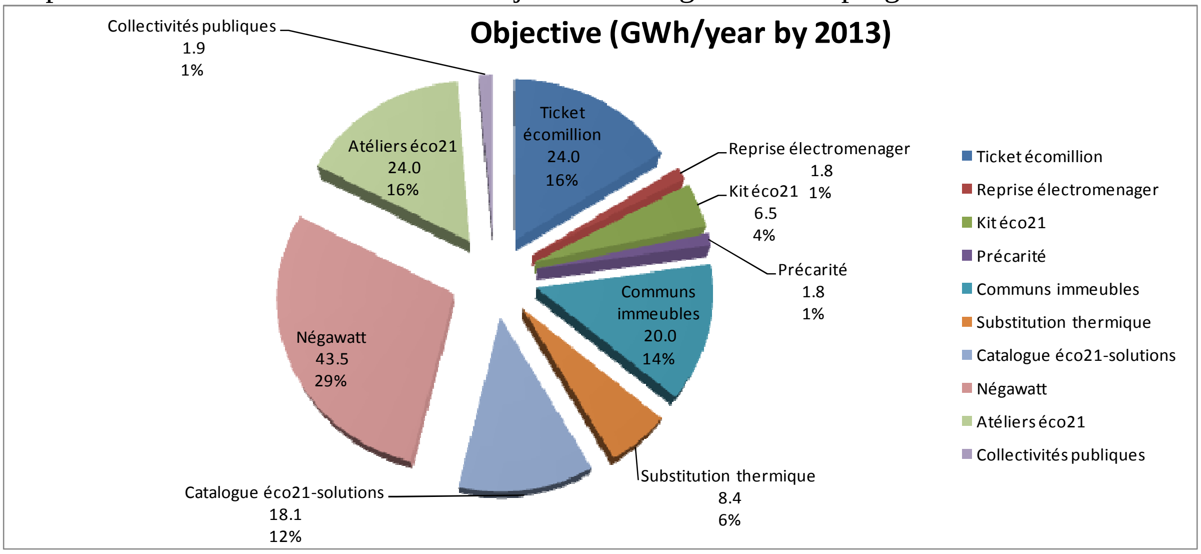
[1] *Résultats statistiques – Bilan et état de la population du canton de Genève en 2008*, Office Cantonal de la Statistique (OCSTAT), p.1.
[2] Rapport de développement durable 2008, Services Industriels de Genève, p.3.
[3] At present exchange rate: 1 CHF = 0.7 EUR.

EUR) and the objective of electricity reduction is 150 GWh/year to be reached by 2013. This is a significant goal since it represents 5% of the present electricity consumption of the canton of Geneva (CERN excepted). The creation of the new program was based on an ex ante estimation and benefited from some of the European experience, in particular the French. This helped to match a realistic budget to the proposed goal of 150 GWh/year electricity reduction by 2013.

The program is divided into 10 subprograms[4] (or action plans) that target different sectors:

- Two of the ten subprograms (*négawatt* and *atelier*) accounting for 45% of the total expected savings (i.e. 67.5 GWh/year by 2013) target large customers. The IPMVP methodology[5], broadly accepted, has been proposed to measure the savings generated by the subprogram *négawatt*. Their advantage is that almost all the large customers already have a preliminary energy audit conducted on their site and a third of them have a detailed audit of efficiency measures focused on electricity. This information is very useful to determine the most appropriate and economical way to perform a measurement and verification process on each site.
- Four of the ten subprograms target the residential sector (*précarité*, *kit éco21*, *écomillion*, and *reprise électromenager*); these four subprograms account for 23% of total expected savings (i.e. 34.8 GWh/year by 2013). The subprogram *précarité* is designed for low income customers. The first implementation experience of *précarité* was conducted at the end of 2009 and different measurement approaches were implemented that are discussed below.
- The remaining four programs[6] (*communs d'immeubles*, *catalogue éco21*, *substitution thermique and collectivités publiques*) account for 32% of the total expected savings (i.e. 46.8 GWh/year by 2013). *Communs d' immeubles*, which targets improvement of the electricity consumption in building communal areas (residential and commercial), is being carried out since 2007.

Graph 1 shows the distribution of the objective among the ten subprograms.



Graph 1

[4] The name of the subprograms is given as a reference since they are still being reflected upon.
[5] EVO (Efficiency Valuation Organization) 2009 ; *International Performance Measurement and Verification Protocol – Concepts and Options for Determining Energy and Water Savings*, www.evo-world.org
[6] The subprogram *catalogue éco21* will probably address large customers too and the subprogram *collectivités publiques* is no longer a subprogram.

Evaluation of the program
The University of Geneva was asked, almost at the very beginning of the new program, to do the monitoring and evaluation of the program, in other words it was asked to consider cost effective measurement and verification methodologies at the implementation stage and even, for some of the subprograms, at the conception stage. The adopted evaluation methodology is mainly based on the work already done in Europe[7].

The evaluation of each subprogram is done on a yearly basis and includes a comparison of the electric savings obtained during the year with those defined by the intermediate objectives of the program; this process should allow the utility to make regular adjustments to the program according to the results obtained. An evaluation of the entire program will be done in 2014. The general methodology for the evaluation of each subprogram is a bottom up approach; it will be supplemented, if necessary, by a top-down approach. The evaluation includes normalization, aggregation and correction of the collected data.

