Abstract

„Incandescent lamp phase out and its effect in Iceland“

The following text is written as an excerpt from the following:

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Introduction

The world as we know it is under threat. Global warming is a problem that affects all living things on earth. The future is bleak if we are to believe worst case scenarios. Glaciers will melt and sea levels will rise. Weather will change, deserts will expand. Animal species will become extinct and the future of food supply for the human race is shrouded in a cloud of uncertainty.[1] This is the background from which governments are acting while proposing energy efficiency measures.

The world relies heavily on energy sources that emit greenhouse gasses which contribritue to global warming. The European Union is no exception. 31% of its electrical energy is produced through burning coal, 22% burning oil and gas, 47% of electrical energy comes from renewable sources, of which 32% comes from nuclear powerplants.[2]

The published goal of the European Union for the year 2020 is to reduce greenhouse gas emission by 20%, reduce energy consumption by 20%, and meeting 20% of energy needs by renewable sources.[3]

One recent addition to energy efficiency measures of the European Union is EU regulation 244/2009 implementing EU directive 2005/32 with regard to ecodesign requirements for non-directional household lamps. This regulation was passed in March of 2009.[4]

The purpose of the regulation is to decrease greenhouse gas emission and reduce electrical energy consumption in the European Union through widespread adoption of household lamps with better energy efficiency than the ones already in place. Lamps are classified according to the EU energy label from A to G. Normally, incandescent lamps fall into categories E, F or G, halogen lamps are class C or D and compact flurorescents (CFL from here on) are either A or B.[5]

The matt incandescent lamps have been banned completely with an energy label requirement of A and the public is encouraged to replace it with CFL. Clear incandescent lamps will be phased out gradually until 2016 when they are required to have a B rating with the exception of G9 and R7 sockets which will need C rating. The public is encouraged to explore CFL, LED or halogen alternatives since all of these require less electricity for operation than incandescent lamps.

Background of regulation

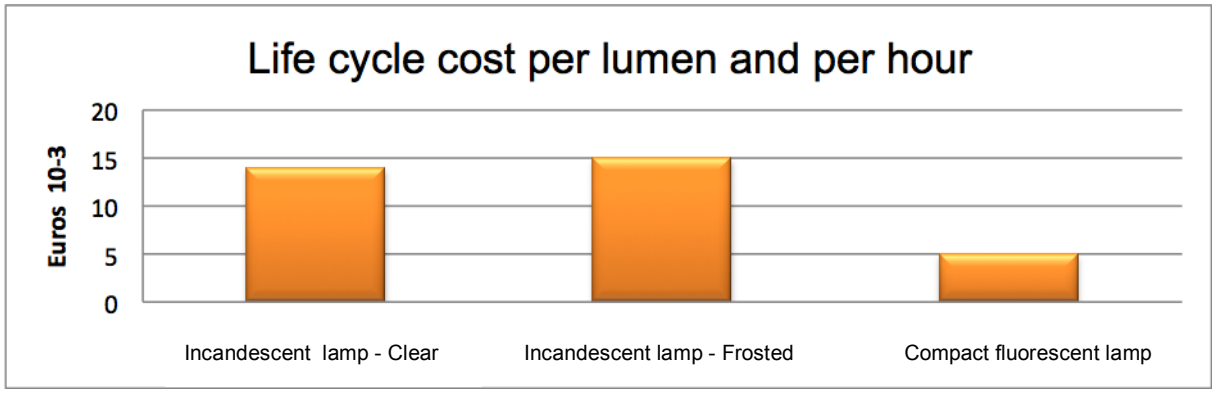
The incandescent lamp is the most common household lamp in the world. It is the undisputed people´s choice of lighting with ca. 79% of worldwide lamp sales in the year 2005. It is also the universal standard in light quality. Regulating such a popular product is a sign of the urgency placed on energy efficiency by government.

Regulation 244/2009 was not put in place without preparation. Independent contractor, VITO in Belgium was commissioned to explore the European lighting market, to identify the best lamp alternatives for energy efficiency and propose alternative routes for governement policy on energy efficiency in domestic lighting. The key argument used in the widespread adoption of CFL is a calculation made by VITO on Life Cycle Cost. The principle of Life Cycle Cost measures the total material and energy consumption of a product from its production phase, distribution phase, use phase, end of life phase and the environmental impact of these phases.[6] The use phase was found to be the most influential factor in energy use and environmental impact. This calculation by VITO

