Assessing the Residential Lighting Efficiency Opportunities in Lithuania

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ABSTRACT

We evaluate the conservation potential of compact fluorescent lamps (CFLs) for managing the residential electrical energy demand in Lithuania. The analysis is undertaken from the three separate perspectives of (1) the national economy, (2) the consumers and (3) the utilities.

The costs of conserved energy of 15 and 23 watt CFLs vary from $0.009 to 0.036 per kWh depending on CFL price and daily lamp use. Replacing only the two most used 60 watt incandescent lamps per household with CFLs would save 190 GWh of electrical energy for Lithuania annually worth 12 million US dollars at long run marginal costs.

We compare the existing residential lighting situation and energy efficiency opportunities in Lithuania with the situation in Hungary, where introduction of CFLs has been much more successful.

We then discuss the barriers to immediate large-scale introduction of CFLs in Lithuania, and policy instruments that could be used for promoting the diffusion of CFLs in the residential sector of Lithuania.

We conclude that future success of CFL penetration in Lithuania will depend on an aggressive information and promotion effort by at least the CFL manufacturers, or by any of the stakeholder institutions (e.g. the state agencies responsible for energy and environment, electric utilities, etc.).

INTRODUCTION

In this paper we assess the electricity conservation potential of CFLs in the Lithuanian residential sector. We chose to focus on this topic because: (1) CFLs remain largely unfamiliar to Lithuanian households, (2) CFLs have else where been shown to have attractively low costs of conserved energy (CCE), (3) the relatively short life of incandescents, and consequently the rapid stock turnover makes the entry for screw-in CFLs easier, and (4) this potentially important conservation opportunity has not been previously quantified for Lithuania. We use the most recent available data sources (although sometimes dated) for our analysis, and compare the Lithuanian situation with that in Hungary to provide perspective.

LITHUANIAN ELECTRICITY SECTOR

A feasibility study of any energy efficient technologies requires certain knowledge of the energy sector of a country.

After the break-up of the Soviet Union Lithuania inherited an economy with an energy intensity several times higher than that of Western economies (Matthes and Mez 1996). Although due to a severe recession Lithuania's primary energy consumption fell from 15 Mtoe in 1991 to 7.2 Mtoe in 1993, indigenous energy resources supplied only about 2% of Lithuania's energy demand in 1993 (Adamantiades et al. 1994). Wasteful energy consumption has become an unaffordable burden for both money-short Lithuanian society as a whole, and for consumers individually.

More than two thirds of electricity in Lithuania is being produced by the potentially unsafe Ignalina Nuclear Power Plant of Chernobyl design. The total installed generating capacity of the Lithuanian Power Company is about 5,600 MW, and due to the economic recession there is a surplus of electricity in Lithuania. Electricity demand is not likely to increase dramatically, so that Ignalina Nuclear Power

Plant and Kruonis Pumped Storage will continue to be the major electricity sources in Lithuania for the next decade. Transmission and distribution losses are estimated to be 11% (Matthes and Mez 1996, Adamantiades et al. 1994).

The Lithuanian energy sector remains largely state-owned with control exercised principally by the Ministry of Energy. Generation and distribution of electricity are the responsibility of the Lithuanian Power Corporation. Seven regional network utilities are responsible for the distribution of electricity, but they have very limited financial autonomy.

Residential customers who have not purchased a multi-tariff meter (90% of customers) are charged a flat rate of US$0.055/kWh. Households with multi-tariff meters (10% of customers) pay $0.065/kWh during day time, and $0.03/kWh for nights and weekends. The energy pricing council of Lithuania claims that these tariffs fully cover costs (Kazakevicius 1997; Baltic News Service 1997).

