

Lighting energy efficiency in residential buildings, evaluation and projects

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Abstract: Paper analyses the energy efficiency of residential buildings electrical lighting installations in European Union countries. The residential sector represents an important potential for reducing the energy consumption, focused on lighting and domestic appliances. In the last years there is an increasing debate about incandescent lamps shift-out and a new CFL charter, related with the residential buildings sector which is the most difficult to regulate or where energy efficient lighting measures face problems in dissemination. The Lighting Engineering Center of the Technical University of Cluj-Napoca, Romania is involved in two programs for promoting the lighting energy efficiency and saving measures in residential buildings: EnERLIn - European efficient residential lighting initiative, an EIE - SAVE program to promote the compact fluorescent lamps in the residential area, and CREFEN - Integrated software system for energy efficiency and saving in residential sector, a Romanian CEEX program. The EnERLIn EIE SAVE program proposes to develop and validate robust scenarios for CFL promotional campaigns in European, national and regional levels. The aim of the CREFEN project is to achieve, at the current level of the European research in the field, an integrated software system for reducing the energy consumption and promoting an advanced energy management in residential buildings.

Keywords: Compact Fluorescent Lamps, Efficient Residential Lighting, European programs

1. INTRODUCTION

Market research has indicated that in order to substantially increase the use of CFLs in the residential sector, it is essential to develop and market attractive and good quality CFLs. The rate of the households owning a CFL covers the range from 0.8

units per household in UK up to over 3 units per household in Denmark. Projects from the SAVE programme consider as a reasonable upper limit the use of up to 8 units per household. An analysis of the residential lighting, realized in 100 households in Denmark, shows a lighting consumption of between 5% and 21% of the total monthly electric energy consumption of the household and the use

of 24% saving lamps – linear fluorescent lamps and compact fluorescent lamps [5]. However, the same market analysis from Lighting Companies show that in Western Europe energy inefficient incandescence lamps (including halogens) still represent 30% of the sales [8].

Ligth Fair Las Vegas 2006 - [11] - presented the big news in CFLs - the proliferation of a new standard base for CFL fixtures that allows bulbs and fixtures to be interchanged freely. This overcomes a major obstacle for widespread use of CFLs (if you buy a 26 W fixture, you must use a 26 W CFL). To solve the problem, Energy Star worked with manufacturers to develop the GU24 standard. Consumers who purchase fixtures that use GU24 components will be able to change out lamps/ballasts of varying wattage and lumen output to meet their specific lighting needs, making the switch just as easy as it's been to screw in a 60 W incandescent light bulb to replace a 75 W bulb.

2. EnERLIn - EUROPEAN EFFICIENT RESIDENTIAL LIGHTING INITIATIVE, SUPPORTED BY INTELLIGENT ENERGY EUROPE PROGRAMME

The European Climate Change Programme (ECCP) identified residential lighting as an important area to CO₂ emission reductions. After a considerable number of promotion and rebate schemes, about 135 million CFLs are used today in European homes. However, only 30% of EU households have at least one CFL, with those households that own them having an average of three or four. The residential lighting market is still dominated by inefficient Incandescent Lamps (GSL – General Service Lamps). The EnERLIn EIE SAVE program proposes to develop and validate robust scenarios for CFL promotional campaigns in European, national and regional levels. The European Union initiated numberless

campaigns to promote compact fluorescent lamps with the purpose of increasing the market share of CFLs at 15%. The EnERLIn EIE SAVE program is aiming at promoting to all the stakeholders a quality charter to assure that the CFL that are marketed and promoted can deliver savings which last overtime and meet the customer expectations of high quality lighting, and the ultimate objective of the program is to substantially increase the efficiency of residential lighting in a number of Member States [15].



Objectives of the EnERLIn action.

Improving the energy efficiency is a central theme of energy policy within the European Community, as indicated in the White Paper “An Energy Policy for the European Union”, since improved energy efficiency meets the three goals of energy policy, namely security of supply, competitiveness and protection of the environment. Lighting represents an important part of building energy consumption in the EU – around 10% of the total electricity consumption, ranging from 5% (Belgium, Luxemburg) to 15% (Denmark, Netherlands, and also Japan) [6]. Residential sector represents 28% from the global electric lighting energy use [8].

