Impact and delay of the phase out of inefficient light bulbs policy

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Abstract

In February 2009, the European Commission decided to implement a planned phase out of inefficient (incandescent and conventional halogen) light bulbs (2009/125/CE and 2009/244/CE). Switzerland started its own policy measures a few months before those of the EU27-member body and later followed the EU's line from September 2010.

This paper presents an analysis of the impact of this policy by analysing an energy efficiency program addressing low to medium income households. The analysis is founded on multiple surveys which took place from 2009 to 2014. An important component of this program is the replacement of inefficient incandescent and halogen lamps by efficient ones (CFLs and LEDs). Data concerning the replaced inefficient lamps has been gathered at every one of the campaigns carried out by the program. This allows for continuous information on the evolution of inefficient lighting equipment of dwellings for the last five years.

While the agenda of market withdrawal was precisely established, the phase out of inefficient lamps operating in households has an inherent inertia that appears to be more important than expected. Indeed, there is a significant number of incandescent lamps still operating in households. In addition, the main substitute for the banned lamps has become the halogen lamp. Our paper appraises the discrepancy concerning the evolution of the stock of inefficient lamps between the projections that were made in 2008 for the 2009/244/CEE directive and the real situation in households of the city of Geneva-Switzerland.

The first five stages of the regulation have already been implemented and it is likely that the outcome will influence the implementation of stage six.

Introduction

The ban of incandescent lamps regulation (2009/244/EC) was introduced in 2009. The regulation was targeting savings of the order of 39 TWh/y in six stages. The scenario used to estimate these savings forecasted the disappearance of the stock of incandescent lamps in 2014–2015 and an important replacement of those lamps by compact fluorescent lamps (CFLs). It was expected that *in 2012, HL-MV-LW lamps would represent a high share of the stock (29.4 %), behind CFLi. [p. 48]* (Toth & al., 2008).[1]

There is at present time some evidence that this has not been the case and the lessons learned these past years should be taken into account for ongoing and future scenarios and policies.

This paper presents an analysis of the impact of the European policy regarding the evolution of the stock of inefficient lamps in households as this component has important repercussions on the expected energy savings. This is done by analysing an energy efficiency program addressing low to medium income households in Geneva–Switzerland. Some conclusions concerning this stock are drawn from monitoring fourteen campaigns carried out by the program between 2009 and 2014 and the analysis focusing on two campaigns at the end of 2014.

1. GLS-F and GLS-C are incandescent bulbs (F: frosted, C: clear). HL stands for Halogen; LV and HV: low or high voltage; LW and HW: low or high power. CFLi stands for compact fluorescent lamp. In this paper we use the term CFL independently that it has an integrated ballast or not.

The program has been designed to favour the implementation of energy efficient technologies in low-income households in Geneva. To achieve this, the program collaborates with local municipalities and organizes campaigns targeting a group of buildings with a high rate of low to medium income households in a determined geographical area. Among a set of energy efficiency measures (fridges, stand-by power, kettle boilers), the inefficient lamps (i.e. incandescent and halogen) found in households are replaced, free of charge, by energy efficient lighting devices (i.e. CFLs and LEDs). An important part of the savings obtained by the program comes from these replacements. Data concerning the replaced lamps has been gathered for every single household that participated to the program. This data is collected for the impact evaluation of the program (in particular to estimate the energy savings generated). The forms used to collect the data have evolved in order to suit the evaluation needs. Additional surveys were conducted at the end of 2014 to better understand the fact that a slower decrease than expected in the average number of inefficient bulbs per household was observed despite the introduction of the ban of incandescent lamps in 2009. This allowed appraising the composition of inefficient lamps operating at present time in households.

The present paper is structured as follows: The first part describes briefly the program and its evaluation methodology that allowed for the collection of data that is used in this analysis; the second part presents the details of the collected data and its evolution, as pertaining to the present analysis; the third part presents the results of the analysis and; the fourth part gives a summary and conclusion of our findings.

