

Energy performance contracts to improve heating efficiency in residential buildings

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ABSTRACT

The demand-side management program « éco21 » of the public multi-utility company « Services Industriels de Genève (SIG) », has developed an energy performance contracting program to minimize heat demand in multi-family residential buildings. The energy savings are obtained through an optimal exploitation of the heating installations and by eliminating overheating of the individual apartments, while ensuring the needed comfort for its occupants. These contracts offer an attractive alternative to costly energy renovation works (to improve the air-tightness of buildings). They do not cost anything and show significant results: the average energy saving for a given building after 3 years of optimization is close to 17% and individual cases show up to 37%. The revenues obtained through these savings serve exclusively to remunerate the heating company which performs the optimization as well as an independent third partner. This latter trains the heating craftsmen, provides a platform to track and analyze the energy consumption throughout the 6 years of contract, offers technical support and certifies the achieved savings according to an international standard. As soon as these program expenses are covered, the occupants benefit from a lowered heating energy bill, often after only 1 or 2 years of optimization. These contracts are available to all residential buildings in the Geneva canton with an annual thermal energy consumption of more than 275 MWh, independently of whether the owner is a private person, an investor, a public entity or a cooperative.

The program started in 2014 and consists today of 224 contracts, covering about 15,500 dwellings. These contracts offer a win-win situation for the Geneva Canton, the property owner, the local heating companies, the occupants and SIG-éco21, whose aim is to push forward the goals set by the Swiss energy transition at the scale of the Geneva Canton. Up to June 2017, the integrated thermal energy savings amount to more than 20 GWh (equivalent to the consumption of ~1,500 entire households) or equivalent to 4,300 t of saved CO₂ emissions.

1) Introduction

a) Legal framework of the Geneva Canton

The Swiss Confederation decides the global objectives of its Energy Strategy through the Swiss Federal Energy Law (Swiss Confederation, 1998). However, the 26 cantons have the freedom to decide the concrete measures to implement. As such, each canton implements its proper energy law based on

the federal law, as well as the objectives set by the Swiss Energy Strategy. In this context, the Geneva Canton has completely revised its energy law in 2010 which has become one of the most demanding one in Switzerland (Etat de Genève, OCEN, 2010).

For example, companies or individual (production) sites which have an annual thermal (electrical) consumption of more than 4 (1) GWh are considered as “high consumers” (Grand consommateurs). They are obliged to undergo an energy audit and to improve their energy performance, thereby lowering their energy consumption.

Another example concerns energy requirements for newly built houses or those undergoing renovation. 1) At least one third of the domestic hot water needs must be produced from local, renewable energies. 2) Buildings with a ventilation system used for at least 500 hours a year and an airflow of more than 1000 m³/h are required to recover the heat stored in the extracted air.

The implementation of the energy law of the Geneva Canton (Etat de Genève, OCEN, 2011) obliges all property owners of heated buildings to report once per year the annual energy consumption for space heating and domestic hot water. This information is stored in a publicly accessible data base called “Système d’Information du Territoire à Genève (SITG)” (Etat de Genève, SITG, 2011). If the associated indicator – the annual thermal energy per square meter “IDC” (indicateur de dépense de chaleur) – is larger than 600 MJ/m²a during two consecutive years, the property owner is requested to install individual heating meters in each flat and to implement energy efficiency measures to reduce the heat consumption. If instead, this indicator is above 800 MJ/m²a during 3 consecutive years, the property owner is obliged to hire an energy auditor to help him identify cost effective measures to be implemented within the following 2 years. Finally, if the IDC is higher than 900 MJ/m²a, averaged over 3 years, the owner is obligated to plan major renovation works to reduce the heat consumption below 600 MJ/m²a within a delay of 5 years.

On the other hand, the most recently constructed buildings consume between 100 and 200 MJ/m²a, as they are requested to use state-of-the art construction materials with a high energetic performance. Switzerland has created its own standard, “Minergie”, which is widely adopted by Swiss architects. This voluntary standard requests even higher energy standards than required by the Swiss law. However, there are numerous studies (J. Khoury, 2018) which show that the real consumption of such buildings is up to a factor of 2 or even higher than the theoretically calculated one (“energy performance gap”).