The following sections describe the general methodology that will be used to evaluate the subprograms low income household energy efficiency (*précarité)* and the building communal areas (*commun d'immeubles)*. The methodology description is accompanied by examples of the very first measurements and of the type of analysis performed. Concerning *précarité*, the first pilot project is described and the different measurement approaches that were adopted for its analysis are given. Concerning *communs d'immeubles*, the measurements of one particular action are given and the results for seven buildings are detailed. The measurement parameters are to be calibrated using the enhanced engineering estimations[8] (method 2 below); this will then enable us in the future to only use the simpler and more cost effective methods (i.e. simple engineering estimations and billing analysis).

Low Income Household Energy Efficiency subprogram (*précarité*)

The aim of this subprogram is to favor the implementation of energy efficient technologies in low income households. More specifically, it provides information on domestic electric consumption to the residents of the buildings selected by the program; the incandescent light bulbs and halogen lamps of participating households are replaced by CFLs (compact fluorescent lamps); energy saving extension leads are installed and rebate vouchers are given to replace existing refrigerators by energy efficient ones. The objective is an electricity reduction of 1.8 GWh/year by end 2013; to achieve this, the subprogram has set a target of 4500 households. Finally an electricity savings potential of 407 kWh/year per household was estimated.

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[7] See the publications of the program 'Intelligent Energy for Europe' (EIE) and those of the 'Active Implementation of the proposed Directive on Energy Efficiency' (AID-EE), http://www.aid-ee.org/documents.htm and also the EMEEES project, http://www.evaluate-energy-savings.eu/emeees/en/home/index.php (c.f. bibliography below).

[8] The terminology is inspired from the Directive 2006/32/EC of the European Parliament and the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC.

Proposed evaluation methodology to estimate gross savings of the subprogram Low Income Household Energy Efficiency (*précarité*)

Three types of data collection and their respective methodologies of saving estimation are proposed[9].
Method 1 – simple engineering estimations[10] (see appendices) – is based on the information (i.e. the electrical power) collected during the replacement of the devices and an estimation of the yearly operating hours; this method is very simple and the savings can be estimated immediately after the action. However, at present, the estimation of operating hours is fairly imprecise. Method 2 below will allow us to reduce this imprecision.

Method 2 – enhanced engineering estimations – is based on the measurement of the electric consumption (meter readings and/or load profiles). The gross annual energy savings are calculated by subtracting the energy consumption after implementation from the energy consumption during the baseline period.
The results on load profiles obtained using method 2 will help us to determine the yearly operating hours.

Method 3 – Billing analysis – The gross annual energy savings are calculated by subtracting the energy consumption after implementation (using one or two bills) from the energy consumption before implementation (using the last two or three bills). Let us note that in Geneva the readings are only done once a year, therefore it is necessary to wait a certain time before making the savings estimations.

The results obtained using method 2 will help us to determine the yearly operating hours; for our purpose, it will then be sufficient to only use methods 1 and 3 that are more cost effective.

Case study (method 1 and methods 2) – Pilot Project *Les Libellules*:

Brief description of the pilot project
For the first pilot project, a building with of 8 entrances was chosen (i.e. address no.: 2, 4, 6, 8, 10, 12, 14 and 16); it comprised 504 households benefiting from social subsidies.
336 of the 504 households participated in the project. The project changed 2912 lights bulbs by CFLs (compact fluorescent lamps), installed 411 energy saving extension leads and replaced 83 halogen lamps. This was accomplished by energy ambassadors[11] who visited the apartments and informed the occupants on issues of rational energy use. In addition, 90 rebate vouchers for refrigerators were used by the participants to replace the existent fridges.

The table below (table I) summarizes the data collected by the energy ambassadors during the action:

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[9] For a detailed description of the different methods, see Appendices.
[10] Regarding the terminology c.f. note 8 above.
[11] People specifically recruited to visit the households and replace the devices.

Address No.	FINAL TOTAL					
	V	***A+***	***A-***	***L***	***M***	***F***
2	**32**	**3'899**	**12'179**	**6**	**45**	**25**
4	**48**	**4'796**	**22'244**	**13**	**57**	**39**
6	**40**	**6'085**	**15'942**	**9**	**69**	**18**
8	**43**	**5'611**	**16'270**	**14**	**63**	**30**
10	**43**	**7'213**	**18'636**	**7**	**45**	**21**
12	**40**	**4'108**	**13'109**	**14**	**49**	**23**
14	**41**	**4'461**	**14'096**	**11**	**41**	**32**
16	**49**	**6'216**	**22'996**	**9**	**42**	**34**
	336	***42'389***	***135'472***	***83***	***411***	***222***

Table I

Where:
V is the number of visits
A+ is the power [Watt] of CFLs installed
A- is the power [Watt] of light bulbs removed
L is the number of halogen lamps replaced
M is the number of energy saving extension leads installed
F is the number of refrigerator vouchers given out (of which 90 were used)

The average wattage of the removed bulbs amounts to **46.5 W/bulb** and the average wattage of installed CFLs is **14.6 W/bulb**.

Simple engineering estimations – ex ante (method 1)
The number of light bulbs replaced is 2912. The reduced power is 93.1 kW, which gives an average of 32 W per replaced light bulb.