Average daily load in Lithuania has two peaks during winter. The higher afternoon peak (400 - 700 MW) lasts from 8:00 a.m. to 3:00 p.m. on business days. The lower evening peak (200 - 400 MW) lasts from 5:00 p.m. to 10:00 p.m., and can be attributed to the residential lighting. Total electric power demand for residential lighting during winter months can reach 260 MW (up to 13% of total power demand), nevertheless as long as the Lithuanian power system peaks around midday, the replacement of residential incandescent lamps with CFLs will not contribute to reducing overall system peak demand (Adamantiades et al. 1994; Kazakevicius 1997).

RESIDENTIAL CHARACTERISTICS

In some Eastern European countries (like Hungary) the highly competitive local market facilitates penetration of new technologies or products, but Lithuania, because of its rather narrow market, has not attracted much attention from the major lighting equipment manufacturers so far.

The population of Lithuania is 3.7 million. By 1994, Lithuania`s housing stock comprised approximately 1.3 million dwellings: of these almost 70% were urban (mostly apartments) and the rest (mainly single family houses) were rural dwellings. The average useful floor area per dwelling is 58 square meters, the average household size is 3. Almost 70% of Lithuanian dwellings are two- or three-room apartments, or houses with size varying from 50 to 70 square meters. Average household monthly income in mid 1997 was around $250 (Kazakevicius et al. 1996; Kazakevicius 1997).

The annual average electricity consumption per household in urban areas is about 1200 kWh, corresponding to 85 kWh per month during the non-winter months (April - September) and 120 kWh per month during the winter months (October–March). Electric appliances (fridges, washing machines, etc.) has the highest average installed capacity – 2090 W per household, lighting has the second place with 585 W, and cooking appliances with 538 W on the third (Arpaillange J. 1995).

RESIDENTIAL LIGHTING MARKET IN LITHUANIA

The majority of residential lighting in Lithuania is provided by incandescent lamps. There is no lamp production in Lithuania, so all lamps on the Lithuanian market are imported. Unfortunately we could not locate data either on lamp import and export, or on lamp sales volumes. In general Russian made incandescents, because of their low price ($0.25–0.30), are still the most purchased among Lithuanian customers. The market share of Western made incandescent lamps is nevertheless increasing (Kazakevicius 1997).

Standard fluorescent lamps are also used in the residential sector. The commonly used linear fluorescent lamps in Lithuania are 40W, 1.2 m long T12 technology (Kazakevicius 1997). Development of new phosphors has allowed the development of more efficient (and thinner) T8 lamps, and these are also marketed in the residential sector of Lithuania. Unfortunately we could not locate any information concerning penetration of T8 lamps with respect to T12s. The price of fluorescent lamps depends on many characteristics, such as their shape, size, or colour rendering index and ranges from $2 to $12 in Lithuania (Kazakevicius, 1997).

The new rare-earth activated phosphor technology has led to the availability of a growing variety of screw-based compact fluorescent lamps. The majority of CFLs sold in Eastern Europe as well as in Lithuania are of the less cost-effective integral design, making penetration of CFLs more difficult. Modular as well as dedicated CFL systems are less common (Vorsatz 1996).

The Lithuanian lighting market is still rather immature. Small private companies import incandescent and fluorescent lamps in small numbers, therefore retail prices of CFLs range from $10 to $23, and depend more on the store than on the type of CFL. In a few years the Lithuanian lighting market should become more mature, and prices for Western made products should be similar to ones in neighbouring countries (Poland, Hungary).

LITHUANIAN RESIDENTIAL LIGHTING CHARACTERISTICS

Incandescent lamps of 60 and 100W dominate the Lithuanian residential lighting market (figure 5.1). Lighting fixtures in most Lithuanian households (including kitchens) are hanging chandeliers usually consisting of 2–5 incandescents, where a direct replacement of them with screw-in CFLs will be possible without regard to the slight dissimilarity in size. Floor lamps and wall mounted fixtures are less popular in Lithuania (Kazakevicius, 1997).