[1] http://en.wikipedia.org/wiki/Global_warming. Viewed 08.1.09
[2] Lot19: Domestic lighting, Final Task Report, Task 5: Definition of base case by VITO, October 2008. P. 18
[3] http://europe.eu/rapid/pressReleasesAction.do?reference=MEMO/09/368&format=HTML&aged=0&language=EN&guiLanguage Viewed11.11.09.
[4] Interview. The Icelandic foreign ministry. April 2009.
[5] http://www.energy.eu/focus/energy-label.php Viewed 10.09.2009.
6 http:www.iaeel.org/IAEEL/Archive/Right_Light_Proceedings/_Body/BOK1/200/1411.PDF. Life cycle analysis of compact fluorescent lamps vs. Incandescent lamps, Gydesen, A. Maimann, D.

assumes the electrical energy generation ratio average of the EU27 mentioned in the introduction above.[7]

Table 1. Life cycle cost per lumen and per hours calculated by VITO.



[8]

As tabel 1 shows, the life cycle cost per lumen and per hour is considerably lower with CFL than with incandescent lamps.

The calculations by VITO, like any other calculations take certain factors into account and assign them a value. Critics of the regulation have pointed out several disadvantages of the CFL. The European Union has acknowledged these in a special press release with answers to frequently asked questions about the regulation.[9] Opponents claim also that focus on lighting technology alone will not bring about the desired change in energy consumption.

Focus of research

The country of Iceland is a member of EFTA (European Free Trade Association) and a member of the EEA (European Economic Area). The country is therefore working in accordance with EU directive 2005/32 under which regulation 244/2009 falls. It is therefore likely that Iceland will adopt this new regulation. Iceland however has an energy profile unlike many other European countries. Nearly 100% of its electrical energy is generated from renewable sources. [10]

It is clear that this regulation will have the biggest impact on households. What will happen in Iceland with the adoption of European Union regulation 244/2009 ? This has been the subject of the authors masters thesis in architectural lighting design at the Royal School of Technology in Sweden. The research explores the rationale behind the regulation and its possible economic and environmental effects in Iceland, if adopted.

Research approach.

The purpose of the research was to evaluate the economic and environmental effects of implementing regulation 244/2009 in Iceland. This was done through exploratory research with a focus on quantifiable variables. Primary information was gathered through interviews and fieldwork. Extensive use was made of published information.

A systematic review was made of criticism of the regulation as put forward by the public and lighting professionals and acknowledged in a press release by the European Union. Each of these criticism

[7] LOT 19: Domestic lighting, Final Task Report, Task 5: Definition of base case by VITO, October 2008. P. 16,18.
[8] LOT 19: Domestic lighting, Final Task Report, Task 5 by VITO, October 2008. P. 45
[9] http://europa.eu/rapid/pressReleasesAction.do?reference=MEMO/09/368&format=HTM&aged=0&language=EN&guiLanguage=en#d1e1600 Viewed 19.11.09
10 http://eng.idnadarraduneti.is/publications/nr/1170. Viewed 17.09.2009

was evaluated and to what extent it had been taken into consideration in the preparatory work for the regulation, performed by the EU commissioned contractor VITO. The readily quantifiable criticism put forward and found valid was included in the calculation of economic and environmental effects. Therefore some of the real world complexities of switching lamp types were given value.

Basis for calculation

In absence of available information, a base case for the lighting and user behaviour of lighting in atypical Icelandic household had to be constructed. This was done with information obtained in interviews, field work, and published information. A profile was set up about the typical use of electricity for household lighting, price of electricity, number of lightpoints, ratios of light source types in use, lamp composition by type, wattage, lifetime and price. Finally the average use of lighting per day for the typical Icelandic household was constructed.

Having established this information, the economic effects for the typical Icelandic household were calculated and compared to a situation where all matt incandescent lamps have been replaced with CFL. Additionally, a scenario from a popular OSRAM brochure in Iceland was calculated and compared to the base case constructed by author. The total effect of this regulation in Iceland is then calculated to show its influence on all households and sales of lamps and electrical energy.

Finally, the base case constructed was utilised to calculate the environmental effects of a switch to CFL with the EcoReport tool, frequently used by the EU.

Two base cases were constructed through interviews, field work and published information for lighting and user behaviour of lighting in the typical Icelandic household to present the situation before and after adoption of regulation 244/2009 or switch to CFL.

The parameters were set as follows:

The two base cases constructed therefore had the following lamp composition.

