ENSURING MARKET SUPPLY AND PENETRATION OF EFFICIENT LIGHTING TECHNOLOGIES

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Abstract

Lighting is one of the major uses of electricity and a significant share of residential and particularly commercial electricity demand is concentrated in this end-use category. State-of-the-art lighting systems provide a means to increase efficiency and to reduce energy demand. However, there are substantial market barriers that hamper the accelerated market penetration of these technologies. In recognising these market realities, electric utilities and government agencies in several IEA Member countries have begun to focus their efforts on demand-side oriented activities. Some of these activities, such as light bulb giveaways, audits, education, installations, standards promulgation, and other programmes, can have significant results in overcoming barriers to customer implementation of efficient lighting technologies. For example, in the United States the shipment of compact fluorescent lamps has almost doubled between 1988 and 1990 and is forecast to increase about 280% between 1991 and 1995. Yet these campaigns can also result in temporary supply shortages, as appliance manufacturers or retailers cannot meet the demand resulting from such initiatives. These supply shortages can impede the successful implementation of demand-side management (DSM) programmes. Improved market information is needed to increase the use of efficient lighting technologies by enhancing cooperation between utilities, manufacturers, and customers.

INTRODUCTION

For the last two decades electricity has been the fastest growing form of final energy. But in recent years there has been rising concern in International Energy Agency (IEA) Member countries about how to meet increasing requirements for new generating capacity while minimising the environmental impacts and other indirect costs associated with electricity supply. Environmental impacts of energy production and use have become an integral concern of energy policy planners. In recognising these concerns, and for other economic reasons such as energy security, governments and utilities in OECD[2] countries have increasingly become involved in campaigns to promote the efficiency of electricity end-use.

In this regard, measures to improve the efficiency of electric lighting are advocated as a cost-effective means to reduce the growth of electricity demand. North American utilities have the most experience to date in initiatives to increase the efficiency of lighting in the residential or commercial sector, but several other IEA Member countries, particularly in northern Europe, have begun similar programmes.[3] While their impact on electricity demand and their economic consequences still need to be comprehensively evaluated, the magnitude of the programmes launched suggests larger achievements in the future, not only in North America, but also in other IEA countries.

Demand Side Management (DSM) programmes help to overcome several barriers to the accelerated market penetration of efficient lighting and to reduce electricity demand relative to demand without such activities. However, these promotional programmes have also resulted in unexpected side-effects and new barriers to their efficient implementation. For several initiatives, supply shortages of energy-efficient products have become apparent. This has primarily been the case for compact fluorescent bulbs (CFLs) and electronic ballasts. In some cases, wholesalers, retailers, and appliance manufacturers could not meet the unexpected demand for efficient technologies that had been induced by utility programmes.

Uncoordinated initiatives can lead to results below expectations, to miscalculation of the load and demand impacts, and last but not least, to loss of consumer confidence, which is a pivotal resource for the successful implementation of DSM initiatives. It is therefore crucial for all parties concerned to avoid such shortages: for utilities, who want to maintain successful consumer and regulatory relations, for manufacturers and distributors, who want to increase their sales, and for consumers who want to receive the full benefits of such initiatives. Market surveys help to alleviate such supply shortages. Careful analysis of utility initiatives could provide manufacturers, wholesalers, and retailers with necessary market information, such as the types and volumes of technologies required and the programme duration. The overlap of similar activities by a number of electric utilities can also create supply shortages.[4] This paper presents market surveys which have been undertaken in the United States and discusses their feasibility and potential usefulness for utilities and manufacturers. This evaluation considers efficiency trends, the realistic energy-saving potential of the main end-uses, and an assessment of market barriers.

EFFICIENCY TRENDS AND SAVINGS POTENTIAL

Lighting accounts for a substantial share of electricity demand in the IEA. In 1986 almost 17% of electricity use was for lighting. It was the second largest single end-use category after electric motors directly used in industry, which accounted for 27%.[5] As far as the total final energy consumption (TFC) of the OECD is concerned, lighting required about 2.6%. Lighting in commercial premises had the largest share, 1.5%, and industry and residential applications required approximately 0.6% of TFC.

Although these shares seem to be minor contributors to the total energy demand, some important characteristics should be considered:

* The use of electricity is still growing in all end-use sectors but particularly for commercial buildings;
* Cost-effective options for further efficiency improvements are readily available;
* There are various market barriers which result in only a minor portion of cost-effective technical potential being achieved by the market, making policy actions and utility initiatives necessary, especially in the residential sector;
* Although "only" about 2.7% of TFC is used for lighting, the primary energy input for electricity generation is significantly higher.