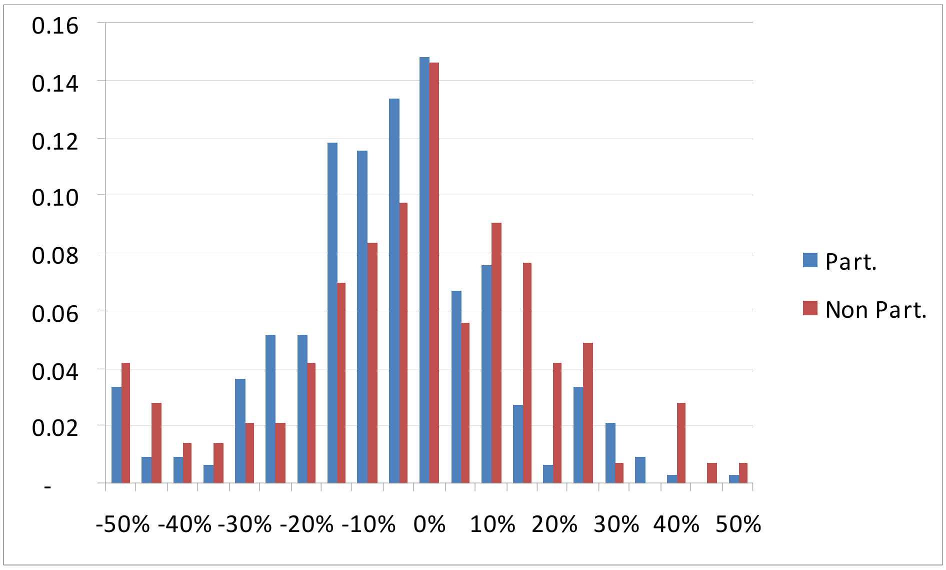
The total electric energy savings can be estimated to be 113 MWh/year, when taking the following hypotheses: the mean use of light bulbs is 2 hours a day; the extension leads allow a consumption reduction of 1 kWh/week, the refrigerators allow a 250 kWh/year economy,.

Further measurements and analysis will allow us to validate or improve these hypotheses.

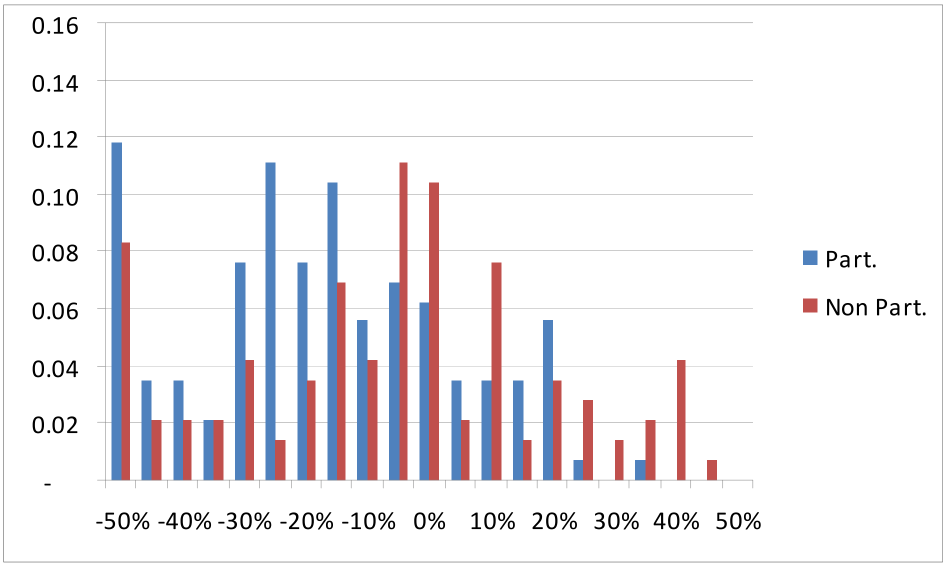
Enhanced engineering estimations –ex post (method 2)
The ex post data collected were of two types: the consumption meter readings for each apartment and the load profiles for all apartments at a given address. The comparison of the two types of data first allowed us to verify their quality and secondly make corrections. In this paper, only the results pertaining to the consumption meters are given.

After removing the data concerning participants with zero consumption, the analysis of the data showed that the households participating in the project reduced their electric consumption by approximately 12%, whereas the consumption of the households that did not take part in the program increased by 1.5%.

Graph 2 and graph 3 show the distribution of energy savings (in %) for participants (in blue) and non-participants (in red). Graph 1 represents the distribution just after the implementation of the pilot project, graph 2 represents the distribution 4 months after implementation. One can see that there are more participants (in blue) to the left side of the graph (graph 2) and this is emphasized after 4 months (graph 3).



Graph 2: distribution just after implementation



Graph 3: distribution 4 months after implementation

First conclusions (Low Income Household Energy Efficiency subprogram)

The preliminary simple engineering estimations (ex ante) are fairly accurate, they are close to the enhanced engineering estimations (ex post) based on meter readings. Our analysis gives 350 kWh/year/household electric savings instead of the 407 kWh/year/household estimated by the program. We calculated that at least 15 similar projects (for a total of 5150 households) will be necessary to reach the final objective of the subprogram. Finally, let us note that the information collected in this subprogram should be of use for the evaluation of other subprograms (e.g. *écomillion, kit éco21*).

Building Communal Areas subprogram (*communs d'immeubles*)

The building communal areas (i.e. the services provided to all the occupants of a building) represent a large potential for electric energy savings; all the more since the cantonal regulation no longer (i.e. since 2005) requires 24 hour per day lighting in building common spaces.