The program and its evaluation

The local utility SIG for Geneva – Switzerland launched an energy efficiency program named éco21 in 2008 (Jeanneret 2011, Reynaud 2014). The program started with a set of subprograms addressing different customer segments. One of these subprograms, named éco-social, was designed to favour the implementation of energy efficient technologies in low-income households in Geneva. To achieve this, among a set of energy efficiency measures (fridges, stand-by power, kettle boilers), the inefficient lamps (i.e. incandescent and halogen) that were found in households are replaced by energy efficient ones (i.e. CFLs and LEDs). After a period of preparation, éco-social launched its first campaign at the end of 2009. By the end of 2014, fourteen campaigns have been implemented with the participation of close to 8,000 households. Close to 70,000 inefficient lamps have been replaced by efficient ones.

In order to put in place a given campaign, éco-social coordinates with a local municipality to select a group of buildings that will participate to the program. Before each campaign, the program proceeds to recruit a team (the energy ambassadors) who will visit the households that agree to participate. The energy ambassadors are trained before the campaign by a local association in charge of the coordination and management of the campaign. In general, every campaign goes for a couple of weeks. The ambassadors, among other tasks, are in charge of recording the data concerning the devices that are replaced.

Few days before the campaign, intensive communication activities are carried out among targeted households. Those who agree to participate, arrange an appointment to receive a visit from an energy ambassador. During the visit, the participants receive, free of charge, a CFL or LED bulb in exchange for every replaced inefficient lamp. The replacement is made by the ambassadors. The replaced bulbs are collected and discarded afterwards by the association in charge of the management of the campaign. The information concerning the power of each replaced bulb is recorded in a form by the ambassadors and registered later in a digital database. This is the database that has been used for the present analysis.

The program éco21 requested the University of Geneva in 2009 to take care of the program evaluation. A methodology was developed for each of the subprograms. Data collection and transfer protocols were organized and reports and results are analysed by the evaluators. The general methodology for the evaluation of savings and the particular methods used for éco-social were described earlier (Cabrera 2012 and Cabrera 2014). It was then necessary to separate the impact of the program from the impact of ongoing policies.

One of the policies that had to be considered was the ban of incandescent lamps (244/2009/EC).

> When ecodesign regulation EC No 244/2009 was introduced in 2009, the Commission forecasted that compact fluorescent lamps (CFLs) would replace the majority of frosted non-directional incandescent lamps, which were phased out starting in 2010. Clear mains-voltage halogen lamps were allowed to remain on the market as a replacement for clear incandescent lamps and they were expected to make up a relatively small share of total sales for non-directional lamps. (Bennich 2014)

It was expected that the reference base could change significantly through the years and that the additional savings generated by éco-social could decrease. This has been the main reason that encouraged the evaluation team to request the collection of data concerning the power of the inefficient bulbs replaced by éco-social.

The collected data

It is important to give some details concerning the source and purpose of the data that has been collected and used here in our analysis. The ideal situation to evaluate the impact of the phase-out policy for incandescent lamps would be to have a complete picture of all kind of installed lamps and reserve stock in households through the years. The collected data under the éco-social program was not meant for evaluating the impact of the 244/2009/EC directive, but just to isolate the impact of the savings coming from the program and not those arising from this directive. It has been necessary to get complementary information from the managers involved in the campaigns who visited a significant part of participating households.

The data used in the analysis are the following:

- Information concerning the inefficient lamps replaced by the program (power). This information was gathered by the ambassadors for almost every single removed lamp (close to 70,000 at the end of 2014) in every participating household (close to 8,000 at the end of 2014).