Residential Sector

Currently, the most widely used lighting technology in the residential sector is low-efficiency incandescent bulbs. For example, in Norway and the United Kingdom light is provided by low-efficiency bulbs in about 95% and 98% of sockets respectively, and similar figures are found in other OECD countries. However, fluorescent lamps and compact fluorescent lamps (CFLs) are substantially more efficient than incandescent lamps. CFLs usually do not require any major changes in the lighting fixture, as the necessary ballast is already included in modern-type CFLs. Because they are so convenient to install, CFLs are the main competitor to incandescent lamps in the residential market.[6]

The total technical potential for residential lighting efficiency improvements in the United States is estimated to be 51 to 74% in the year 2000.[7] (This figure, and the technical potential figures quoted below for the commercial and industrial sectors, are based on all technically possible efficiency improvements and do not consider whether or not the technology is cost-effective.) For example, the CFL replacement for a 100 W incandescent bulb has a power consumption of about 20-25 W, and the CFL replacement for a 60 W bulb consumes 13-16 W. This represents a theoretical savings potential in the range of 60-80% as CFLs are four to five times more efficient. To date, fluorescent bulbs have achieved little success in the residential market. Table 1 provides efficacy data for lighting in several countries.

Table 1: Efficacy of Lighting Technologies (lumens/watt) (1988)

	Existing Stock			Average Sold			Best Available		
Country	Incandescent	Fluorescent	CFL	Incandescent	Fluorescent	CFL	Incandescent	Fluorescent	CFL
Austria	10	100	50-80	--	--	--	--	--	--
Italy	11.5	50	60	12.8	77	53	--	--	--
Norway	10	80	82	10	80	82	10	80	82
United Kingdom	9-19	35-72	35-60	12	40	50	19	70	55
United States	15	78	45	15	63	45	16.5	100	60

Source: Ref. 8.

The major drawback for the accelerated market penetration of CFLs is their high initial costs, combined with information barriers regarding their economic payback. While pricing varies widely, the purchase price of a CFL is typically 15 to 20 times higher than for a conventional incandescent bulb, although a CFL's lifetime (8 000 to 10 000 hours) is notably longer than that of an incandescent (about 1 000 hours).

Commercial Sector

Electricity use for lighting accounts for approximately 40% of the OECD's commercial and public sector electricity needs. Unlike the residential buildings sector, fluorescent lighting technologies are the dominant lighting system in the commercial and public sector, with market shares ranging from 59% in Italy, up to about 90% in Norway, as shown in Table 2. The rest of the market is covered by incandescent and high-intensity systems.

The total technical potential for commercial lighting efficiency improvements in the United States is estimated to be 22 to 56% in the year 2000.[9] Substantial improvements can be made either by replacing incandescent bulbs with CFLs or by using electronic ballasts and higher-efficiency fluorescent lamps. Major savings can also be obtained by better lighting system design, more efficient reflectors, light-level dimming according to function or daylight availability, using natural light through better building design, and controls that turn off lights when they are not needed.[10] Improved efficiency or reduced artificial lighting levels also reduce the amount of heat added to air-conditioned buildings. Unfortunately, because energy usually represents a small share of total business costs, existing lighting systems are only likely to be replaced when major building modifications are undertaken.

Table 2: Estimates of Electricity End-Use for Lighting in Commercial Sector

	Total Lighting Demand (TWh)	Percent Incandescent	Percent Fluorescent	Percent High Intensity	Percent Other
Canada	n.a.	29	71	0	0
Ireland (1988)	--	5	90	3	2
Italy (1986)	n.a.	25	50	25	0
Norway (1988)	3.57	8	89	1	2
Sweden (1985)	6.3	18	79	3	0
United States (1988)	220	14	75	5	6
United Kingdom	23.1	45	55	0	0

Source: op cit, Ref. 8.