During the first stage (i.e. 2007 to present) the subprogram merely considered the implementation of lighting retrofits and is now reflecting upon an action plan including all aspects of electricity savings within the building communal areas, e.g. the replacement of domestic electrical equipment for common use, such as laundry equipment; the optimization of the consumption of lifts; the improvement of electric fans etc. The objective of this subprogram is 20 GWh/year of electricity savings by end 2013; to accomplish this it targets 5000 buildings (4000 kWh/year per project).

Proposed evaluation methodology to estimate gross savings of the subprogram Building Communal Areas (*communs d'immeubles*)

The electricity consumption of building common areas shows two different aspects: part of the consumption can be easily calculated for it is controlled by clocks (fans, 12h/24 lighting etc.) or is running continuously (24h/day lighting). However, another part of this consumption is related to the behavior of the building's occupants (the more or less frequent use of the lift, laundry machines and now the new lights equipped with motion sensors).

As for the Low Income Households Energy Efficiency subprogram, three types of data collection and their respective methodologies of saving estimations are proposed: simple engineering estimates (method 1) based on the information collected about the replaced and installed devices during the implementation of a given project; enhanced engineering estimates (method 2) based on measurement of the energy consumption and/or hours of operation (i.e. meter readings, load profiles and/or use information); the analysis of the electric bills (method 3) based on a yearly reading.
The different options of method 2 – that are to be used with a sample of projects – will enable to refine the hypotheses used in method 1; the aim is to drop method 2 later in favor of method 1 (more time and cost effective). Method 3 will be used systematically to double check the estimates and to evaluate the lifetime of the actions. For a detailed description of the different methods, see Appendix 2.

Whenever possible, prediction models[12] (method 1) will be used and, concerning the behavior related consumptions, the average time of use of the various equipments will be estimated on the basis of measurements[13] (method 2).

For example, the duration and the standard deviation of the use of lighting equipped with motion sensors are poorly documented in Switzerland[14]. Therefore a series of measurements based on a random sample of buildings would be very helpful in this matter.

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[12] See E. Langlo, O. Ouzilou, P. Schmid, J.L. Bertholet, F. Carlevaro, 1996 ; GENIE : *Etude de l'indice de consommation d'énergie électrique dans le secteur immobilier genevois*, OCEN and J.L. Bertholet, 2008 ; *Trois essais de métrologie économétrique dans le domaine énergétique*, Thèse No. 657 de l'Université de Genève.
[13] Note that the variability of the intensities will be included in order to consider the specificity of the different buildings.
[14] In Switzerland only non-verified hypotheses have been given, for example a publication of the Federal Energy Office (OFEN) suggests a 3 hours/day reduction for office lighting. ['Evaluation und Konzeption von Systemen

The evaluation methodology can be summarized in the following way:

1) Compare the consumptions of the common areas before and after the achievement of the action using IPMVP (option C)[15]. Two methods are possible: i) use the utility meter readings (method 3); the inconvenience being that, in general, the meters are only read on a yearly basis. ii) make a series of extraordinary consumption measurements (using the utility meters) before and after the implementation of the action (method 2a[16]).
2) Perform measurements of the load profile and/or use patterns in order to deduce the duration and frequency of consumption (method 2b et method 2c[17]).
3) Improve our prediction models by comparing the simple engineering estimations ex ante estimates (method 1) of the electricians with the results obtained from the above measurements (utility meter readings and load profiles). Note that, as just mentioned, this point requires the choice of a sample of buildings.

Case study A: lighting retrofit - measurement of duration of lighting use (method 2)
The *éco21* program performed some measurements related to the duration of lighting use in one of the buildings that participated in the program during 2008. The building is a residential building with 9 floors and 36 apartments. In this project 1948 W of 24h/24h lighting were replaced by 1138 W of efficient lighting equipped with motion sensors (i.e. when nobody is detected by the sensors, the lights are dimmed to a 30% level). The details are given in Table II below and the results presented here correspond to the second line of Table II.

Quantity	Pbefore/unit (W)	Ptot before (W)
5	60	300
20	50	1000
4	112	448
4	50	200
Total		**1948**

Quantity	Pafter/unit (W)	Ptot after (W)
5	31	155
20	31	620
4	52	208
5	31	155
Total		**1138**

Table II

After the implementation of this project, the measurement of the load profile - during one week - was made for the building staircase (i.e. 20 lights amounting to 1000 W prior to action and 620 W after action) in order to determine the duration of the use of the new lights.

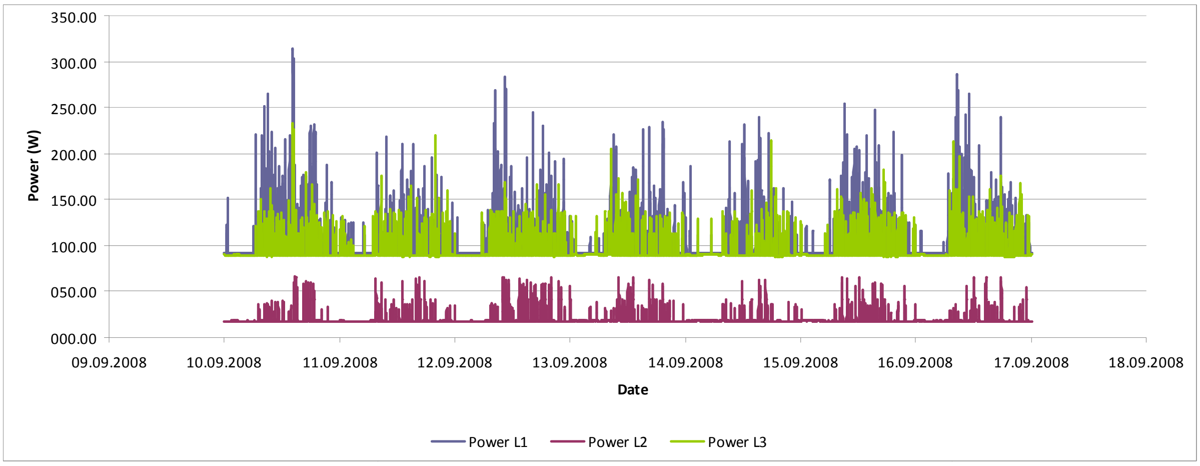
Graph 4 shows the three power phases measured from September 10 to September 17 2008.