Overall electric appliances in households, industry and the tertiary sector represent 40% of the EU total electricity consumption, its generation being one of the most important sources of CO₂ emissions. Several EU and National Initiatives and Directives tented to promote energy efficient lighting for services sector buildings. These efforts can be judged as very successful because nowadays the CFL market share represents 20% of the global European market whereas the same figure in world scale is limited to 17%.

The ultimate objective of the EnERLIN program is to substantially increase the efficiency of residential lighting in a number of Member States and Candidate Countries, and this can be done by offering them good arguments necessary to overcome the above cited barrier. To achieve successful residential market transformation we should promote that both light fixture outlets as well as design and specialty stores display their luminaires with CFLs (good and aesthetic ones) rather than GSL. At the same time the program is aiming at promoting to all the stakeholders a quality charter to assure that the CFL that are marketed and promoted can deliver savings which last overtime and meet the customer expectations of high quality lighting. All the program objectives will lead to a higher market share for the most efficient CFLs and dedicated luminaires. The final beneficiaries will be end-users of equipment mainly in domestic sector.

In his presentation [14], Professor Zissis considers that the energy saving policies and environmental constraints imposed by European regulations push strongly to develop “green” solutions for lighting. At the present case, CFL seems to be the most valid solution. Several European and national programs are devoted to the promotion of this type of lamps and try to limit the GLS use in households. These campaigns are today very efficient and the number of CFL sales increases in Europe rapidly. The average observed growth rate concerning CFL numbers is the order of 13.5% per year (in the order of 11.5% in western and 17% in eastern countries). It should notice that the annual growth rate of the global lighting industry is in the order of 0.8%.

EnERLIN consortium. 14 partners from 14 countries constitute the proposed consortium, covering a large part of the Europe from north to south and from east to west.

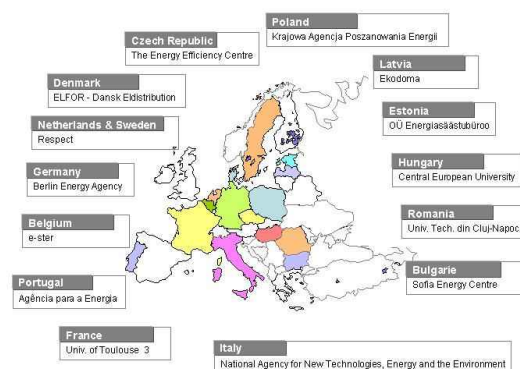


Figure 1: The EnERLIN consortium map. [15]

This is an important issue; because, concerning lighting the reaction of the individual customers is quite different from a country to the other (north countries prefer low colour temperatures lamps, hot ambiance, and south countries are more sensitive to high colour temperatures, cold ambiance). The consortium includes western countries with high GDPs compared to eastern countries that they just integrated EU (Poland, Hungary, Czech Rep., Latvia and Estonia), and the newest EU countries (Bulgaria and Romania). The ENERLIN consortium is strongly cross-disciplinary including National or Regional Energy Agencies (ADENE, KAPE, ENEA, SEC, SEVEN, BE), one ESCO in Belgium, academic institutions (France, Hungary and Romania), a values-based consultancy focussing on sustainability (Respect) as well as independent consulting SMEs (Ekodoma, Energy Saving Bureau). Each partner has solid experience with EU projects (especially from DG TREN), and strong links with international organisms like CIE and projects like ELI, other European networks (COST-529) and programs (GreenLight). Some partners are quite influential for policy-making bodies in both national (regional) and European levels.

3. CREFEN – INTEGRATED SOFTWARE SYSTEM FOR ENERGY EFFICIENCY AND SAVING IN RESIDENTIAL SECTOR



The **CREFEN project** aims: - to create an integrated software system-tool focused on the applications concerning the electric energy efficient use and saving in residential sector in Romania; - to develop the necessary databases of equipment and endowments from residential sector, using the market surveys and questionnaires; - to develop an advanced modelling and simulation software system-tool of electric energy consumption in residential sector and of economical effects; - to implement an application with databases, an interactive educational application and electronic book related to the energy efficiency use in order to influence the consumers' options in selecting energy efficient appliances for environmental protection [1].

The **Romanian National Strategy in the energy efficiency field - 2004** - underlines that the residential sector has a primary energy saving potential at 3.6 millions tones equivalent petrol through 6.8 million tones of the total final consumers; it means more than 50%. This potential can be capitalized by the rehabilitation of the buildings heating insulation, the improvement of the heating and lighting systems and of the electric domestic appliances.