The energy performance contracts to be discussed in this article target all kind of residential buildings with a yearly energy consumption of more than 275 MWh, independently of whether the associated indicator sits at the lower edge of the spectrum (“Minergie”) or above 600 MJ/m²a; overconsumption is present everywhere; 90% of the audited buildings in this program show sufficient potential to capture the savings potential.

b) SIG and the Swiss Energy Strategy

In order to put into practice the goals of the Swiss Energy Strategy, the public multi-utility company of the Geneva Canton, SIG (Services Industriels de Genève, 2018), which is owned by the State of Geneva, the Geneva city and the 45 municipalities of the Geneva Canton, is actively engaged in two of the pillars of the energy transition, namely the development and systematic deployment of renewable energies and the implementation of energy efficiency programs.

Among the renewable energies, SIG is involved in the strategic deployment of photovoltaic solar farms and exploits three hydro-electric power stations along the river Rhône, apart from being engaged in the development and deployment of wind farms in Switzerland and particularly, in the Jura mountain. Furthermore, SIG has scanned the whole Geneva Canton to assess geothermal resources. The first borehole pilot project was launched in 2017 and warm water has been found at a depth of 740 m.

Industrial écoParcs are created in collaboration with the FTI (Fondation pour les Terrains Industriels de Genève). The aim is to use heat produced by the local industry and local enterprises for heating neighboring (residential) buildings. Furthermore, the electricity sold to the SIG clients is free of nuclear power and, since 2017, is entirely based on renewable energy sources with a low carbon footprint. SIG also provides an infrastructure allowing clients to change from heating oil to gas, or to connect to the district heating system, run by SIG. It is worth noting that the latter is supplied to 50% by a renewable energy source, coming from the incineration of non-recyclable household waste. Last, currently under construction is a local network (called “GeniLac”) which uses the water extracted at a depth of 40 m of the Geneva lake to provide cooling of office space in summer and supply heating pumps in winter for space heating and domestic hot water. This will be used by a large fraction of the international organizations based in Geneva and by the international airport of Geneva, among other quarters close to the lake.

c) Energy efficiency and SIG-éco21

éco21 was formed, 10 years ago, by two people, with the aim to develop the branch of energy efficiency within the public multi-utility company SIG. Today, the group consists of ~35 people and has developed a large variety of solutions, ready to use and available to all kind of clients, ranging from individuals, over small and medium sized companies and industries up to “large consumers” and property owners of residential buildings. The aim of SIG-éco21 is to reduce the energy demand despite of a growing population and economic growth, thereby reducing the carbon footprint.

As such, SIG-éco21 acts as a market transformer and works together with supermarkets and distributors located in the canton of Geneva to promote energetically performant light bulbs (LEDs of class A++). An important share of their costs is subsidized, allowing to reach a large part of the population.

The solutions developed for residential buildings include subsidies for the replacement of standard Halogen lamps by low-energy LED lamps, combined with motion-monitors, the replacement of poorly performing household appliances by A++ ones. In line with the SIG slogan to “consume less and better”, experts are paid to visit households to inform and raise awareness of the occupants about their energy consumption.

Figure 1 shows the effect of the efforts SIG-éco21 has put in place since 2007. Despite of the economic growth and an increase of the population by 20.8% between 2000 and 2017 (dotted line), the electricity demand per inhabitant has decreased by 8.4% in the same period. This implies that the intermediate objective set by the Swiss Energy Strategy 2050, namely to reduce the electric energy consumption per inhabitant by 3% in 2020 with respect to the consumption in 2000, have been met already. Soon the intermediate objective for 2035 will be reached, requesting a 13% reduction with respect to 2000. Moreover, considering only the period in which SIG-éco21 is active (from 2007 to 2017), the effect is even more dramatic: 12% of electric energy savings per inhabitant have been achieved in the Geneva Canton. The same figure shows an estimation of the electric consumption without the effect of SIG-éco21, estimated by the University of Geneva, who validates as an independent institution the energy savings established by SIG-éco21 (Evaluation of energy efficiency program in Geneva, 2012): the decoupling of the economic growth and energy consumption is still visible, but without SIG-éco21 the energy consumption in 2017 would still be at the level of 2000 and no reduction per inhabitant would have been achieved. Even more impressive: also, the absolute energy consumption (not normalized to the number of inhabitants) has already started to decrease.