zur einfachen Nachrüstung von Beleuchtung mit Bedarfssteuerungen', Schlussbericht, OFEN, M. Stalder and R. Naef, August 2008]

[15] EVO (Efficiency Valuation Organization) 2009 ; International Performance Measurement and Verification Protocol – Concepts and Options for Determining Energy and Water Savings, Vol 1 p.29, www.evo-world.org

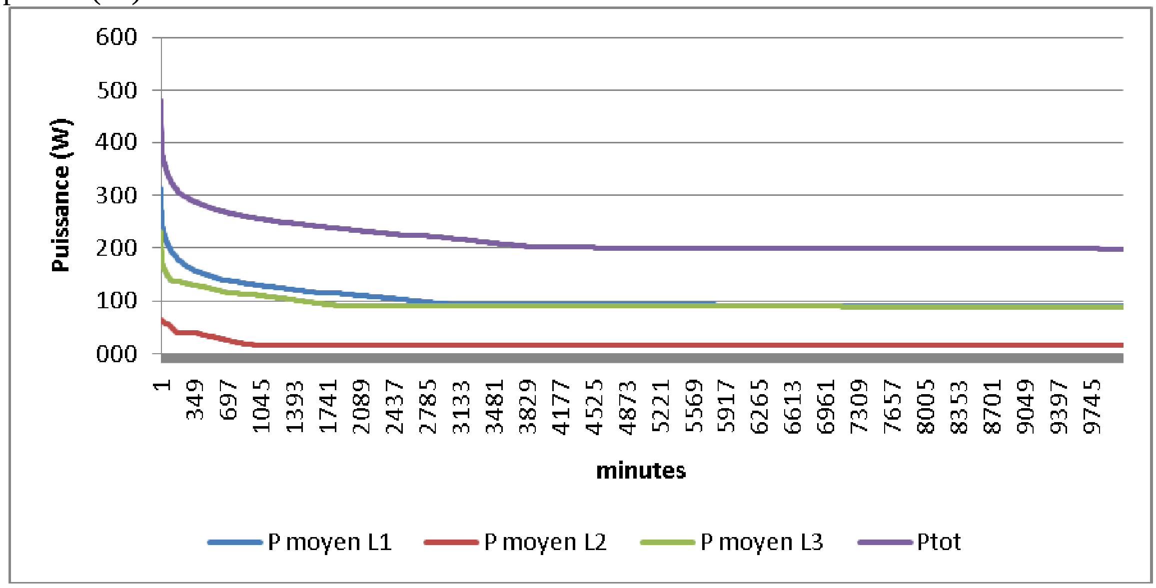
[16] See appendices for more information.

[17] See appendices for details.



Graph 4

Graph 5 gives the monotonic load curve for the power (W) of the three phases and the total power (W).



Graph 5

The average operation hours of lights in high mode is calculated from the installed power (620 W) and the monotonic load curve. This analysis shows that the average operation time of the staircase lighting is close to **1hour and 10minutes per day**.

Similar measurements will permit us to refine our prediction model concerning the duration and the standard deviation of lighting equipped with motion sensors.