- Detailed information (type, brand, type of socket, power) for a sample of 1,687 lamps collected in 2014. Let's note that the inefficient lamps replaced by the program are mainly E27 and E14 incandescent and halogen light bulbs. Spot halogen lamps (main and low voltage) started to be replaced in the second campaign and represent, at present time, close to 15 % of replaced lamps. As this study focuses on non-directional lamps that are addressed by the 244/2009/EC regulation, spotlights were removed from our sample, leaving 1,429 bulbs.
- A good appreciation of the existing stock of inefficient light bulbs that couldn't be replaced by the program. This information has been gathered from program managers. The part of inefficient bulbs replaced in each household depends on the following factors: the available offer at the moment of the campaign[2] (i.e. the availability of an efficient lamp that fits in the existing socket and fixture to replace the inefficient one); the ability of the energy ambassadors to find all the replaceable lamps and the agreement of the owner (or tenant) to have a given lamp replaced by a new efficient one.[3] It is estimated that 15 to 30 % of inefficient lamps were not replaced during the first two campaigns and 10 to 20 % from the third campaign on.
- A rather rough appreciation of the efficient lamps already installed in households that gives an idea of the total number of lamps per household. It is estimated that the total number of lamps in households that participated in éco-social is on average 15 to 20. As most of households are occupied by low to medium income families, their flats are relatively small (in number of rooms and surface) compared to the average. This could explain the fact that the estimated number of lamps is smaller than the average number of lamps per household that is usually found in literature (see for example Intertek 2012). Let's note however that this number is not really important for our analysis and conclusions here below.

Results of the analysis

Let's first recall the situation at the moment of the introduction of the 244/2009/EC regulation. The scenario "Option 2 Clear B Slow" was used for this directive (Toth 2008). This scenario forecasted that the stock of incandescent bulbs in households was practically zero in 2014 and that a large part of them would be replaced by CFLs and a smaller part by halogen bulbs. Figure 1 shows the projected scenario reproduced from data contained in the Annex 8–6: Main economic and environmental data for the scenario "Option 2 Clear B Slow" in the Preparatory Studies for Eco-design Requirements. Table 1 shows the share of different type of lamps as it was forecasted in 2008.

2. The offer has evolved, in particular during the first's campaigns. For example, during the first campaign, halogen spotlights of type GU3.5 could not be replaced because the program did not have at this time a replacement alternative.

3. It is possible that not all the inefficient lamps in some households were found by the energy ambassador and/or the ambassador didn't convince the tenant to replace a given lamp. Indeed, we noticed that some ambassadors, probably less motivated, were doing less changes than others.

It is of course difficult to forecast out of contingencies, but this is the most accurate information that was available in 2009 when the éco-social program started, almost simultaneously with the 244/2009/EC directive. It was expected that, at a given moment, few inefficient bulbs will be found in households. We were afraid that this could occur before the finalization of the éco-social. As savings obtained with the replacement of light bulbs is the largest part of the savings generated by éco-social, there was a risk that lower savings could potentially impact the achievement of the objective of the program.

The data collected from households during each campaign of éco-social showed that the number and average power of inefficient bulbs has indeed reduced, but slightly. A visual inspection in 2013 of the discarded inefficient lamps allowed us to notice the following two facts that explain the previous observations:

- There was an important number of incandescent bulbs still in operation in households. Part of the inefficient light bulbs found in households was bought before the ban deadline.
- Instead of the replacement of incandescent bulbs by energy saving technologies (like CFLs or LED), incandescent bulbs were gradually replaced by the new type of halogens, those that have a shape similar to the incandescent bulbs and fit in E27 and E14 sockets.

These two observations seem obvious at present time, but this was not the case in 2009.

We thought that it was important to have a better understanding of the share of the different type of lamps in the existing stock of inefficient lamps. In November 2014, a group of households of two different campaigns benefited of a deeper analysis. In addition to the information that was usually gathered, the type of lamp and socket were registered for every lamp. We found that close to 80 % of replaced lamps were those fitting in E27 and E14 sockets and less than 20 % are of the spot halogen type that fits in G10, GU3.5 and MR16 sockets.

In the specific Nov. 2014 sample, 10.3 light bulbs per household were replaced on average. This statistic includes the GLS-F, GLS-C, HL-MV-LW, HL-MV-HW, HL-LV bulbs and spot lights. Since already installed LED and CFL in households were not replaced by the ambassadors, no information was gathered. This means that we do not know exactly how many efficient lamps were in the flat, preventing us to estimate the mean total number of lamps per household.