Before switch to CFL	**After switch to CFL**
11 pcs of 35W Halogen lamps, lifetime 2000 hours	11 pcs of 35W Halogen lamps, lifetime 2000 hours
14 pcs of 60W Incandescent lamps, lifetime 1000 hours	22 pcs of fluorescent lamps **of which**
8 pcs of fluorescent lamps **of which**	15 pcs of 15W CFl with a lifetime 6000 hours
5 pcs of 15W CFL, lifetime of 6000 hours	2 pcs of 18W CFL, dimmable, lifetime 10.000 hours
3 pcs of 18W T8 linear fluorescent lamps, lifetime 20.000 hours	2 pcs of 15W CFL, lifetime 3000 hours due to frequent switching.
	3 pcs of 18W T8 linear fluorescent lamps, lifetime 20.000 hours.

Total economic impact

Table 1: Lamp expenditure of a typical household before and after switch to CFL and accrued savings

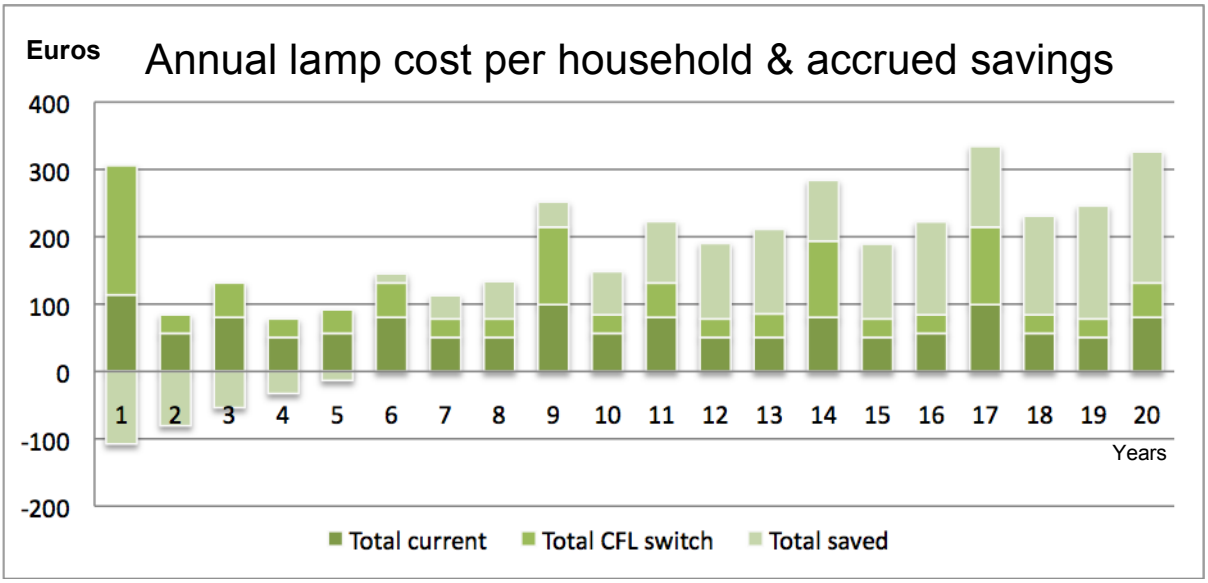


Table 1 shows the lamp expenditure of a single typical Icelandic household before and after a swith to CFL. The dark green columns denote the lamp expenditure before a switch to CFL, the middle green columns denote the lamp expenditure after a switch from incandescent lamps to CFL. The light green columns denote the total accrued savings by switching to CFL. As can be seen the cost of swithcing over to CFL with higher lamp purchasing price and luminaire replacement of 27 euros takes away all of the savings for the first 5 years. In the sixth year the savings start to accumulate. The savings take a dip when there is purchasing of lamps. As can be seen by the green column in year 20, the accrued savings after 20 years is 194 Euros. If divided by 20 years the savings are 9,7 Euros per year, per household.

Table 2: Comparison of accrued savings for a single typical Icelandic household with information from OSRAM brochure vs. Base case by author