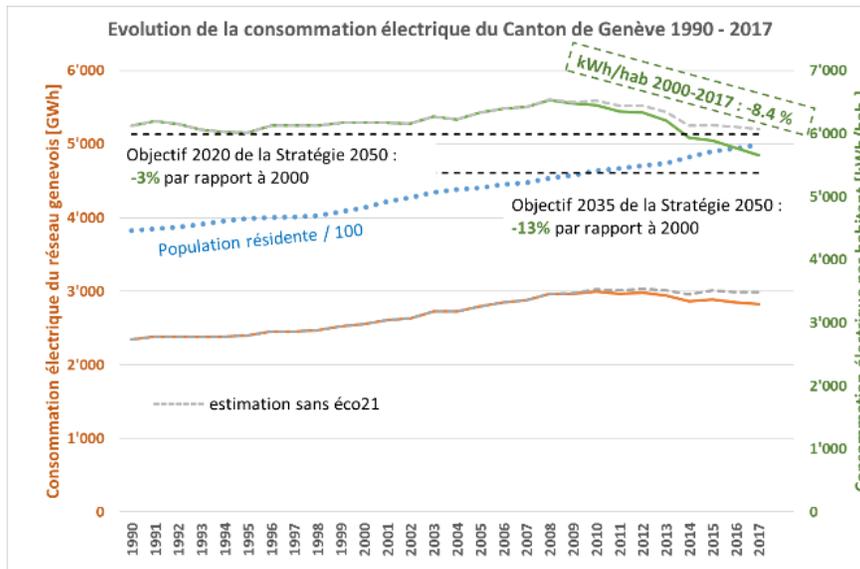


Figure 1: Electric energy consumption of the Geneva network (orange) and normalized per inhabitant (green) as a function of time. Overlaid is the increase of the residential population in the canton (in units of 100), as well as the intermediate objectives of the Swiss Energy Strategy 2050 for the years 2020 and 2035.

In 2014, SIG-éco21 has enlarged its offer to include solutions to reduce the thermal energy needs of the Geneva canton. This covers space heating, domestic hot water production and ventilation of residential buildings. SIG-éco21 proposes 4 programs: 1) Subsidies to use more powerful pumps for water circulation, as the existing ones are largely oversized and, hence, consume unnecessarily large quantities of electricity. 2) Subsidies for the replacement of the widely-used ventilation system which extracts unnecessarily large quantities of air (by using two regimes of constant air flow), by a system which adapts the amount of extracted air to the presence of people in the room. This can be achieved by using low-tech air extraction valves whose effective diameter is modulated by the level of humidity contained in the connected rooms. Those systems automatically limit the extracted air to the flow level foreseen by the Suisse norms to ensure the needed level of oxygen is available. 3) Subsidies to perform a hydraulic balancing of the individual radiators of each apartment. 4) 6-year long contracts to optimize the entire heating system in a systematic way. This allows to reduce the thermal energy consumption and, hence, to reduce the associated CO₂ emissions. This program allows to offer our SIG clients the (fossil fueled) gas, sold through the Geneva based gas network, as CO₂ compensated and neutral.

For single family homes, located far away from both gas and district heating networks, SIG offers technical support on top of the financial subsidy attributed by the State of Geneva to promote the installation of heating pumps for space heating and domestic hot water. The client benefits from support and advice throughout the whole planning and installation process.

SIG-éco21 is currently developing a program to encourage the deployment of large scale heat pumps in residential buildings with more than 10 dwellings, and an installed power of several hundreds of kW.