The project is connected with energy efficient use according to EU directives from one side and with the implementation of database applications using web-based technologies for assisting and influencing the consumers decision in selecting the domestic and lighting appliances from the other side, that leading to sustainable environment management. The last aim of the project is for environmental protection by reducing the CO₂ emissions.

The software application architecture will be a modular one, with the possibility of its extension with new functionalities, without perturbing the other components or requiring the reorganization of the system data.

4. ANALYSIS OF ELECTRIC LIGHTING ENERGY CONSUMPTION IN THE RESIDENTIAL SECTOR IN ROMANIA

The statistic data [16] for the period 2000 - 2004 allow us to determine the variation of total household consumption, total number of household consumers, average consumption per household consumer, and of the specific consumption kWh/m² per year - Figure 2.

During November 2005 a study has been realized on the CREFEN project using feed-back reply forms concerning the usage degree of GSL and CFLs in households in Western Romania. We received 295 replies, namely 220 apartments (with 1–4 rooms - living room and bedrooms) and 75 houses (with 2–more than 7 rooms - living room and bedrooms). The light source equipment is presented in Table 1, and the average installed power - in Figure 3. The specific data referring to the Lamps usage were collected only on the UTC-N questionnaires for the use of received information under the frame of the IEE program EnERLIn, as an explanatory study.

The analysis of the presented data allows us to estimate a few characteristics of electric energy consumption of households. The annual electric lighting household consumption in Romania in 2004 was about 6.83 kWh/m²/year (based on the average consumption of 255.3 kWh/ household/year and average household surface of 37.39 m²/ household and the average contribution of the consumption on the lighting circuits - 25% according to the study [3]).

Table 1: Light source usage statistics for GSL and CFLs in Romanian households.

Household		GSL		CFL		Installed power
Type	No.	Units	Average	Units	Average	kW
Apartment	220	2624	11,98	367	1,67	0,770
Single-family house	75	1088	14,51	196	2,61	1,028
Total	295	3712	12,58	563	1,91	0,835

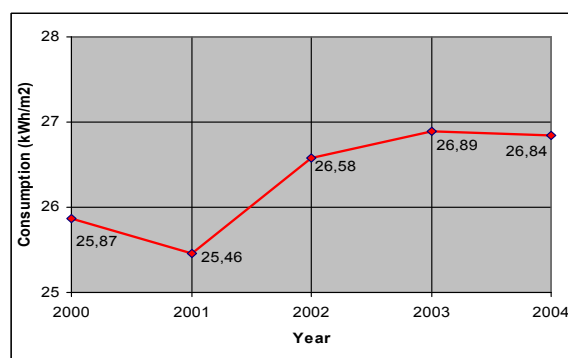


Figure 2: Household consumption per m² in Romania - [9, 15].

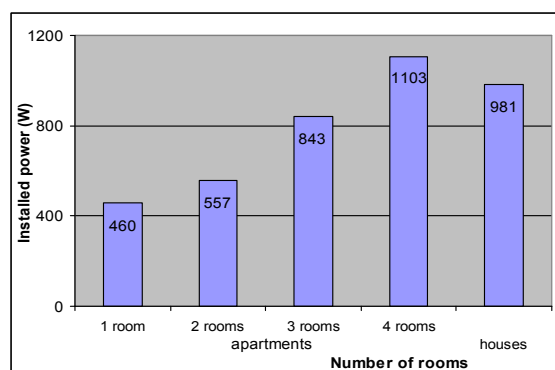


Figure 3: Average installed power in residential lighting - [9].

The EnERLIN questionnaire campaign was promoted by two subcontractors of the project and the local Electrica distribution company in seven steps, starting with November 2006 till May 2008. There were 545 answers (it means households) and 1804 CFLs used, so the average number of the CFLs is 3.31 units per household. Finally, both campaigns - CREFEN (November 2005) and EnERLIN (November 2006 - May 2008) denote on average **2.82 CFLs per household**.

The CFL distribution power is presented in Figure 4 - 545 households.