Industry

The share of electricity consumption for lighting for industrial facilities is usually well below 10% of total industrial electricity consumption.[11] A study covering member countries of the European Community analyzed the structure of industrial lighting.[12] The main systems were fluorescent lamps which account for about 75% of electricity consumption for lighting. About 15% is required by high-pressure lamps and about 10% by incandescent lamps. The replacement of old fluorescent systems by state-of-the-art lighting technologies that include efficient electronic ballasts could lead to savings of up to 35%. The total technical potential for industrial lighting efficiency improvements in the United States is estimated to be 17 - 33%.[13]

Summary of Possible Efficiency Improvements

Total technical potential for lighting efficiency improvement in the United States and in Europe is estimated to be 30-60% in the year 2000, depending on end-use sector. These measures are among the least expensive options available to save electric energy. The efforts of European utilities (mainly in northern Europe), have focused on measures to increase market penetration of CFLs for residential consumers, while North American government and utility programmes have emphasised improvements in commercial lighting systems. These programmes have applied several different measures, including energy audits, promotional campaigns, such as CFL give-away programmes, or loans for retrofitting of residential or commercial and public buildings. The gap between available technologies and current efficiency levels is beginning to narrow. However, such initiatives have in some cases created new barriers, as wholesalers, retailers and manufacturers of ballasts and especially of CFLs cannot meet the demand induced by utility DSM initiatives.

MARKET BARRIERS AND SUPPLY SHORTAGES

One of the first measures likely to accelerate the market penetration of efficient lighting systems is the removal of market distortions and institutional barriers which still hinder the efficient use of energy. In the second half of this paper, we focus on barriers in the residential and commercial sectors. There are many examples of such market imperfections which reduce the incentive for consumers to invest in efficiency. In addition, there are barriers which are a result of the technological characteristics of efficient lighting systems or of imperfect market information available to consumers, utilities, manufacturers, and distributors.

Barriers Affecting Consumers

In both the residential and commercial sectors, the lack of information and capital, the reluctance to adopt unfamiliar technologies, and only moderate interest in energy costs and in reducing energy expenses all combine to hamper the widespread introduction of energy-efficient technologies. Individual consumers often do not have access to information on financing investments in general and on energy efficiency expenditure in particular. They make decisions to meet day-to-day requirements, and energy efficiency is usually not an important criterion for purchase decisions. Such behaviour, together with limited access to capital, means that a consumer's implicit discount rate is well above those usually applied in business; 35% is probably a minimum and in some cases, i.e. low income households, it can exceed 200%.

The appearance of the lamp and the quality of its light output are examples of other criteria which may affect consumer purchasing. For instance, the consumer may believe that the new bulbs do not produce the "usual" light or that the colours are distorted. Because CFLs which incorporate the ballast are heavier and larger than incandescent bulbs, they may not be suitable in some existing fixtures.

The relatively higher initial costs of advanced lighting technologies also pose barriers to their widespread use. In the U.S.A., CFLs cost $12-18 (10-15 ECU[15]), while incandescent lamps cost only about $1.00 (0.83 ECU). For residential customers, lamps operating slightly over five hours per day (2 000 hours per year) typically have payback around two years, while for commercial customers operating 3 500 to 4 000 hours per year, the investment often is returned in less than a year. The required hours-of-use to be cost-effective ultimately limits the achievable saving potential, particularly in the residential market.

Utility incentives, such as give-away or rebate programmes, can result in substantial impacts on initial costs. Increased sales induced by such programmes may result in noticeable cost degression. For example, in Denmark it has been found that between 1986 and 1990 the costs for CFLs have been more than halved. This was significantly influenced by the initiatives of Danish utilities, without which the sales of CFLs would have remained at low levels as prior to 1988.[14] The price for CFLs has decreased from about DKr 300 (39 ECU[16]) in 1987 to DKr 125 (16 ECU) in 1991, a price level which is lower than in neighbouring countries that have less experience in DSM. Prior to 1988 there were no substantial sales of CFLs, but cost degression and technical developments such as longer lifetimes and greater flexibility in use make their purchase increasingly more attractive. As a result, the availability of CFLs has been increased so that they can now be found on supermarket shelves.

Barriers Affecting Suppliers and Utilities

The limited sales to date of CFLs, primarily due to the high initial costs, have led manufacturers and retailers to put less emphasis on the successful marketing of this technology. When retailers see little demand for a product, they become reluctant to put much effort into promoting it. Usually, CFLs are only available in specially equipped stores, or are displayed in areas that do not catch the consumer's eye.

There are also some technical problems related to the product performance. For instance, there is concern that widespread use of CFLs and electronic ballasts could cause harmonic distortions in the electric grid.[17] In some cases, such perturbations can have potentially negative effects on the performance of some types of office equipment or otherwise reduce the quality of the electricity service. Utilities and customers must understand the effects of harmonics and other power quality issues if these technologies are to gain substantial market shares in the residential and commercial sectors. Accurate test data, reliable technical information, and performance guidelines would clearly help to resolve these problems.