Lighting contributes from 14 to 24% of total residential electricity consumption (figure 5.2) for different income groups (the average contribution is about 20% per urban household) (Arpaillange J. 1995). A recent spot survey suggests that the lighting contribution may be even higher, about 30% (Kazakevicius 1997). Residential lighting power demand and daily light use are presented in figures 5.3, 5.4. There is no significant difference in the hours of lighting use among income groups. However, the number of incandescent lamps ("light points" in technical jargon) per household in different income groups differs significantly.

Data on the size of the Lithuanian residential incandescent lamp market is unavailable. However, we can estimate

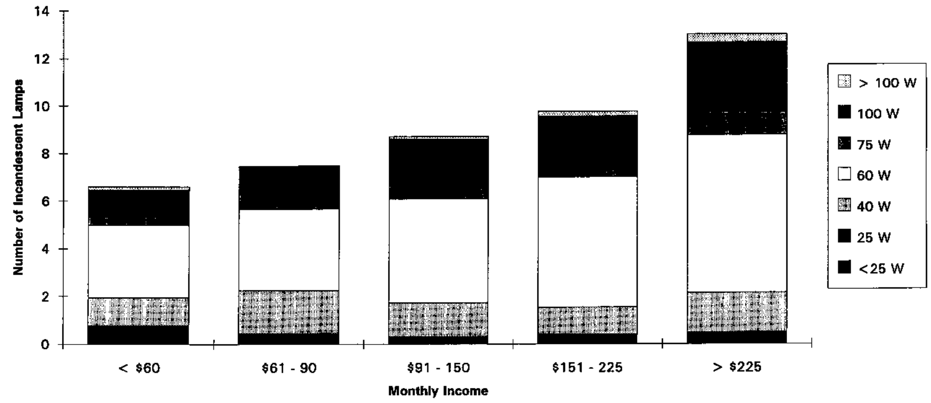

Figure 5.1. Incandescent Lamp Stock of Lithuanian Urban Households by Income (Source: Arpaillange J. 1995)

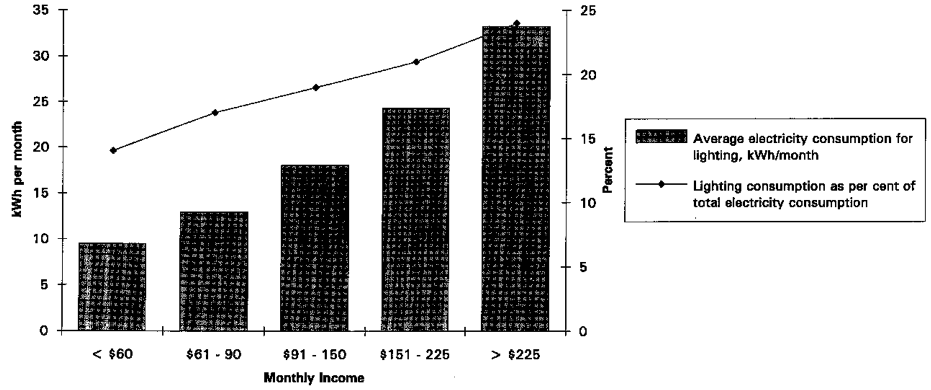

Figure 5.2 Consumption of Electricity for Lighting by Income Group, 1995 (Source: Arpaillange J. 1995)