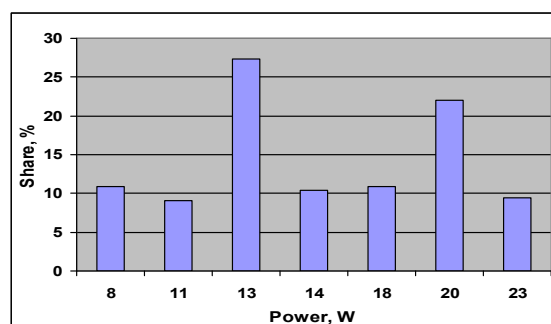


Figure 4: CFL distribution power in Romania - 545 households, 2008.

Newly updated CFL sales figures for Denmark show the CFL distribution power on 2000 Danish households - Figure 5. There are on average 9 incandescent lamps per household, **6 CFL**, and 8 halogen lamps. 16% of Danish households still do not own a CFL. [12]

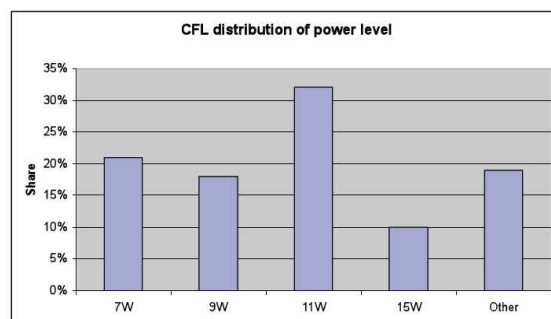


Figure 5: CFL distribution power in Denmark - 2000 households - [12].

In Bulgaria, there are on average 0,6 CFLs per households [12].

A CREFEN Questionnaire Summer 2006 campaign was realized in order to acquire information as ownership rate for each appliance, rated power, average operation period and others (efficiency, resources consumption). The households' composition was desegregated by urban multi-apartment block, single urban dwelling and single rural dwelling. The households' distribution was made according different criteria as: geographic site, rural or urban environment, family income, dwelling size. A total of 204 questionnaires were obtained from a large geographical area. The first obtained data

regards the attitude of the questioned people to the energy efficient domestic appliances topic - more than 70% agree that the decision to buy an appliance should be based on energy efficiency class as well. The consumption in the household utilities is presented in the Figure 6. The motivation of the CFLs use is presented in Figure 7.

In further works, after receiving and processing the data, the reference status of the residential electricity consumption at the level of the year 2006 will be obtained. The residential electricity demand will be estimated using the MAED model elaborated by the IEA, following development scenarios on medium and long terms.

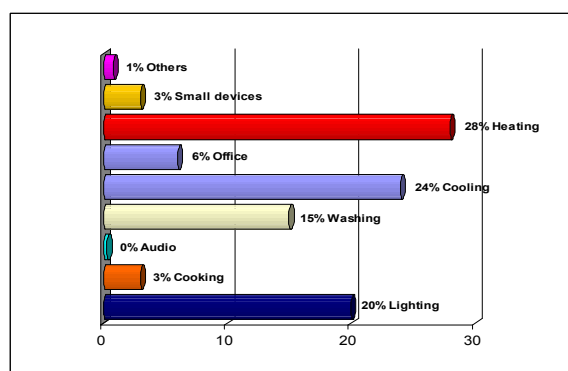


Figure 6: Consumption of household appliances [1].

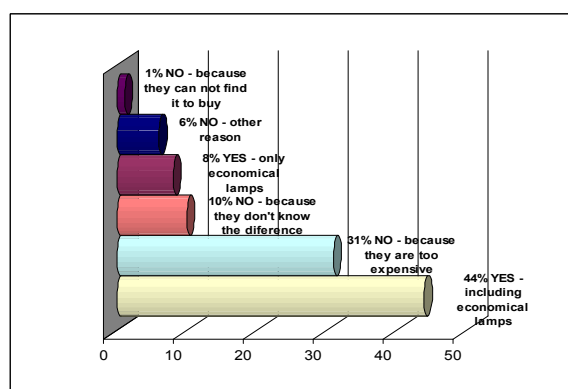


Figure 7: Motivation of the CFLs use [1].