Figure 2 shows the thermal energy consumption in the Geneva canton as a function of time, as well as the associated amount of CO₂ emissions. One clearly sees the systematic replacement of heating oil (in grey) by gas (in blue and orange), called “fuel switch”, and the associated reduction of CO₂ emissions (black line). The figure shows that the overall need for space heating and domestic hot water production steadily decreases, being the result of various factors (fuel switch, replacement of old boilers by condensing gas boilers, arrival of newly built houses with a high energetic performance, renovation of older buildings and the effects of energy efficiency).

In concrete terms, the CO₂ emissions in the Geneva Canton due to space heating and domestic hot water production have decreased from 1'356 kt CO₂ emitted in 1990 (average over the years 1988-1992) to 1'091 kt CO₂ in 2016. This gives a decrease of 19%. The Swiss law on CO₂ emissions (Office fédérale de l'environnement Suisse, 2011) requests that by the horizon of 2020 CO₂ emissions decrease overall by 20%, out of which 26.4% should be achieved in the building sector. When only considering the Geneva canton, the 5.3% requested by the Swiss Confederation have, hence, largely been achieved by the 19% reduction observed and the trend is still steadily decreasing.

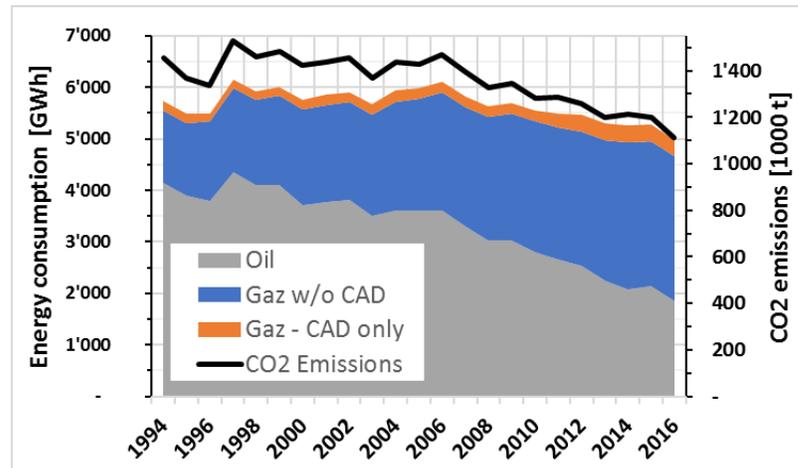


Figure 2: Thermal energy consumption in the canton of Geneva as a function of time as needed for space heating and production of domestic hot water, split into the components Oil and Gas (used in local distribution networks "CAD" or without). The values () have been corrected for climatic effects, following the prescription proposed by the Geneva cantonal energy office (Office Cantonal de l'énergie Genève, 2018).

2) Goals and objectives of the energy performance contracts

The energy needs of buildings in Switzerland represent around 50% of the totally consumed energy, mostly being due to space heating and domestic hot water. It is therefore, important to ensure that heating systems are highly energy efficient, while ensuring or improving the comfort of its inhabitants. In fact, 90% of all heating installations audited through this program are not optimally exploited.

Established in 2014, the corresponding energy performance contracts of SIG-éco21 have saved a total of 20.6 GWh of thermal energy until the end of June 2017, corresponding to an equivalent of 4'300 t of saved CO₂ emissions. The numbers expected for the upcoming accounting in June 2018 promise to show an even more important figure (estimated between 30 GWh and 35 GWh) given that significantly more contracts were signed since then and given that the buildings under energy efficiency exploitation since the beginning of the program have reached impressively large numbers of energy savings.

The contractual objectives requested from the heating craftsman who exploits the heating installation are 6% in the first year, 9% in the second and 12% in the third year. This allows to gradually, but systematically reach a stable set of around 20 settings steering heat and domestic hot water production, their corresponding distribution, and the temperature delivered to the individual apartments. The optimization can include settings related to a proper ventilation of the apartments, which is a significant source of energy losses, as well as the correct exploitation of heat pumps or solar thermal panels, if applicable. After this first period of optimization (3 years), follow 3 years in which the obtained settings must be maintained to avoid deviations from the generated energy savings. The corresponding

objectives are fixed to 12% throughout the remaining phase of exploitation. By the end of the 6 years, the property owner is encouraged to continue the program for another 4 years.