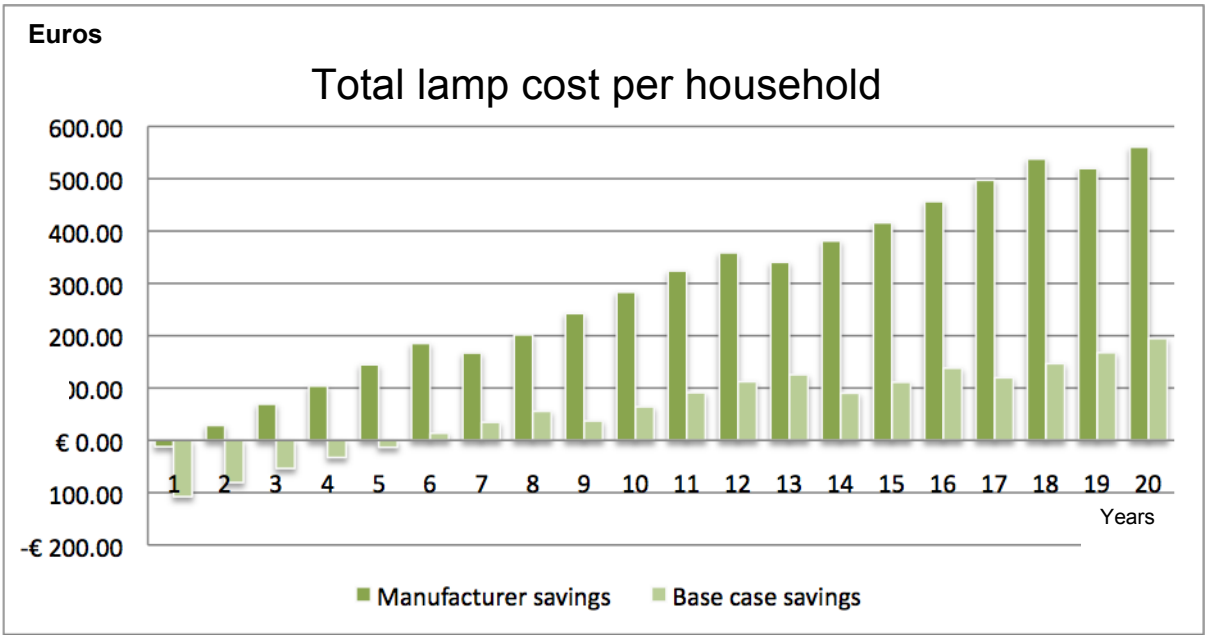


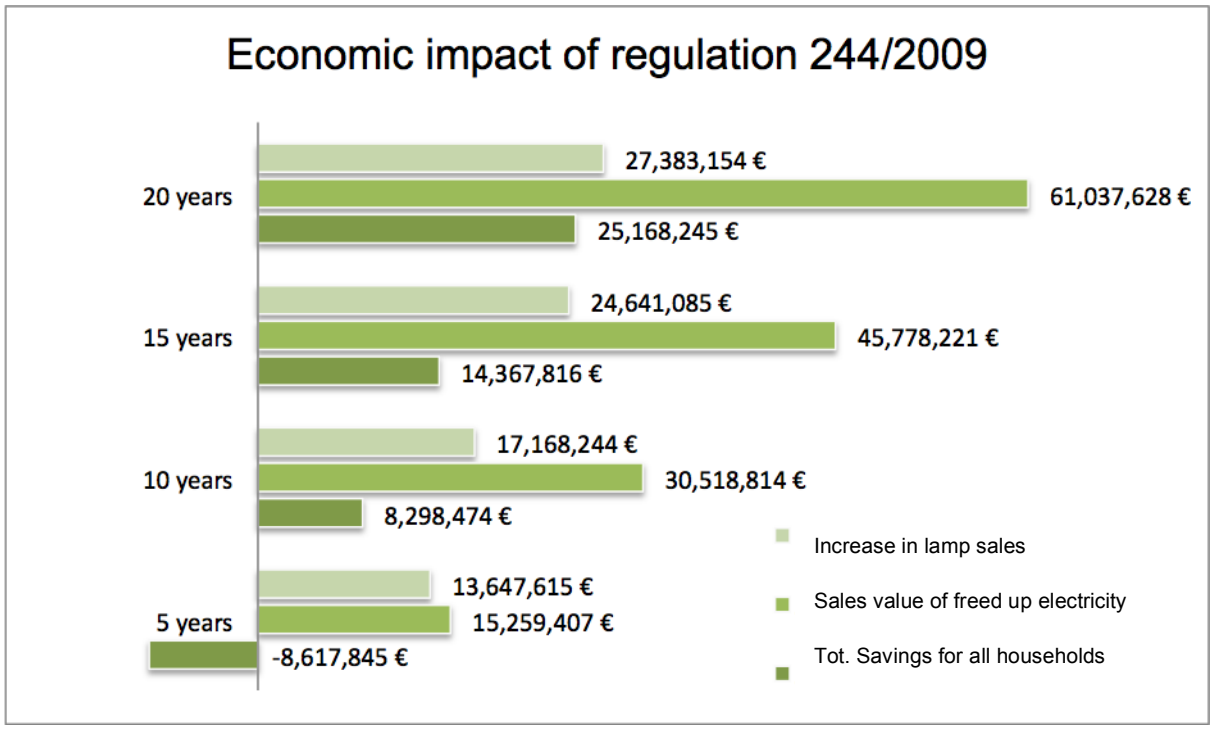
Table 2 shows the accrued savings for a single typical Icelandic household in lamp purchasing cost after a switch to CFL. The light green columns show the savings already shown in table 1, with information from the base case as constructed by the author. The dark green columns show the savings in lamp purchasing after a switch from incandescent lamps to CFL as calculated by author, using information from an OSRAM brochure published in Iceland. This brochure is readily available to the public at most stores of the Bonus retail chain in Iceland, which is a popular low cost retail outlet in Iceland.