Consequently, in order to make the comparisons, we need to take apart the CFL from the previous EC scenario and compute the shares for the four other technologies (without CFL). The sum of the shares of these technologies amounted to 51 % of the lamps in household (cf. Table 1) and now become 100 % (cf. Table 2). This new breakdown is given in the "scenario" row of the next table. In the second row "éco-social", we have the share corresponding to our survey that was carried out at the end of 2014. The total (100 %) corresponds to 1,429 bulbs after elimination of the spotlights.

The observed reality in Geneva and the scenario are very different:

- The share of GLS lamps is much larger than the expected scenario. Clearly, the scenario was very optimistic and has probably under evaluated the reserve stock of new lamps

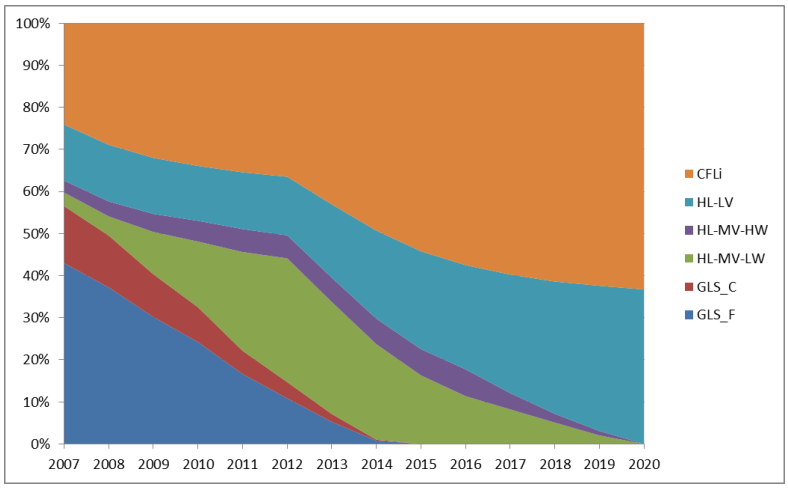

Figure 1. Scenario reproduced from data contained in the Annex 8–6: Main economic and environmental data for the scenario "Option 2 Clear B Slow" in the Preparatory Studies for Eco-design Requirements (Toth 2008).

Table 1. Shares of lighting technologies in 2014 according to scenario "Option 2 Clear B Slow".

	GLS-F/GLS-C	HL-MV-LW	HL-MV-HW	HL-LV	CFLi	
2014	1%	23%	6%	21%	49%	100%

Table 2. Shares of lighting technologies in 2014 (without CFL), according to scenario "Option 2 Clear B Slow" and the "éco-social" survey.

	GLS-F/GLS-C	HL-MV-LW	HL-MV-HW	HL-LV	
Scenario	2%	45%	12%	41%	100%
éco-social	55%	44%	2%	0%	100%

that the households kept at home or the life expectancy[4] of incandescent bulbs or over evaluated the intensity of use[5].

- HL-MV-LW are close to our findings. However, let's note that this match depends also on the shares of the other categories. We expect the share of this category to increase in éco-social as the GLS continue to disappear. Indeed, our surveys show that HL-MV-LW lamps are almost systematically chosen by households when they have to buy a new one. One reason could be that this technology is the cheapest one, another one is related to the rather negative image of the CFL technology. In addition, as mentioned in the section concerning the collected data, the offer of efficient lamps was not able to replace all kind of incandescent bulbs, especially during the first stages of the regulation.
- HL-MV-HW is underrepresented in éco-social because no technology allowed to change the 300 W light bulbs. Only a limited number of floor lamps with 300 W light bulbs were replaced by the program.
- HL-LV in the éco-social are inexistent (at least in our sample), whereas the scenario expected that GLS-C to be replaced by this type of lamps. The European scenario was optimistic with the replacement of GSL-C by HL-LV. These HL-LV bulbs are almost inexistent on the Swiss market. Maybe, the complexity of that technology prevented its spread.[6]

In summary, among the inefficient light bulbs the number of incandescent bulbs is still significant, more than half of them.

4. The scenario applies a rectangular distribution of life expectancy and neglects its standard deviation. In the real world, not all the lamps disappear simultaneously at a given time.