The method used is based on a continuous improvement (analogous to the ISO 50001 norm of energy management systems) in which actions are followed by an analysis and visualization of the achieved result leading to further actions and improvements of the previously tested settings.

a) Program description and its implementation

Following the involvement of the property owner by signing a 6-years contract, an audit of the heating system takes place in which an assessment of the potential energy savings is made. If at least 10 to 15% energy savings are estimated, the contract can start. At this moment, a baseline is calculated based on the energy consumption *before* optimization. It is with respect to this reference curve that the future energy savings are being calculated, following the prescription of the international protocol IMVP (Efficiency Valuation Organization, 1994).

The contract is now ready to start: a perpetual cycle of improving the regulation settings begins. The heating craftsman is requested to physically visit the installation every two weeks to read out the meters and to try out a new set of parameters, based on the experience of the previous settings. Both, the past consumption, as well as the tried settings are stored in a specially developed platform. Algorithms process the data to calculate the energy savings with respect to the baseline. In case of deviations from the trend, the craftsman is contacted to justify its origin (i.e. a sudden over-consumption) and to undertake measures to correct the deviation.

As discussed before, it is of utmost importance to respect the occupant's comfort. Indeed, the contract includes recommendations of the Geneva cantonal energy office as well as of the Swiss norms for each room's temperature. In most cases the craftsman does not set a temperature lower than 21-22 °C.

To put this program into place, SIG-éco21 has chosen to collaborate with a third partner, who is specialized in the technical aspects of energy efficiency in buildings and who is supported by the Swiss Confederation through its program "SuisseEnergy" (Office fédéral de l'énergie, OFEN, 2018). This non-profit-making association is called "energo" (energo, 2018). In this way the program ideally profits from the complementary competences of its three key actors:

1. **SIG-éco21** who is in charge of the coordination and continuous evolvement of the program, as well as the contact to the clients and heating enterprises. It also builds up a network for all involved partners, organizing regular events. SIG-éco21, furthermore, manages all the administrative aspects.
2. The **heating sanitary enterprise** which implements the energy saving measures during its exploitation and follows the evolution of the consumptions throughout the whole contract's lifespan
3. The independent association **energo** which ensures the technical support by providing training and coaching of the heating craftsman. energo conducts the initial audit of the heating installation in the presence of the heating craftsman, and calculates the annual energy savings, given its impartial role (no conflict of interests with the heating craftsman and SIG-éco21). The aforementioned platform to analyze the data is also provided by energo.

In most cases, the audit is the first contact of a new craftsman with the program, even if before he has been invited to participate in the 4-day training course. The audit, hence, is of crucial importance given that the craftsman can learn about the "best practices" and that he is being taught a series of concrete measures to engage in the field of energy efficiency. The report is a useful tool for the craftsman throughout the whole lifespan of the contract, as it includes the final settings, potentially to be achieved through the optimization process, if the quality of the insulation of the building allows (If the insulation of the building does not allow a proper optimization, the energy savings stay at the few percent level. The

property owner gets informed about the state of its building and he can decide whether to undergo renovation works to improve the air-tightness of its building). The audit report is shared with the property owner, or its administrative delegation, as well as with the heating craftsman himself.

Once per year, a report with the achieved energy savings is issued. This report includes the real thermal energy consumption of the building, the calculated reference consumption (established on the basis of the established reference curve and the daily outside temperature of the past 365 days), the real energy savings (in kWh and CHF), the achieved performance (in %) as well as a list of the energy efficiency measures implemented by the craftsman to achieve the energy savings. This report serves to communicate the results with all the partners involved (i.e. the property owners, the property management service and the craftsman), as well as to initiate the payment process.