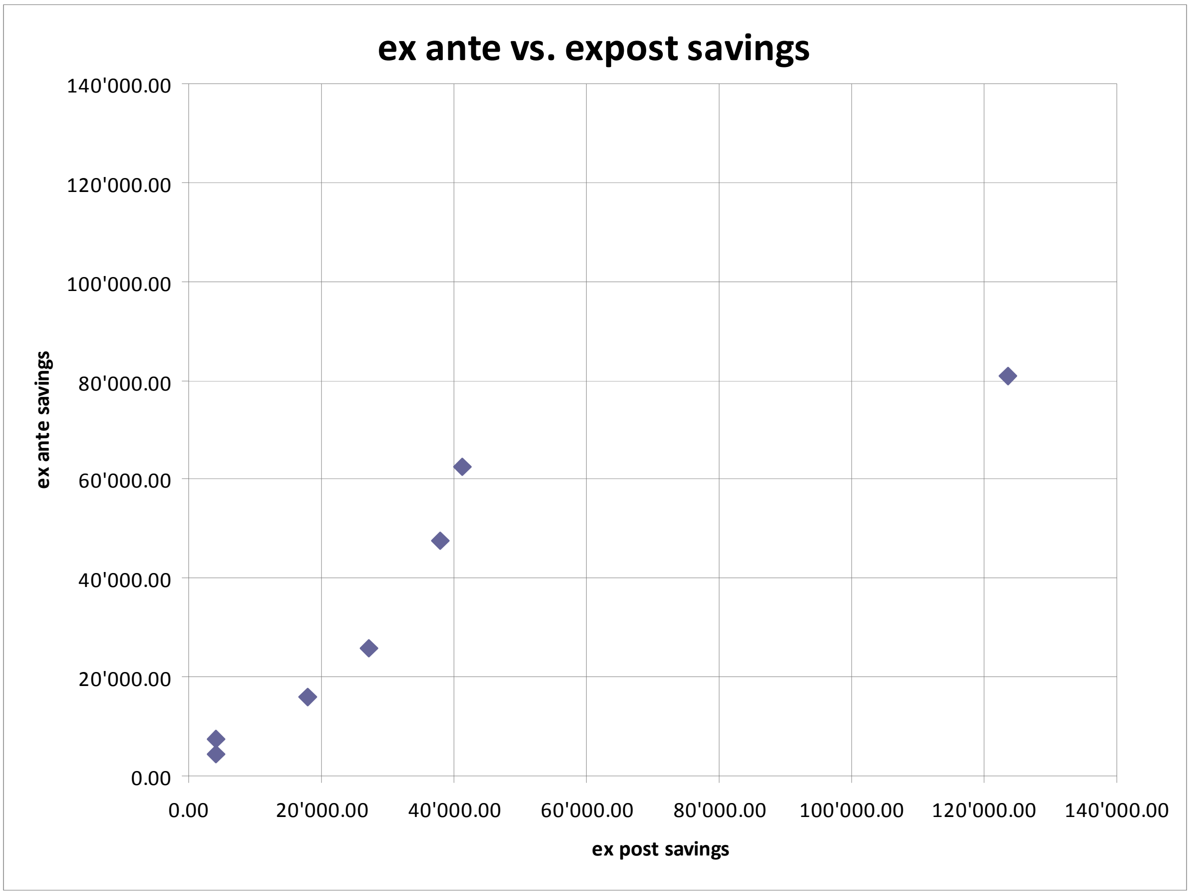
Case study B: comparison of ex post and ex ante estimations

This case study compares the ex ante estimates (i.e. the simple engineering estimations - method 1) performed by the electricians with the ex post evaluation based on billing information (method 3), see graph 6. The comparison is based on 23 projects carried out during 2009 - corresponding to 7 buildings - for which an electric bill has already been issued after the implementation of the project.

The electricians in charge of the implementation of the project performed the energy saving estimates on the basis of the characteristics of the existing equipment, those of the new equipment and their personal experience.

The ex post calculations of energy savings are merely based on the difference between the energy consumed before and after implementation. The data used for the calculations is the 2008 energy consumption (calculated by the utility using the electric bills), and a yearly extrapolation made on the basis of the last two readings of the utility meter that were available at the time this paper was written.

The total energy savings for the 23 projects is 256 MWh (~11000 kWh/year per project); this represents 37% less than the electricity consumed during 2008. This relatively large reduction can be explained by the fact that a considerable part of the lighting systems in the common areas of the participating buildings was operating 24h per day. The total ex ante estimations (method 1) made by the electricians is not far from the ex post calculations (method 3); the average difference amounts to 4%. However, if we make the same comparisons site by site, the differences go from -35% to +81%. The graph 6 compares the calculated ex post savings with the saving estimations made by the electricians.



Graph 6

Similar measurements will help us to improve the prediction models that will be used by the electricians in the future projects.

First conclusions (Building Communal Areas subprogram)
The first results of the preliminary ex post evaluations using enhanced engineering estimations (method 2) and billing analysis (method 3) should enable us to improve the parameters (e.g. the average operating hours of lighting) to be used in the models for ex ante estimations (method 1); this should also provide information on the potential of electric savings of individual projects helping to assess if the target of the subprogram can be achieved as it is now planned.
The average savings per project is higher than the 4000 kWh estimated by the program.

General conclusions

The University of Geneva was requested to develop the evaluation methodology for the program *éco21* (energy efficiency program addressing the electricity sector in Geneva-Switzerland) and perform the corresponding monitoring and evaluation. For two subprograms three types of data collection and their methodologies of savings estimates are tested in case studies. They provide the following information:

- At the project level (i.e. for the particular case study projects analyzed here), the enhanced engineering estimations are close to the simple engineering estimations. Therefore, a few additional enhanced engineering estimations should be enough to improve the original hypotheses on the simple engineering estimations enabling to use the latter -more time and cost effective- alone in the future.
- At the subprogram level, the savings obtained by these first results can be used to improve the original estimates of the goal and target of the two subprograms.

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Appendix 1: Description of evaluation methodology for the Low Income Household Energy Efficiency subprogram (*précarité*)

Method 1: Simple engineering estimations (ex ante)

Data

The data consist of the electrical power of the devices which were removed and installed by the energy ambassadors.

Gross annual energy calculations

The gross annual energy savings are calculated using the collected information (electrical power) during the replacement of the devices and an estimation of the yearly operation hours.

Advantages

The advantage of this methodology is that the calculation is simple and can be performed just after the implementation.

The savings are calculated for each participant, and this calculation can be compared with the estimations of method 3.