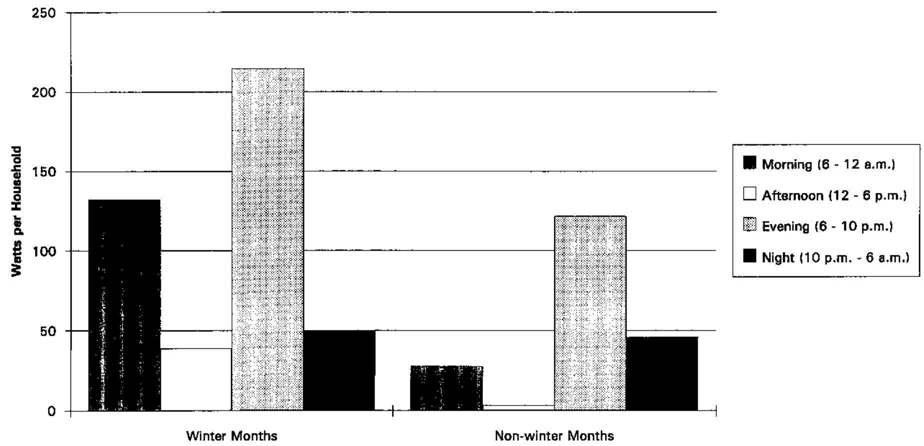

Figure 5.3 Average Electric Power Demand per Household for the Residential Lighting in Lithuanian Urban Areas.

it as follows. There are around 1.3 million occupied dwellings in Lithuania, and the households use at least two 60 or 100W incandescents for four or more hours per day (i.e. at least 1460 hs per year) (Kazakevicius 1997). Since the average burning life of incandescents is about 800 hours, we estimate the annual turnover of residential incandescents in Lithuania to be (1.3 million households * 2 heavy use lighting points/household * 1460 hs/lighting point/year * 1 incandescent/800 hours) = at least 4.7 million lamps per year. This yearly import could be significantly reduced by wider use of CFLs in Lithuanian households.

ECONOMIC ANALYSIS

Method

We analyse below the economic benefits of replacing incandescent lamps with CFLs from the three separate viewpoints of (1) the national economies, (2) the consumers, and (3) the electric utilities. Much of this analysis follows the one used by Gadgil and Jannuzzi (1990, 1991).

(1) From the national perspective, the comparison is between the cost of conserved energy versus the long run

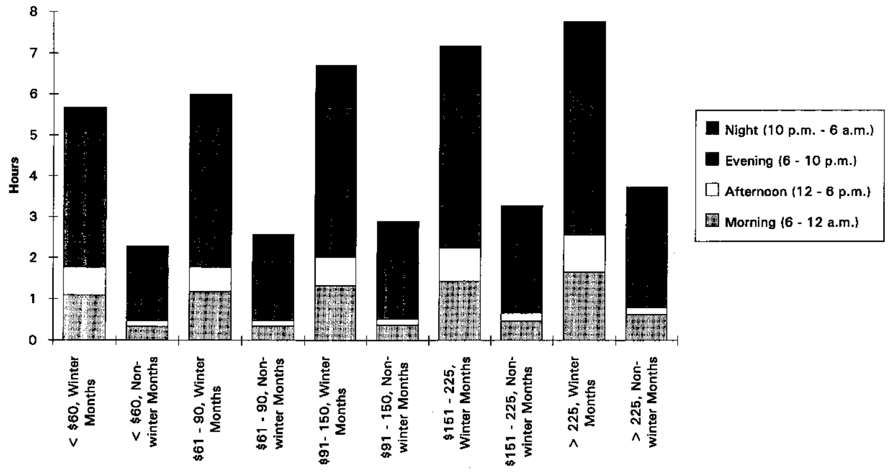

Figure 5.4 Daily Lighting Use of Lithuanian Urban Households by Monthly Income and Season, 1995, 1995
(Source: Arpaillange J. 1995)