As table 2 shows, there is a significant difference between the case as constructed by author and what is being presented to the public by this particular manufacturer brochure. The accrued savings at year 5 are 985% higher according to the brochure, at year 10 the accrued savings are 341% higher, at year 15 the accrued savings are 275% higher and at year 20 the accrued savings are 188% higher. This comparison shows in the authors opinion that information in this particular manufacturers brochure misleads the public about the real savings in switching from incandescent lamps to CFL.

What explains this large difference ?

The assumed lamp replacement by author of 27,03 Euros is the biggest contributor to the large difference in savings in the first 5 years. The main difference in information used is the following. The brochure assumes 2,7 hours average use of lighting per day as opposed to 2 hours used by author, 60W incandescent lamps are replaced with 11W CFL in the brochure instead of 15W used by author. Lifetime is the same. The author gives value to frequent switching and assumes that 10% of regular CFL will fail at 3000 hours, 2 pcs of 18W of the more expensive dimmable CFL are used. Heat replacement factor is taken into account but does not weigh heavily since the alternative heat source of hot water is cheaper at 0,009 Euro per KWh than electricity at 0,06 Euro per KWh in Iceland.[11]

Table 3 Economic impact of regulation 244/2009 for the stakeholders in Iceland.



[11] Icelandic energy institution, calculations by Ivar Thorsteinsson, electrical engineer. April 2009

Table 3 shows the economic impact of regulation 244/2009 for all homes, lamp importers and energy companies in Iceland, using the constructed base case. A total of 59.494 MWh of electric energy would be freed up annually. This is loss of sales for energy companies. However, if business is starved of electricity, the freed electricity can be used for other purposes to stimulate economic growth. The calculation in table 4 assumes that energy companies will be able to sell the extra electricity at the same price as before or 9,49kr/0,06 Euro per KWh, without meter fee, which holds for usage under 200.000 KWh per year.[12]

The total projected electrical usage in Iceland in 2009 is 14,6 TWh.[13] Total use of electricity for lighting is 127.801 MWh per year with the current base case constructed by author. Domestic use of electricity without house heating in Iceland was 600.190 MWh in 2008.[14] Lighting is therefore ca. 21% of total domestic electrical use. Domestic lighting is therefore currently at 0,87% of total electric use in the country. With a switch to CFL, electric use for household lighting would drop further to 0,46% of total electric use. The significance of this post for total electricity use in Iceland is therefore limited.

Further it can be seen that the added sales by lamp importers outweigh the savings achieved by households by switching to CFL.

Total environmental impact

The EcoReport tool is used by VITO to show the total environmental impact of a lamp type in their preparatory report for the EU. However, this tool is not directly applicable to the situation in Iceland since nearly 100% of electricity is generated without greenhouse gas emission. Recycling of CFL´s is also underdeveloped in Iceland with WEEE regulation only adopted in 2009.[15] The results from the distribution phase, use phase, debit and credit points regarding recycling are therefore ignored. The parts of the EcoReport tool used provide an indication of the production phase and volume of material to reach the end of life phase.

The same before and after base cases are used as in previous calculations. Only incandescent lamps and CFL are included in the calculations since Halogen and Linear fluorescent lamps will not change before and after switch to CFL. The numbers are presented in a simplified set of tables and represent a period of 8 years and ca. 3 months or 6000 hours of lifetime at the average use of 730 hours per year.

Case 1 represents the situation after switch from incandescent lamps over to CFL. It includes 19 CFL with a lifetime of 6000 hours + 2 with early failure at 3000 hours. A total of 21 CFL

Case 2 represents the current situation with 14 incandescent lamps that have to be replaced at 1000 hours or a total of 84 incandescent lamps. It also includes 5 CFL with full 6000 hours of lifetime.

The number of lamps needed for each home is then multiplied with the number of Icelandic homes in the year 2008 or 129.300.