Supply Shortages

The use of high-efficiency lighting technologies in some IEA regions, such as in North America and northern Europe, is increasingly due to regulatory requirements, the rapid increase of utility activities, and U.S. government-sponsored programmes such as the Environmental Protection Agency's (EPA) "Green Lights" and the Department of Energy's (DOE) Federal Relighting Initiative. The resulting increase in the demand for advanced lighting products has created backlogs for some of these products such as CFLs and electronic ballasts. However, an adequate market supply is an indispensable prerequisite for proper functioning of programmes. For example, an evaluation of recent activities in Sweden revealed that the initial programme objectives were not achieved due to inability to meet the unexpected demand.[18] The penetration rates of four different programmes that were analyzed were unexpectedly low, particularly for smaller modern CFLs that are more tailored to consumer quality requirements. After approximately two weeks of programme duration, retailers and wholesalers were not able to meet the demand. The distributors were not experienced with lighting programmes and had obviously underestimated their possible sales. In Denmark, for instance, supply shortages for CFLs obliged a regional utility (SEAS) to delay the start of its give-away programme for nine months. The manufacturers could not deliver earlier, as otherwise the European market would have been drained of the requested types of efficient lamps.

The substantial increase in sales of efficient technologies requires changes in the production lines of the lighting manufacturers. To switch from the production of incandescent bulbs to CFLs would typically take two years. Industries must be ready to invest in new production facilities. Some manufacturing industries see the supply shortages that have occurred in several northern European countries, such as in Denmark or in Sweden, as short-term problems. They believe that once new production lines have been established these problems will be overcome. The European experience has demonstrated that short-term shortages have been particularly common for CFLs which can easily replace incandescent bulbs without requiring changes to the fixture.[19,20]

This situation illustrates the need for better information on the demand and supply of lighting products and for the close cooperation between utilities, government, manufacturers, and distributors. Perfect market information is an important part of efficient market supply. Consumers should be provided with reliable information about initial costs, possible cost savings, and technical characteristics, such as quality of light or the expected lifetime. On the other side, retailers, wholesalers, and CFL manufacturers should have appropriate information to assess likely market trends. It is in the interest of both the utilities and the suppliers to avoid market distortions which may happen in the course of DSM-programmes.

Experience in the United States as well as in Europe has shown that a key concern of the DSM stimulators is that product manufacturers may not be able to supply the products and therefore could become a major barrier to meeting the programme goals. On the other hand, manufacturers are concerned that without information on the magnitude and duration of the DSM stimulation efforts they cannot plan for and justify major product capacity expansion.

MARKETPLACE SUPPLY AND DEMAND SURVEYS

A study by the Electric Power Research Institute (EPRI), the California Institute for Energy Efficiency (CIEE), U. S. DOE, and EPA was developed to address these issues. The study, "Survey and Forecast of Marketplace Supply and Demand for Energy-Efficient Lighting Products," shows a significant increase in utility DSM incentives for the use of CFLs and electronic ballasts.[21] The objectives of the study are to develop a five-year demand and supply forecast for energy-efficient lighting products and to establish a process to update this information and communicate it to the industry. The project is being conducted in two phases. In the first phase, a limited number of utilities and manufacturers were surveyed to obtain data and insights on the key issues. The results of this phase are presented in this paper. The second phase, to be completed by the end of 1991, will expand the survey efforts and information database, and also develop technology transfer plans.

Such surveys are in the mutual interest of all parties concerned. Utilities can coordinate their activities with other participating companies or with distributors and manufacturers, and the suppliers of technologies can accommodate their production plans to provide an appropriately supplied market. Moreover, manufacturers are partially collecting the benefits of utility activities, as they help to substantially increase product turnover and reduce often costly product advertisement. An appropriately supplied market also benefits utilities and their promotional campaigns because programme failures and reduced consumer confidence can be avoided.

Utility DSM Activities

The first phase of the EPRI, CIEE, DOE, and EPA project has reviewed existing utility lighting programmes in the United States and has selected 27 sample utilities that represent the largest and most mature programmes. The sample utilities represent approximately 25% of U.S. annual kWh sales and 25% of the utilities offering lighting incentives. These utilities estimated their lighting incentives expenditures at $113 million (94 million ECU) in 1990, increasing by 64% to $185 million (154 million ECU) in 1991, and further to $239 million (198 million ECU) in 1994. Using these new data and reviewing the data from other sources, three extrapolated cases were developed to estimate and forecast the total U.S. utility incentives.