5. NEW CFL QUALITY CHARTER

This year the European Commission, through Joint Research Centre, is preparing

a new European Compact Fluorescent Lamps Quality Charter. In the introduction is mentioned that “total domestic lighting consumes about 86 TWh in the Union and it is predicted to raise to 102 TWh by 2020. Compact fluorescent light bulbs (CFLs) use at least 60% less electricity than the traditional incandescent lamps while lasting ten to twelve times as long and can therefore deliver substantial savings in terms of both electricity and money.” The idea of this quality charter is to promote CFL for the remaining 95% of the residential lamp market, but with minimum quality criteria in order to increase consumer confidence. The mains modifications are related to stabilised light output (time to 80% of stabilised light output, after switch-on from cold, at normal room temperature, shall be less than 60 seconds and 30% of stabilised light output after switch-on from cold, at normal room temperature, shall be less than 2 seconds) and comparison CFL/GLS (instead of previous 1:5 ratio, a new 1:4 is indicated).

6. INCANDESCENT LAMPS SHIFT-OUT

The European Union has proposed a ban on incandescent light bulbs, planned to come into effect in the near future, but this will not affect existing incandescent bulbs, only the production of new bulbs. This proposal has to be approved by all member states or the European Parliament. Italy will ban the sale of incandescent light bulbs as of 2010. Germany's Environment Minister has urged the European Commission to ban inefficient light bulbs in the EU in the fight against global warming. The EU could reduce carbon dioxide emissions by 25 million tonnes a year if energy saving light bulbs were used in both the domestic and services sectors. Belgium's Minister of the Environment is intent to ban incandescent light bulbs, and thinks the ban on incandescent light bulbs should be included in the list of measures under the Kyoto

Protocol. In Ireland, the government proposes to ban traditional incandescent light bulbs in January 2009. On the 27 September 2007, the government in the United Kingdom announced plans to phase out the sale of incandescent light bulbs by 2011. Under the plan, retailers will voluntarily decline to stock 150 W bulbs from January 2008, 100 W bulbs from January 2009, 40 W bulbs in 2010, and all remaining bulbs by 2011. These plans are voluntarily, however they have had wide support from retailers and consumers. Though the initiative has been criticised by environmental groups such as Greenpeace, and other political parties, who believe mandatory measures should be introduced.

7. LESSONS LEARNT DURING THE FIRST TWO YEARS OPERATION OF EnERLIn PROGRAMME

Professor Zissis considers that during the past 24 months since the starting of the project, the main lessons learned by the consortium are the following [13]:

- End-user is very regarding on CFL-Quality. Low quality devices “pollute” the market and seriously impede the increase of market penetration of that energy efficient technology. A systematic CFL-quality control is imposed in EU level following a well-defined unique testing protocol and associated with readable and compulsory labelling.
- There is a significant lack of knowledge and data on the penetration and the trends in use of various lighting technologies in households. This is especially true in Eastern European countries, therefore it is difficult to clearly articulate what we would like to achieve with a campaign and whom exactly we could target in order to increase efficient light sources penetration.
- The involvement of many different actors and coordinating with the government authorities and ministries level needs an important investment on time than

expected but it is necessary. The politic attention on Climate Change have created activities in many levels in the society which have engaged the EnERLIn people in many discussions to coordinate action.

- Energy efficient lighting has become a more and more relevant topic in all sectors: private consumers, public authorities, and in enterprises. Increasing costs for energy and maintenance, environmental debates, and several EU Directives have especially increased the demand for energy saving solutions in municipalities. Also in the sector of private end-consumers, the awareness for environmental integrity and high-energy prices have lead to a rethinking in the use of energy saving lighting. The potential for the implementation of environmental friendly and cost saving lighting measurements is still very high. Initiatives such as EnERLIn play a major part in promoting such technologies and help to overcome barriers. The high number of participants in the workshop series and the high demand for advisory on the one hand and the still low number of good practice examples proves this.

8. CONCLUSIONS

The estimated total electric energy consumption, 255.3 kWh/household/year, and the total lighting energy consumption in the Romanian residential sector, 25% of the total household electric energy consumption, are values that fit in the references limits. The average number of the CFLs is 2.82 units per household. One CFL mounted in each household of Romania would lead to a decrease of the household electric energy consumption of around 45,246 MWh/year, saving 2.5 kTones CO₂ emissions [9]. The predictable economic impact could be established by the adoption of policies towards an electric energy consumption reduction, both locally and nationally. It is essential to increase the awareness of the energy efficiency both by

users and by electric energy providers, in order to reduce the consumption peaks that are specifically due to lighting.

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