[12] http:/www.or.is/fyrirtaeki/rafmagn/almennraforkunotkun/. Viewed 18.11.09
[13] Energy in Iceland, historical perspective, present status, future outlook. Second edition, published 2006, Icelandic Energy Institution. P. 9
[14] The Icelandic electric forecast 2009-2030., published 2009, Icelandc Energy Institution. Appendix 2. P. 3.
[15] Interview with managing director of Efnamottakan, Jon H. Steingrimsson, August, September 2009.

Table 4 Total materials disposed and recycled

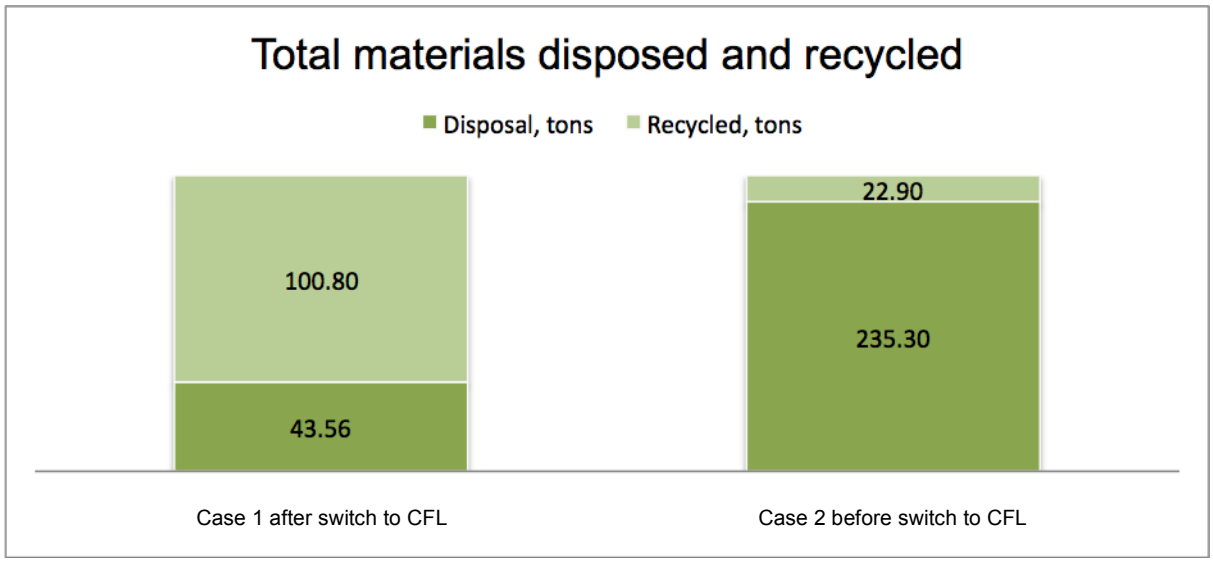
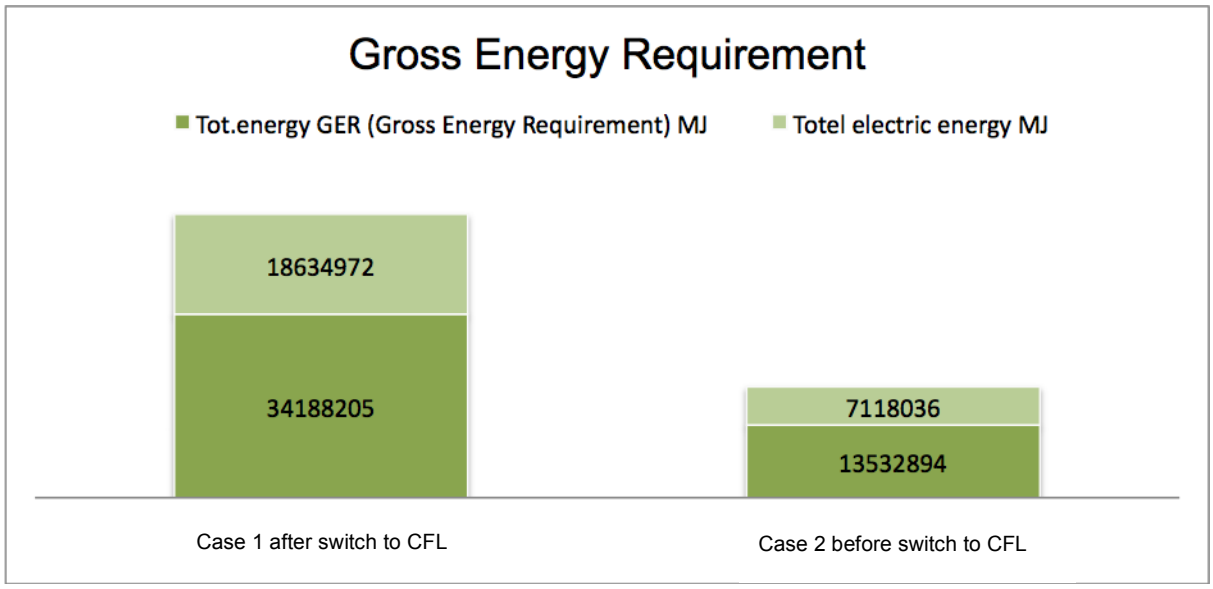