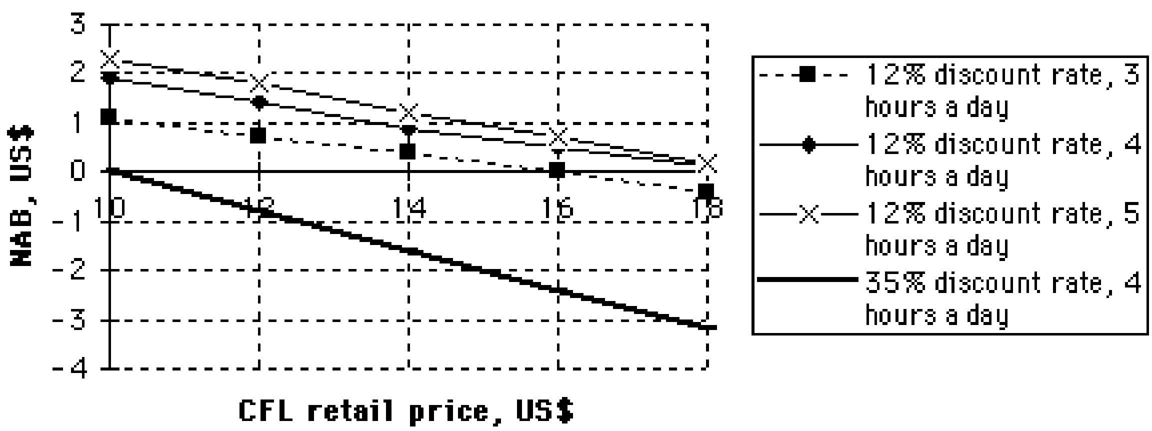

Figure 6.1 The Net Annual Benefit to the Lithuanian Consumer Replacing a 60W Incandescent lamp with a 15W CFL at Different Discount Rates, CFL Prices and Daily Use.

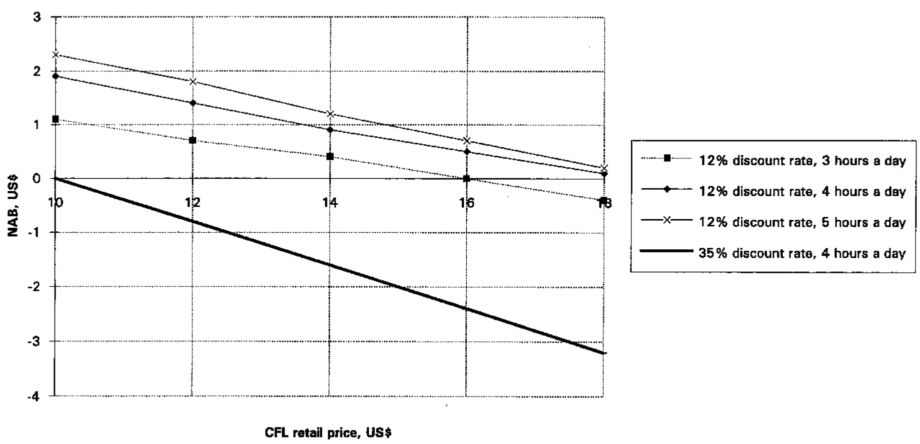

Figure 6.2 The Net Annual Benefit to the Lithuanian Consumer Replacing 1 100W Incandescent Lamp with a 23W CFL at Different Discount Rates, CFL Prices and Daily Use.

marginal cost of generating electricity. The cost of conserved energy is the annualised cost of implementing an efficiency measure, divided by the annual energy savings.

(2) The consumer's cost and benefit depend on the electricity tariffs, prices of CFLs and incandescents, and the consumer's discount rate for future savings. The benefit of a CFL installation for the consumer can be defined by Net Annual Benefit = (value of annually saved electricity) + (avoided annual costs of incandescents) – (annualised costs of CFL).

(3) From the utility's perspective the economics of CFLs can be calculated in two ways. First, the annual benefit to the utility of subsidising the purchase of CFL can be calculated. The Net Annual Benefit = (avoided annual generation expenditure) – (any annualised subsidy offered for CFL) – (loss of annual revenue from decreased electricity sale). An alternative measure of the economic merit of subsidising conservation is the cost of conserved energy (i.e., the cost to the utility of conserving a kWh). So long as this cost is less than the cost of generating a kWh, the utility system should invest to conserve rather than generate electricity for meeting new demand.

The National Perspective

We will calculate costs of conserved energy from the national perspective for two cases: (1) a replacement of the most popular 60 W incandescent by integral 15 W CFL, and (2) a replacement of 100 W incandescent by also integral 23 W CFL.