The payment of the craftsman for the optimization work, as well as of *energo*, is entirely ensured by the achieved energy savings. Given that most of the energy savings take place in the later years of the contract, while the costs due to the installation of the program are highest at the beginning of the contract, SIG plays the role of an ESCO which pays the craftsman and *energo* until the energy savings are high enough to fully cover the expenses. As soon as the energy savings outperform the (accumulated) expenses, the surplus goes entirely to the occupants. SIG does not get directly remunerated for the coordination of the project but uses the corresponding CO₂ savings to compensate the CO₂ emissions of the sold gas “Vital vert”. In case the contractual objectives are not met (due to various reasons), SIG-éco21 covers the resulting extra expenses. SIG covers equally the expenses of the audit in case the potential is estimated too low in which case the contract does not start. In this way, the property owner does not carry any financial risk.

In order to boost the energy savings and to fully exploit the building’s potential, the payment of the craftsmen is subject to a bonus malus system: if the achieved savings outperform the set goal (6, 9 and 12%, respectively for the years 1, 2 and 3-6), the craftsmen receives a bonus; if he does not achieve the goals his payment is lowered.

It has to be emphasized that this program does not require any investment from the owner (no “up-front costs”), apart from a possible installation of an energy meter.

3) Results

a) Global results and recognition

The program started with 41 contracts at the beginning of 2014, corresponding to 2,065 dwellings. Today (May 2018), the program exists of 224 contracts, covering a heated surface of 1,142,155 m², equivalent to about 13,760 dwellings. More than 40 property owners and 20 property management services are engaged in this program.



The energy office of the Swiss Confederation in Bern allocates a yearly prize for the best energy projects in 5 different categories. The program described in this article has been awarded the “Watt d’Or 2018” in January 2018 in the Energy Efficiency category, because of its originality, its large scale, its exemplary role to put into practice the objectives of the Swiss Energy Transition (Office fédéral de l’énergie, Watt d’Or, 2018).

A point particularly emphasized by the jury was the human aspect of the project: 1) Involvement of the local craftsman and enhancing their skills through a specially designed training course, 2) supervision of the craftsman throughout the course of the project, 3) establishment of a network of experts and 4) regular communication to the clients.

b) Energy savings

For heating installations under optimization between 6 and 36 months, the average energy saving achieved is 12% and for the 41 cases under exploitation since the beginning of the program this figure reaches to 17%. The accumulated energy savings until June 2017 amount to 20.6 GWh, equivalent to 4300 t of saved CO₂ emissions. It is worth observing that the achieved results outstand by 5% the fixed objectives, on average.

Moreover, energy savings reached on individual buildings can be as high as 35%, as indicated in Figure 3 (left), which shows the distribution of the energy savings for the individual contracts. The resulting financial energy savings accumulated by June 2017 amount to more than 1400000 CHF out of which 680000 CHF correspond to reduced heating bills of buildings' occupants and 720000 CHF have been paid to the local heating craftsman and energo.

These encouraging results emphasize the importance of an optimal use of the heating installation in order to achieve the energy reduction targets, set by the canton of Geneva, the Swiss Confederation, as well as the European union in order to reduce the emission of greenhouse gases. Updated results are expected to be ready by the time of the IEPPEC 2018 conference.