Table 4 shows that there is more material used in case 2 with incandescent lamps because of their shorter lifetime. The nature of the products play a role however. The incandescent lamp can be dumped in a landfill without much environmental damage. The CFL on the other hand contains harmful materials such as mercury and electronic components. Mercury is a toxic substance and will be banned in all EU exports from October 2011 with the exception of CFL products. [16] CFL´s therefore need to be recycled. Case 1 after a switch to CFL produces 90% more materials that need to be recycled. Recycling requires transport and energy. In the case of Iceland there is equipment availabe to process linear fluorescent lamps but no special equipment is currently available to dispose of CFL´s. The waste would therefore need to be processed and shipped abroad for recycling if it will not simply be dumped in landfill.[17]

Table 5 Gross energy requirement



[16] http://www.euractiv.com/en/environment/europe-hopes-world -follow-mercury-ban/article-175762. Viewed 12.09.09
[17] Interview with managing director of Efnamottakan, Jón H. Steingrimsson. August and Septemer 2009.

Table 5 shows the gross energy requirement (GER) or the total energy needed to manufacture all of the lamps used by all Icelandic homes according to the constructed base case. It also shows the electrical energy needed for the manufacturing measured in Megajoules. One megajoule equals 0,277 KWh. As can be seen there is 152% more gross energy requirement with a switch to CFL. The same can be said about electrical energy requirement which is 161% higher with a switch to CFL.

Table 6 Global warming potential

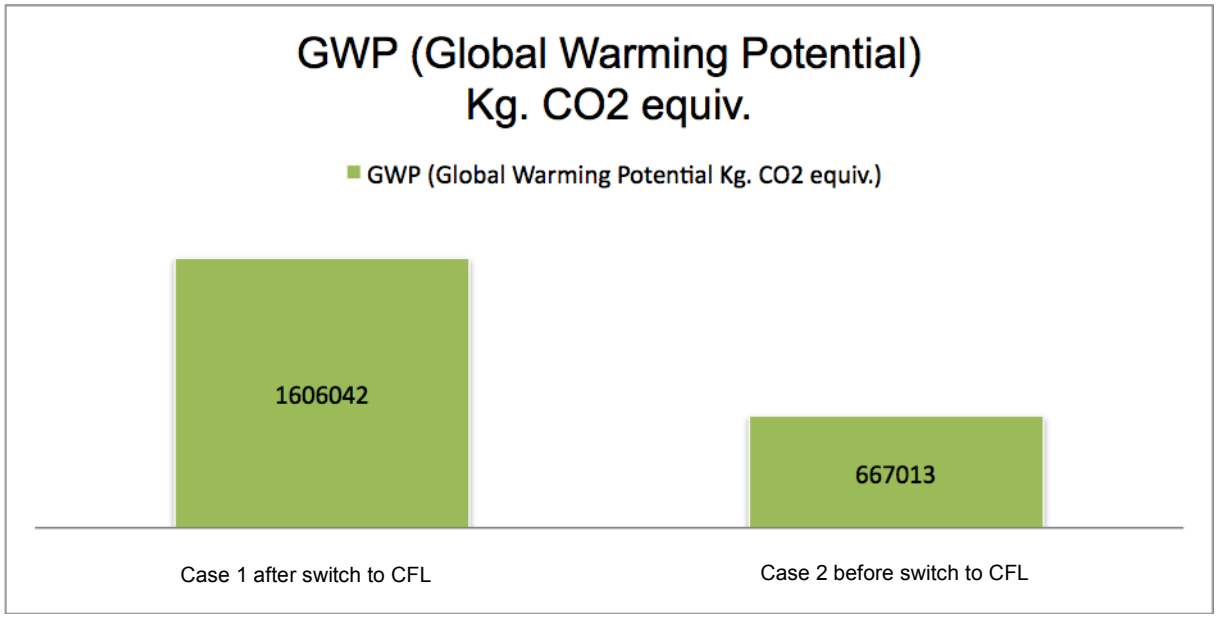


Table 6 shows the GWP or global warming potential. This indicator measures all greenhouse gasses emitted into the air from each phase in the EcoReport tool. As can be seen the GWP is 140% higher after a switch to CFL during the time period measured of 8 years and ca. 3 months in the Icelandic situation.