The CCE values, based on the assumptions described in the end-notes [1] for these two scenarios are:

$0.015/kWh*CCE(15W)=[(0.196*P15($)–$0.45)/73kWh]*$0.036/kWh
and
$0.009/kWh*CCE(23W)=[(0.196*P23($)–$0.45)/125kWh]*$0.021/kWh

where P15($) and P23($) are the wholesale prices of 15 and 23 watt CFLs (ranging from $8 to $16) in Lithuania. These prices are not reliably stable and unique at present owing to market immaturity, hence the CCE values are presented as simple formulae. In comparison, the long run marginal cost of electricity for the energy system of Lithuania is around $0.07/kWh [2]. We can see that from the national perspective the investment into residential CFLs is very beneficial. There are also additional benefits from avoided costs of environmental damage, which were not quantified here. In the case of the modular CFL systems, because of their lower price and the avoidance of premature discarding of the ballast, the CCE is even lower.

The Consumer's Perspective

While the consumer may choose to obtain and value various non-economic benefits from CFL use (e.g. longer life leading to fewer replacements of lamps in hard-to-reach luminaires, increased lighting levels from cheaper-to-operate CFLs, social prestige from display of more expensive lighting sources, etc.), we calculate the costs and benefits to the consumers only from straight replacement with CFL at the same lighting levels.

The consumer's cost and benefit depend on the price of electricity, and any subsidy that the electric utility system may offer towards the purchase of the compact fluorescent lamp. We calculated the net annual benefit for three different discount rates. Lithuanian households can get bank loans with the lowest interest rate of 12% annually. However, actual behaviour and consumer choices display a much higher implicit discount rate (even in wealthy industrial countries) (Gadgil and Jannuzzi 1990, 1991). We use a 35% discount rate in our analysis to understand consumer decisions regarding lighting source choices.

We used the current flat electricity tariff - $0.055/kWh for our calculations. The price of incandescent lamps was assumed to be $0.25. We performed our calculations for different retail CFL prices observed in the Lithuanian residential lighting market - $10, 12, 14, 16, 18. Figure 6.1 shows the net annual benefit to the consumer (for a variety of CFL prices, CFL use per day, and discount rates), for replacing a 60W incandescent with a 15W CFL. Figure 6.2 shows the same calculations for replacing a 100W incandescent with a 23W CFL. Evidently 15W CFLs will be unattractive at the un-subsidized market price at 35% discount rate displayed by consumers (at 4 hour a day use). However, the same CFL, if made available at no first-cost (e.g. via a lease purchase program at 12% interest) is attractive to the customers at the full range of prices observed in the market [3]. Tungsram reports that between 70 and 80% of their CFL sales in Hungary have taken place during the ”promotion” (i.e. sales) (Whol, pers. comm.). The 23W CFL should be attractive to the consumers even at a 35% discount rate.

The Perspective of the Electric Supply System

The Lithuanian power system is fully state owned, although there are some plans for privatisation in the future. On the basis of IC Consult data, we calculated the cost of generation at the capacity factor 0.5 (data for 1996, Baltic News Service 1997) from the Ignalina NPP to be $0.025/kWh. However, in this estimate, the construction costs of the power plant, the costs of the spent nuclear fuel storage facilities, as well as the cost of upcoming safety upgrades to Ignalina NPP are all excluded from calculation (IC Consult et al. 1995, Baltic News Service 1997). We believe that the generation cost of $0.025/kWh contains a large hidden subsidy. Furthermore, owing to the recession, Lithuania has an excess generation capacity for now. This excess capacity will disappear when (1) Ignalina NPP reactors get retired in 2005 and 2010, or (2) Ignalina NPP gets shut down for a lack of safety, or (3) Ignalina NPP power generation is significantly derated for improved safety, or (4) economic expansion catches up with excess capacity, or (5) the Lithuanian government decides to export cheap surplus electricity to Poland and EU. The cost of power from new generation is variously estimated at $0.05/kWh (OECD Nuclear Energy Agency, International Energy Agency 1989). If new generation is needed, Lithuanian electricity tariffs will have to be raised upwards to pay for the higher average cost of generation. Since the CCE of CFLs is about $0.02/kWh and Lithuania has a pumped storage plant for peaking capacity, it would make sense to invest in CFLs to save electricity rather than in new gen-