Disadvantages

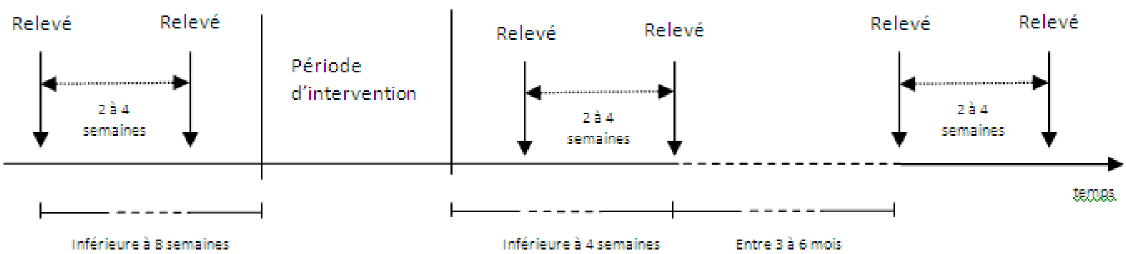
The disadvantage is there is not information, at present time, to perform accurate estimates. The main uncertainty is the operation hours of the replaced devices. However, the precision will be improved later, once more information is gathered (through method 2).

Method 2: Enhanced engineering estimations (ex post)

Method 2a) Meter readings

Data

The data consist of three sets of 2 extraordinary readings of the electric utility meters (including date, hour, and kWh). The readings are performed the same day of the week at the same hour (+/- 1 hour) and are done at the following times (see graph 1 below):



Graph 1

- Reading interval for the determination of the baseline (i.e. energy consumption before implementation of the project).
- First reading interval just after the implementation of the project
- Second reading interval a few months after the implementation of the project

Gross annual energy savings calculations

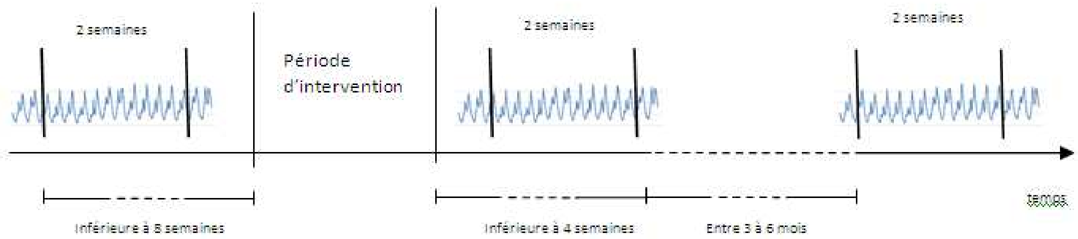
The gross annual energy savings are calculated by subtracting the energy consumption after implementation from the energy consumption during the baseline period. The energy consumption measured during the second reading interval will serve to quantify the different normalization factors (meteorological conditions, etc.) that will be used for the calculation of the net annual energy savings.

Advantages

Good precision. It allows the calculation of energy savings for each participant (household) and therefore, it allows comparisons between the participants - and also the non-participants - to the project.

This information could be very useful for other subprograms (*ticket écomillion*, *kit éco21*) that target a similar type of participants.
<u>Disadvantages</u>
The cost is relatively high.
If the meters are located inside the apartments, the readings and the precision can be affected.
The availability of the utility technicians, who perform the reading tasks, could be a problem, because they will also be needed by other subprograms.
It does not give information about the hourly electric demand (load profiles).

Method 2b) Load profiles by group of participants
<u>Data:</u>
To obtain this kind of information, electrical loggers have to be installed. The loggers are installed in order to measure the consumption of a group of participants sharing the same address.
Three series of measurements - load profiles- over a period of at least 2 weeks each are made. The three series start the same day of the week; the following information is recorded: the active power and the reactive power for the three phases every 15 minutes.



Graph 2

<u>Calculation of the gross annual energy savings</u>
The gross annual energy savings are calculated by subtracting the energy consumption after implementation from the consumption before implementation.
The reduction of the peak power is also calculated.
<u>Advantages</u>
Good precision. The hourly energy consumption is available; this will allow to identify changes in energy consumption and will be used to quantify the different normalization factors (meteorological conditions, etc.).
<u>Disadvantages</u>
The cost is relatively high (it can vary, according to the electrical distribution system of the building).
The availability of engineering service providers might pose a problem, since they will be also involved in measurement and verification activities for other subprograms.

N.B.: Let us make two remarks:
1) The two alternatives of method 2 provide information of different nature. While method 2a gives information on each participant (and non-participant) of a given project, method 2b gives more detailed general information (e.g. time series information, reactive power).
2) As already mentioned, the results of the analyses of method 2 should enable us to refine the estimations of operation hours of method 1, which is cost and time effective.

Method 3: Billing analysis (ex post)
<u>Data</u>
Meter reading data collected for billing purposes. For the small residential customers, a single yearly reading is performed by the utility.
<u>Calculation of the gross annual energy savings</u>
The gross annual energy savings are calculated subtracting the energy consumption after implementation (using one or two bills) from the energy consumption before implementation (using the last two or three bills).

Advantages

The cost of the data collection for this method is relatively low.

It allows a comparison between the participants (and non-participants) to the program.

Disadvantages

As the readings are performed only once a year, it is necessary to wait a long time before being able to make saving estimations.

Appendix 2: Description of evaluation methodology for the Building Common Areas subprogram (*commun d'immeubles*)

Method 1: Simple engineering estimations (ex ante)

Data

The data consist of the electrical power of the devices which were removed and installed by the electricians who are in charge of the implementation of the project.

Gross annual energy calculations

The gross annual energy savings are calculated using the collected information (electrical power) during the replacement of the devices and an estimation of the yearly operation hours. The estimation of the yearly operation hours will be obtained through the application of method 2 to a sample of representative projects.

The savings are calculated for each project, and this calculation is compared later with the estimations of method 3.

Advantages

The advantage of this methodology is that the calculation is simple and can be performed at the time of the implementation.