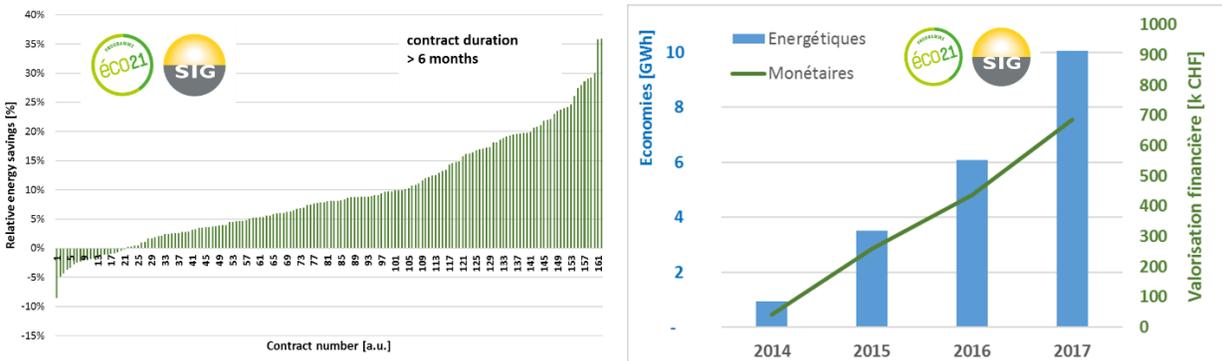


Figure 3, Left: Thermal energy savings of individual energy performance contracts. Right: Thermal energy savings, in GWh (left scale) and CHF (right scale) integrated within the individual years. Both figures correspond to the results obtained in June 2017.

c) Collaboration and partnership with heating craftsman's enterprises

Up to today, 27 different craftsman enterprises, specialized in the maintenance of heating installations are collaborating to this program. This corresponds to an estimated 60% of the companies active in the Geneva canton. In the meantime, 95 individual craftsmen have been trained, 24 have undergone a process of certification and 6 craftsman enterprises are qualified to be a special "partner of SIG-éco21", having demonstrated their optimization competences through the optimization of at least 5 buildings where more than 80% of the objectives have been met.

Given that a large number of craftsmen enterprises participate in the program, SIG-éco21 produces 3 times a year a ranking ("benchmark") of the individual companies, based on their performance, which is distributed to each enterprise in a quasi-anonymous way. Each company sees only its own performance with respect to the position of the others. High performing companies can use this benchmark in the communication with their clients, others can use this information to increase their performance. The same is done to rank the individual property management services. The clients can then ask on one hand the property management company, on the other hand the heating installation company for their rank to select the best performing company.

Furthermore, in April 2018, an award was attributed to the best craftsmen enterprise for their outstanding performance, in the context of the “Trophée SIG for the best electrician and heating craftsmen”. This annual award rewards the best performer of the five programs SIG-éco21 has been set in place in collaboration with the local service providers.

Through these actions, the individual companies can enhance their competences and are stimulated to participate in the proposed program. Given that the program has been well established, the local property owners and property management services have become aware of energy efficiency and SIG-éco21 is about to shift the market of the local electricity and heating companies using once again the SIG’s slogan “to consume less and better”.

4) A program in continuous improvement

The program will soon benefit from a specifically developed software to assist in all the practical and administrative aspects related to the management of the contracts. The program is evolving continuously to better support the client and the associated property management services. Below we just mention one example of such actions, currently under development.

a) A dedicated training program for property management services

Among the ~20 property management services which are involved in this program, quite a different level of engagement in the Energy Strategy and in administrative was noticed, as well as in technical competences. In order to assist these services as well as possible, SIG-éco21 is currently developing a 5-days training program. It will cover different competences in the field of energy efficiency, which include the technical aspects necessary to better understand the objective and modality of the present energy performance contracts. This corresponding accredited training with different sessions, will be free of charge and open to all property management services in the canton of Geneva. The contents of this training being developed in partnership with the umbrella organization of the property management services.

5) Conclusions

The policy framework of the Geneva Canton (obligation to declare the thermal energy consumption; a management of the public multi-utility company SIG fully supporting the activities developed by SIG-éco21; the high fraction of residential building with an annual energy consumption above 275 MWh, representing a large potential to create energy savings), has enabled SIG-éco21 to develop a highly-performant energy saving contracts program. The aim is to reduce the energy demand for space heating and domestic hot water. The achieved results after 3 years of exploration are encouraging. In fact, the average energy saving is 17%, with some individual contracts with more than 35% savings compared to the baseline. Property owners benefit from this program without any up-front investment cost and take advantage of the optimization of their heating systems to reducing their carbon footprint. The program has achieved a total of 20.6 GWh of thermal energy savings by June 2017. This corresponds roughly to the total thermal energy consumption of around 1500 households and is equivalent to a reduction of 4300 t of CO₂ emissions.

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