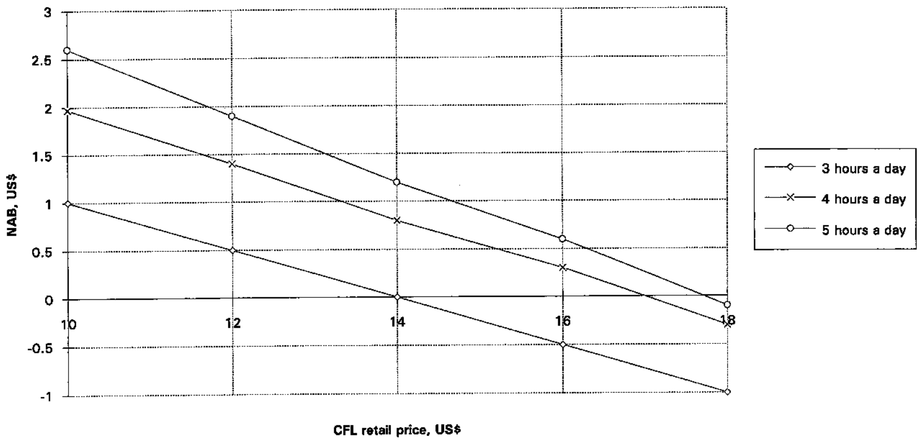

Figure 7.1 The Net Annual Benefit to the Hungarian Consumer Replacing a 60W Incandescent with a 15W CFL at 20% Discount Rage (average bank interest rate in Hungary, 1997).

eration to produce electricity.

If the society could invest $10 million into CFLs in order to replace just one of the most used 60 W incandescent bulbs in each of 811,000 urban households in Lithuania, the Net Present Value of the investment would be $6.5 million, assuming $12 CFL price, 12% discount rate, and $0.25 price of incandescent. If any investor were to invest into 23W CFLs for $12 per lamp to replace 100W incandescent being used for 4 hours a day, and were able to receive 60 per cent of the current value of saved electricity, the net annual profits of the investment would amount to $2.2 million.

If 1.3 million Lithuanian households could replace at least two of the most heavily used 60 W incandescent bulbs operating 4 hours a day by 15 W CFLs, the annual savings in end-use electricity would equal 170 GWh, worth almost $12 million for consumers, at long-run marginal costs. At the generation point the annual savings would be around 190 GWh. Over the 10,000 hour lifetime, the CFLs would save around 1.2 TWh of electricity, worth $84 million at long-run marginal costs.

An alternative implementation scheme for the electricity sector to introduce CFLs massively could be as follows. Invest $10 million to purchase 1 million CFLs which then are offered free of charge to selected households (via a lottery, or low-income criteria). The costs plus interest are recovered through a small increase in tariff. Such an increase would still be substantially smaller than electricity generated by new facilities. The increase in tariff could be tuned so that the 1 million CFLs are offered every 6 years to replace burnt-out ones. This would operate the 1 million CFL-power-plant indefinitely.

POSSIBLE CAUSES FOR LACK OF MARKET SUCCESS OF CFLS IN LITHUANIA

Despite the evident economic benefits of replacing incandescent bulbs with CFLs for households with large monthly electricity consumption, and private entrepreneurs, the current penetration levels of CFLs are almost negligible in the Lithuanian lighting market. In contrast, Hungary, especially Budapest, exhibits up to 30% saturation of CFLs in the residential sector (Kazakevicius 1997). Prices of residential electricity are similar in Lithuania and Hungary (Erno 1997), as well as the prices of CFLs. Income levels in Hungary are higher, but by less than 50%, therefore it seems that the penetration level of CFLs into residential lighting markets of all three countries should be similar on purely economic grounds (see figure 7.1 for Hungary and note its quantitative similarity to figure 6.1 for Lithuania). However, it is not.