Conclusions

Using the constructed base case, it has been shown that a switch to CFL is beneficial for Icelandc household economically. However, the benefit is much less than the public is led to believe in advertising by manufacturers. As shown in table 1, the break even point is somewhere between the 5th and 6th year. After 20 years, the savings amount to 9,7 Euros per year, for each household in Iceland.

It can therefore be concluded that Icelandic consumers are being misinformed about the true economic benefits of switching to CFL.

Energy companies will lose sales. It remains to be seen whether alternative customers can be found for the freed up electric energy but judging from local news that will not be a problem. However, it remains to be seen at what price the electric energy can be sold. The Icelandic society as a whole will probably benefit as the energy saved by households can be used by business to stimulate economic growth.

As mentioned earlier, the EU preparatory report by VITO, found the biggest environmental impact of lamps to be during their use phase. Their calculations assume the EU27 average for electricity generation, which is 31% from coal, 22% from oil and gas and 47% from renewable sources, of which 32% comes from nuclear powerplants. Iceland obtains nearly 100% of its electricity and heat from

renewable sources.[18] The use phase therefore does not contribute to global warming. As has been shown, using parts of the EcoReport tool, adoption of regulation 244/2009 with universal household adoption of CFL in Iceland, results in more environmental costs both in Iceland and internationally.

This goes agains the spirit and intention of EU regulation 244/2009.

In light of these results it is logical to ask further. If nothing else changes, at what point is the electricity generation ratio of a country such that switching to CFL causes more environmental damage than good ?

Iceland is not the only country in Europe with a high percentage of its electrical energy coming from sources that do not emit greenhouse gasses. If the benchmark is set for example at 60% or more, it is found that Austria, France, Lithuania, Norway (EFTA country), Slovakia, Slovenia, Sweden, and Switzerland (EFTA country) fall into this category.[19] These countries have a combined population of ca. 106.3 million people.[20] Is it possible that regulation 244/2009 with universal adoption of CFL in these countries would increase their contribution to global warming ?

This weakness in EU legislation to promote energy efficiency also raises questions about the most effective way of achieving energy efficiency in lighting.

„The amount of energy used is determined by the lighting equipment e.g. lamps and luminaries. It will also be determined by the lighting requirement for the application„[21] The validity of this point is perhaps best shown in the case of Japan. The country has the highest average lighting system efficacy installed in 2005. Despite this fact, they were along with South Korea, the second highest per capita consumer of light in the world in 2005. This is explained with higher illumination levels from fluorescent light sources and higher average operational hours of 3,7 hours per day.[22] This suggests that lighting requirement as judged by the user is a significant contributor to energy consumption.

User behaviour in lighting is difficult to research in practice. Some studies have been done but this is still a relatively unresearched area.[23]

Indication on possible ways forward can perhaps be had from a Swedish study on user behviour in lighting by Bladh, M. And Krantz, H. Published in 2008. This study was a qualitative one with a cross section of family types and age groups. It showed that energy used for lighting is an interplay of various factors. The importance of the three most used lamps in a household is established. They account for more than half of the electric consumption for lighting in all cases but one. It also showed that people´s cost consciousness in relation to lighting is very low. Older people tend to consume less electricity for lighting than other age groups. This contradicts what is known about vision in older people. It is a well known fact that the human eye needs more light to perform as it gets older. Bladh and Krantz suggest that older people in general tend to have a more cost conscious behaviour than other age groups. The lights that are not needed are simply turned off.[24] This possibly suggests that user behviour is even more important than previously thought.

It is probably safe to say that we all want to protect the environment for ourselves and future generations. How do government regulators achieve that ? Banning the most popular lamp type on the market with the possible negative side effects shown in this research is questionable public policy.

[18] Energy in Icelnd, historical perspective, present status, future outlook. Second ed. 2006 published by Orkustofnun. P. 24
[19] eea.eionet.europa.eu/Public/irc/eionet.../library?l=/.../electricity.. Viewed 04.02.10
[20] http://en.wikipedia.org/wiki/List_of_countries_by_population Viewed 04.02.10
[21] DL. Loe, Energy efficiency in lighting-considerations and possibilities. Lighting Research Technology;2009 41: P. 2
[22] Light´s Labour´s Lost. Published by the IEA in 2006. P. 173, P189
[23] Towards a brighter future ? Household use of electric light: A microlevel study. Bladh. M., Krantz.,H. Energy Policy, Vol. 36, issue 9. 2008. P. 3
[24] Towards a brighter future ? P. 12,13.