Disadvantages

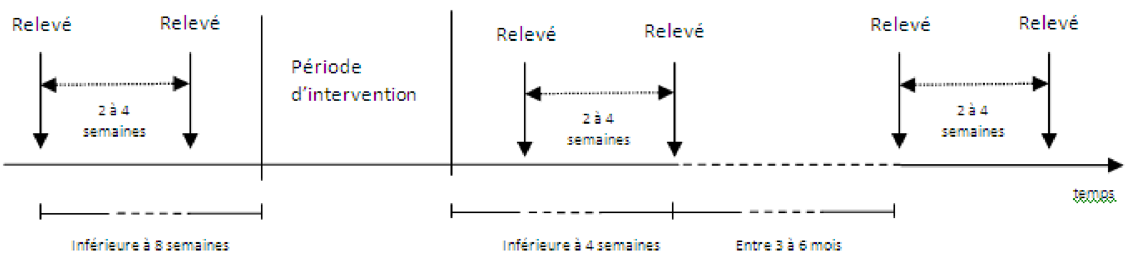
The disadvantage is that there is not information, at present time, to perform accurate estimates. The main uncertainty is the operation hours of the replaced devices. However, the precision will be improved later, once more information is gathered (through method 2).

Method 2: Enhanced engineering estimations (ex post)

Method 2a) Utility meter readings

Data

The data consist of three sets of 2 extraordinary readings of the electric utility meter for common areas and services of the building (including date, hour, and kWh). The readings are performed the same day of the week at the same hour (+/- 1 hour) and are done at the following times (see graph 1 below):



Graph 1

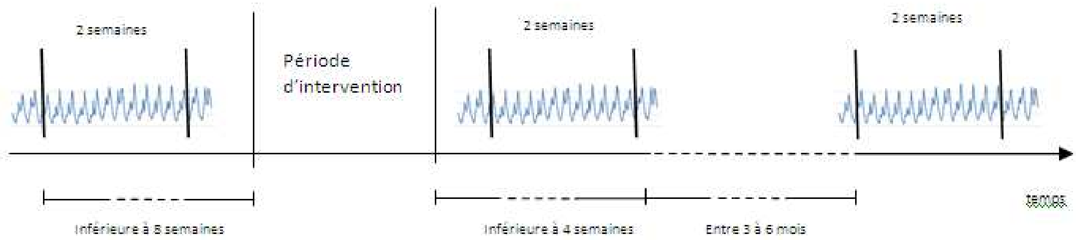
- Reading interval for the determination of the baseline (i.e. energy consumption before implementation of the project).
- First reading interval just after the implementation of the project
- Second reading interval a few months after the implementation of the project

Gross annual energy savings calculations

The gross annual energy savings are calculated by subtracting the energy consumption after implementation from the energy consumption during the baseline period. The energy consumption measured during the second reading interval will serve to quantify the different normalization factors (meteorological conditions, etc.) that will be used for the calculation of the net annual energy savings.

Advantages
Relatively low cost, since one or a few meters are concerned, this reading task can be performed by the custodian of the building.
Relatively good precision.
Disadvantages
It does not give information about the hourly electric demand (load profiles).

Method 2b) Load profiles
Data:
To obtain this kind of information, electrical loggers have to be installed. The loggers are installed in order to measure the consumption of common areas and services.
Three series of measurements - load profiles- over a period of at least 2 weeks each are made. The three series start the same day of the week; the following information is recorded: the active power and the reactive power for the three phases every 15 minutes.



Graph 2

Calculation of the gross annual energy savings
The gross annual energy savings are calculated by subtracting the energy consumption after implementation from the consumption before implementation.
The reduction of the peak power is also calculated.
Advantages
Good precision. The hourly energy consumption is available; this will allow to identify changes in energy consumption and will be used to quantify the different normalization factors (operation hours, meteorological conditions, etc.).
Disadvantages
The cost is relatively high (it can vary, according to the electrical distribution system of the building).
The availability of engineering service providers might pose a problem, since they will be also involved in measurement and verification activities for other subprograms.

Method 2c) State sensor dataloggers
Data:
To obtain this kind of information, light and/or motor sensor loggers are installed to measure a sample of representative devices. The loggers measure the state (i.e. on/off) of operation of the lights, respectively the motors.
Three series of measurements over a period of at least 2 weeks each are made. The three series start the same day of the week.
Calculation of the gross annual energy savings
The gross annual energy savings are calculated by subtracting the energy consumption after implementation from the consumption before implementation.
Advantages
Good precision. The hourly operation of devices is available; this will allow to estimate the yearly operation hours of different devices.

Disadvantages
This method has variable cost.
It does not give information about power use.

N.B.: Let us make two remarks:
1) The alternatives of method 2 provide information of different nature.
2) As already mentioned, the results of the analyses of method 2 should enable us to refine the estimations of operation hours of method 1 that is cost and time effective.

Method 3: Billing analysis (ex post)
Data
Meter reading data collected for billing purposes. For the common areas of buildings, in general a single yearly reading (or in some cases a single monthly reading) is performed by the utility.
Calculation of the gross annual energy savings
The gross annual energy savings are calculated subtracting the energy consumption after implementation (using one or two bills) from the energy consumption before implementation (using the last two or three bills).
Advantages
The cost of the data collection for this method is relatively low.
It allows a comparison between the participants (and non-participants) to the program.
Disadvantages
As the readings are performed only once a year for several buildings, it is necessary to wait a long time before being able to make saving estimations.