Table 3 shows the low, medium, and high forecasts thus developed for 1990 to 1994. The medium case predicts a 230% increase in utility lighting incentive programmes from $165 million (137 million ECU) in 1990 to $547 million (454 million ECU) in 1994. These figures are only for incentive payments, which typically represent

70% of total programme costs, so overall lighting DSM costs in the 1991 medium case would be about $385 million (320 million ECU). To put these expenditures in perspective, the total U.S. DSM expenditures are estimated by EPRI to be roughly one billion dollars (830 million ECU) in 1991. Thus, lighting incentives represent about 39% of total U.S. utility DSM expenditures.

Table 3: United States Forecasts Utility Incentives for Efficient Lighting (1000s of Dollars by Forecast Year)

	1990	1991	1992	1993	1994
Low	$141 194	$231 591	$242 706	$278 821	$298 163
Medium	$164 726	$270 190	$315 518	$418 232	$546 631
High	$188 258	$308 788	$388 330	$557 643	$795 100

Source: op cit, Ref. 21.

A survey of European lighting incentive programmes in six countries (Austria, Denmark, Italy, the Netherlands, Sweden, and Germany) has found that such programmes have opened up and accelerated the market for energy-efficient CFLs. Table 4 illustrates, for five countries, the shipment of lamps and the penetration rate (lamps per household). The programmes resulted in the introduction of 2 million CFLs throughout Europe, for an average of 0.35 lamps per eligible household. These initiatives had a substantial impact on the sales of CFLs. For instance, in Denmark, the Netherlands, and Sweden, between 1987 and 1990, the period that has seen most of the incentive campaigns, the sales increased by five to six times. The programmes were very cost-effective, with a societal cost of conserved energy of 2.1¢/kWh (0.02 ECU), including all administrative and advertising costs.[22]

Table 4 : Survey of European Incentive Programmes

Country	Lamps received due to program	Penetration (Lamps/eligible household)
Austria	108 000	0.06
Denmark	558 209	0.53
Germany	104 200	0.08
Netherlands	1 173 375	0.37
Sweden	217 062	0.39

Source: op cit, Ref. 3.

Fluorescent Lamp Supply Survey in the United States

Seven manufacturing companies were surveyed, representing more than 95% of the fluorescent lamp supply to the U.S. market. In addition to providing product data, the manufacturers expressed a critical need for DSM forecasts. They wanted information, as specific as possible, on the unit volumes and types of lamp products needed, as well as the total incentive dollars available. They also consistently recommended stronger two-way partnerships with distributors and lighting trade allies.

As illustrated in Table 5, the survey projected a significant increase of T-8 (25) lamps from 2 million lamps in 1988--about 1% of the total market for 17 to 40 W rapid-start lamps--to about 66 million lamps or 20% in 1995. This represents a major increase in the use of T-8 lamps.

Table 5: United States Shipments of 17 to 40 Watt Rapid Start Lamps--History and Projection (millions)

17 to 40 Watt Rapid Start	1988	1989	1990	1991	1992	1993	1994	1995
T-12	230	235	236	243	244	247	252	257
T-8	2	3	6	10	22	33	48	66
Total	232	238	242	253	266	280	300	323
T-8 % of total	1%	1%	3%	4%	8%	12%	16%	20%

Source: op cit, Ref. 21.

Table 6 shows the estimated growth of CFLs. The shipment of CFLs grew by over 70% from 10 million in 1988 to almost 17 million in 1990. This dramatic growth is projected to continue from 1991 shipments of 25 million units to 1995 shipments of 72 million units. The survey indicated that quad-tube lamp CFLs will increase from about 10% of CFL lamps shipped in 1989 to over 50% by 1995. This survey and other studies indicate a supply problem in providing CFLs which may continue into 1992 or 1993.

Table 6: United States Shipments of Compact Fluorescent Lamps--History and Projection (millions)

	1988	1989	1990	1991	1992	1993	1994	1995
Total CFLs	9.8	11.6	16.7	25.2	35.6	47.0	58.8	71.8

Source: op cit, Ref. 21.