Several possible causes may be responsible for the slow pace of CFL introduction in Lithuania. In Hungary as well as in Lithuania, there is negligible practical support for CFL market penetration from any governmental agency or from any electric utility. There are two major differences between Lithuanian and Hungarian situations that appear to explain the differences in the residential CFL saturation. (1) Hungary, in contrast to Lithuania, displays a strong fascination with new technologies and innovation. This leads to quicker adoption and penetration of new technologies such as CFLs. (2) Tungsram, the Hungarian lighting manufacturer, has invested a lot of efforts in education and advertising regarding CFLs over the last 10 years (Wohl, pers. comm.). An opened up CFL market has then attracted Philips and Osram to push CFLs further and also contained costs through competition. No such awareness regarding CFLs exists in Lithuania. In fact 94% of Lithuanian urban households consider electricity expensive, and 82% agree that saving energy will reduce their energy bills, nevertheless 60% of households do not know how to save energy and 69% do not even know where to get advice on saving energy (Arpaillange J. 1995).

FUTURE RESEARCH DIRECTIONS

Surveys (Arpaillange J. 1995) give some ideas about average use of incandescent and fluorescent lighting among urban households of different income groups, but data on the most used sockets, where the installation of CFLs is the most cost-effective, are missing. It is also unclear how familiar Lithuanian households are with CFLs, and if they have any misconceptions or prejudices toward fluorescent lamps. Such information could be obtained through household surveys in both urban and rural areas.

A more complete picture of Lithuanian lighting market is also missing, including data on sales by different technology, price range of the main lighting technologies, lighting market trends and future development. This makes it difficult to perform precise economic analysis taking into account prevailing lighting technologies and real prices. Such information could be collected by surveying local lighting equipment dealers, and by interviewing importers and representatives of major manufacturers of lighting appliances.

CONCLUSIONS

Compact fluorescent lamps offer an opportunity to conserve energy without decreasing energy services. Lack of information and the initial high costs will be significant barriers to initial purchase of CFLs by Lithuanian residential consumers. State ownership and very limited financial autonomy of the regional electric utilities restrict their ability to participate in lighting efficiency programs.

The costs of conserved energy of 15 and 23 watt CFLs vary from $0.009 to 0.036 per kWh depending on CFL price and daily lamp use. The replacement of the two most used incandescents in each Lithuanian household would save around 1.2 TWh of electricity, worth $84 million over the lifetime of CFLs.

Future success of CFL penetration in Lithuania will depend on an aggressive information and promotion effort by at least the CFL manufacturers, or by any of the stakeholder institutions (e.g. the state agencies responsible for energy and environment, electric utilities, etc.). In addition, financing (lease) schemes and rebates would certainly help transform the Lithuanian residential lighting market.

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ENDNOTES

1) Discount rate of 8% per year (equal to the average loan interest from multilateral agencies), (2) daily lamp use of 4 hours per day, (3) electricity transmission and distribution losses of 11%, (4) price of 60 and 100 watt incandescents of $ 0.25, (5) burning life of 10,000 hours for CFLs, and 800 hours for incandescents.

2) There are no elaborated plans for the new capacity construction in Lithuania, nevertheless the typical projected costs of generated electricity for Denmark and Netherlands in the case of gas turbine power plant range from US $0.051/kWh to $0.053/kWh (OECD Nuclear Energy Agency, International Energy Agency, 1989). It is likely that Lithuanian gas turbine plant will have similar generation costs. We assume distribution and transmission costs in Lithuania to be $ 0.02/kWh , so that the long run marginal costs (LRMC) should be around $ 0.07/kWh.

3) It is not known if consumer behaviour displays a high-discount rate even for lease purchase of energy efficient equipment for which there is no cash outflow. We assume that under such conditions consumers will not display a high discount rate.