5. Other hypotheses like circumvention of regulations and the possibility to buy incandescent bulbs by internet were discarded by the authors for the following reasons: It is unlikely that the retail market take this kind of risk in Switzerland (we observed that some large suppliers –supermarkets removed from shelves incandescent bulbs even before the deadline). Concerning the possibility that people buy incandescent bulbs through internet, we estimate that the amount is negligible (transportation costs exceeds bulb price, fragility, etc.).

6. "Recent technology. Applying an infrared coating to the wall of halogen lamp capsules considerably improves their energy efficiency, the lamp will use about 45 % less energy for the same light output compared to the best conventional incandescents. However, for technical reasons, this is only possible with low voltage lamps, so a transformer is needed, either as a separate unit, or integrated into the luminaire, or integrated into the lamp for an conventional incandescent retrofit solution. As with the Halogen C lamps, both the special socket capsules and improved incandescent bulbs with halogen technology are available in B class, however currently only one manufacturer is producing retrofit bulb-shaped lamps (even though the technology is not protected by patents)", MEMO/09/368 FAQ about Ecodesign Directive (2005/32/EC), 2009.

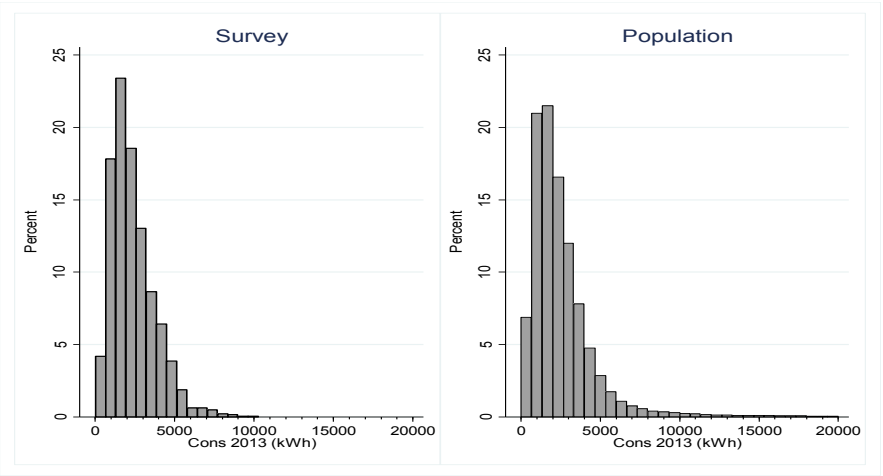

Figure 2. Distribution of the electricity consumption for 2013 among households in éco-social and the canton of Geneva (only flats in buildings).

In addition, incandescent bulbs arriving at the end of life are in general replaced by halogen bulbs.

FROM GENEVA TO EUROPE

To what extent can the data collected from éco-social can be considered as representative for households elsewhere in Geneva, Switzerland or Europe? We need to be very careful in extrapolating these findings to the European context. We can however find some support that allows us to suspect that it is likely that we could find a similar situation.

We do not find any reason to assume that incandescent bulbs will last longer in low to medium households. We can therefore assume that an important part of incandescent light bulbs that were bought before the ban is still in operation in the residential sector at canton level. Sales data market (unpublished and still confidential) supports our findings concerning the replacement of incandescent bulbs by halogen ones at the canton and country level. It is therefore likely that in the rest of the country households are buying halogen bulbs as well to replace the banned incandescent light bulbs.

We compared a group of 2000 households participating in éco-social (four campaigns carried out between the end of 2013 and June 2014) with the rest of households in residential buildings in Geneva. The average annual electricity consumption for our sample of participating households was 2,390 kWh/year in 2013. As the program addresses buildings with a high rate of low to medium income households, flats are usually smaller than the average, and the average electricity consumption is also lower than the average for the canton of Geneva (2,540 kWh/year per household). Figure 2 shows the distribution of the annual electricity consumption for our sample and the canton of Geneva. As the distributions of the two groups are rather similar, particularly for consumption less than 5,000 kWh/year, we assume that the income effect concerning the electricity use is low (i.e. a first necessity good in Engels terminology), and maybe the choice of lamps, are also similar in these two populations.