Electronic Ballast Supply Survey in the United States

Ten ballast companies were surveyed, representing over 85% of the U.S. market supply of power-factor-corrected ballasts. These companies also expressed the need for information on DSM incentives and for closer cooperation with utilities on DSM issues. Tables 7 and 8 show the significant rise estimated for the use of electronic ballasts. In 1988, 1.2 million electronic ballasts or 2% of total power-factor-corrected ballasts were shipped. By 1990, 3.0 million electronic ballasts or 5% of the total were shipped. The projections show an increase to 27 million electronic ballasts by 1995 or 40% of the market. The survey also projects that electronic ballasts with dimming control could grow from less than 5% of the electronic ballast market or 200 000 units shipped in 1991, to 30% or 7.5 million units by 1995.

Table 7: Estimated United States Shipments of Power-Factor Corrected Ballasts (thousands)

Ballast Type	1988	1989	1990
Magnetic	56 280	58 070	55 675
Electronic	1 220	1 550	3 070
Total	57 500	59 600	58 745
Electronic % of Total	2.1%	2.6%	5.2%

Source: op cit, Ref. 21.

Table 9 shows the forecast of the ballast industry's ability to meet the market demand for electronic ballasts, expressed as capability (in percent) to ship the units expected to be needed. The range of percentages represents the upper and lower consensus inputs from the respondents. As shown, electronic ballast manufacturers' capability to meet the demand ranges from 60 to 90% for 1991, and from 85 to 100% for 1992. By 1993 the industry projects excess capacity to supply the market for electronic ballasts. It is important to remember that these capability estimates are very sensitive to the forecast market demand and the estimated industry capacity and depend on the basic assumptions.

Table 8: United States Forecast Market Demand for Power-Factor Corrected Ballasts (thousands)

Ballast Type	1991	1992	1993	1994	1995
Magnetic	53 000	53 700	53 200	48 500	43 100
Electronic	6 390	9 100	13 900	19 100	27 980
Total	59 390	62 800	67 200	67 610	71 080
Electronic % of Total	10.8%	14.5%	20.1%	28.3%	39.4%

Source: op cit, Ref. 21.

Table 9: Forecast of the United States Ballast Industry's Ability to Meet Demand(capability of the industry to ship the number of units forecasted)

Electronic Ballasts	1991	1992	1993	1994	1995
Capability in percent	60-90	85-100	100+	100+	100+

Source: op cit, Ref. 21.

CONCLUSION

Recent experience in North America and Europe has demonstrated that DSM activities have increased substantially over the last few years and will increase 100% in the United States and even more in Europe. These rapid increases can result in temporary shortages of some efficient lighting products. For example, programmes that have focused on the substitution of CFLs for incandescents in residential and commercial applications have resulted in shortages of CFLs. Given current estimates, this shortage is likely to last for at least 18-24 months.

Commercial DSM activities in the United States have also created a rapid growth in the use of electronic ballasts, resulting in a supply shortage for electronic ballasts that will last 6 to 18 months.

Shortages in high-efficiency lighting products create a significant new barrier with the potential to limit the success of DSM activities. Utilities and other DSM stimulators can help avoid these shortages by providing better information to manufacturers on upcoming DSM programmes. The DSM information needs to be as detailed as possible and provide an historic database and accurate forecasts for use in planning the supply of energy-efficient lighting products. This type of database and market information would help remove some of the uncertainty from forecasts of lighting product demand and DSM programmes. Manufacturers and distributors need to participate in this process and work closely with the utilities and others to avoid future shortages.

Surveys to forecast supply and demand can best be performed by those actors who benefit from an accurate market supply. While the EPRI, CIEE, DOE, and EPA study is a first step in providing important information on the U.S. market, no such study has to date been performed in Europe. These surveys could be performed by utilities or their orgnaisations, such as UNIPEDE in Europe, by government agencies, and/or by appliance manufacturers, either independently or jointly.

Improved data and forecasts on marketplace demand and supply of efficient lighting products can help avoid future product shortages. Improved cooperation of utilities, governments, and manufacturers is needed to accelerate and maximise the penetration of advanced lighting technologies into the marketplace. These lighting efficiency improvements can have significant benefits in the form of reduced energy costs and environmental impacts, and increased energy security and economic well-being in the IEA countries.

REFERENCES AND NOTES

[1] The opinions expressed in this paper are those of the authors and do not necessarily reflect the views of the Electric Power Research Institute and its members, or of the International Energy Agency and its Member countries.

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