The extrapolation to the European level concerning the existing stock of incandescent lamps in households is more complicated. We didn't find any similar studies addressing this issue and we believe that it would be important to have this kind of analysis in other countries.

Concerning the replacement of incandescents by halogen lamps, the Ecodesign Preparatory Study on Light Sources (ENER Lot 8/9/19) indicates that:

> … as regards the installed stock of light sources, the MELISA data indicates that from 2008 to 2013 the share of incandescent lamps (GLS) in the installed stock decreased from 33 % to 10 %. They are mainly being substituted by halogen lamps that increased their share in the stock from 16 % to 27 % in the same period. (Kubiak 2014)

Concerning the share of incandescent lamps, there is a discrepancy with what we observe at present time in households in Geneva. We have to remark that the estimations made by MELISA are apparently the result of a model. In our case, it is the result of direct observation.

There are some other references concerning the share of halogen light bulbs in the sales market. In July 2011, a benchmarking document from the International Energy Agency stated that:

> … in countries where recent regulation is most advanced (Australia and the UK), there is clear evidence that a higher proportion of the market than expected is migrating from traditional incandescent lamps to halogen lamps rather than CFLs. (IEA 4E 2011)

Based on LightingEurope information and trade data imports, the task 2 of the preparatory Ecodesign Preparatory Study on Light Sources (ENER Lot 8/9/19) concludes that:

> … from 2008 to 2013 the share of incandescent lamps (GLS) in unit sales decreased from 46 % to 9 %. They are mainly being substituted by halogen lamps that increased their share from 18 % to 45 % in the same period. (Kubiak 2014)

Another report concerning LED light bulbs states that:

> … the non- directional household lamp regulation has failed to move frosted incandescent toward sales of CFLs, and instead has simply moved both clear and frosted incandescent lamp users to clear halogen lamps, eroding much of the anticipated energy savings. (Bennich 2014)

These statements match with our findings. The results from the surveys performed under the umbrella of the eco-social pro-

gram in Geneva matches with the previous statements at the European level that are based mainly in sales data. Households are replacing old incandescent bulbs mostly with halogen bulbs and only partially with more efficient ones.

Conclusions

Stages 1 to 5 of the directive concerning the phase-out of incandescent lamps (CE 244/2009) have already been implemented. Since September 2012, incandescent lamps disappeared from the sales market in Switzerland. The projections made in 2008 for the European Union forecasted that the stock of incandescent lamps would practically disappear in 2014–2015. However, we find at present time (end of 2014) a non-negligible stock of classic incandescent lamps are still operating in households. We didn't find in the literature similar studies addressing this issue and we find that it would be important to have this kind of analysis in other countries.

In addition, we observe that most of incandescent lamps in households have been replaced progressively in the period 2009–2014 by halogen lamps instead of more efficient ones (CFLs) as it was initially expected. It is likely that it will continue to be the case in the following years for the remaining stock of incandescent lamps. In our study, an important amount of the collected data concerns Swiss low to medium income households, but comparisons of electricity consumption and sales data market at country level support the fact that our findings can be generalised to the rest of the local population. There is also increasing evidence that this is the case at the European level.

Based on these two observations, we conclude that the impact of the CE 244/2009 directive at the end of 2014 concerning the stock of inefficient lighting in households is lower than it was initially forecasted. The hypothesis and models used for the projections need to be reviewed, in particular if they are planned to be used in the studies concerning the delay of stage 6 of the 244/2009 regulation.

If our findings can be extrapolated to the rest of Europe, postponing stage 6 of the 244/2009 regulation would have a larger negative impact regarding the expected 39 TWh/y savings for 2020. If the present tendency to replace the stock of incandescent lamps by halogen ones in households doesn't change, an important number of incandescent lamps that will be still operating after 2016 will be replaced by halogen rather than more efficient ones. As a consequence, the stock of halogen lamps will increase. Considering the longer lifetime of halogen lamps compared for those of incandescent lamps, the rate of replacement of inefficient bulbs could decrease in the future and it will take a longer time to achieve the expected savings.

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