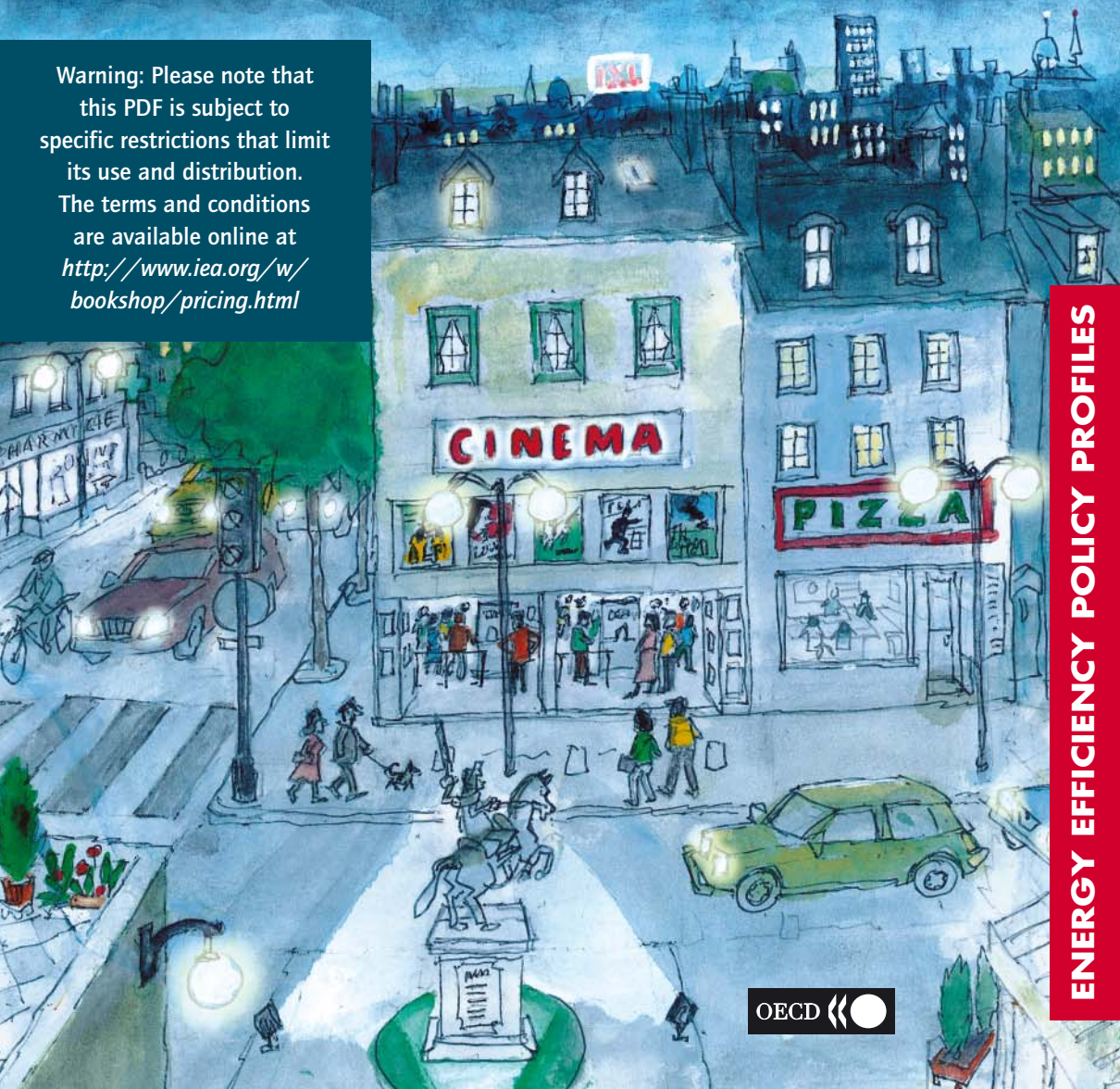
INTERNATIONAL ENERGY AGENCY

LIGHT'S LABOUR'S LOST

Policies for Energy-efficient Lighting

In support of the G8 Plan of Action



ENERGY EFFICIENCY POLICY PROFILES

EXECUTIVE SUMMARY

A GLOBAL VIEW

When William Shakespeare wrote *Love's Labour's Lost* he would have used light from tallow candles at a cost (today) of GBP 12 000 for a measure of light.[1] The same amount of light from electric lamps now costs GBP 2, while the supply of artificial light in the country of Shakespeare's birth has increased 350 000 times! In both historic and economic terms, human civilisation revolves around artificial light. As the first service offered by electric utilities, lighting ranks among the end-uses dominating global power demand. Worldwide, grid-based electric lighting consumes 19% of total global electricity production, slightly more electricity than used by the nations of OECD Europe for all purposes. Lighting requires as much electricity as is produced by all gas-fired generation and 15% more than produced by either hydro or nuclear power. The annual cost of this service including energy, lighting equipment and labour is USD 360 billion, which is roughly 1% of global GDP. Electricity accounts for some two-thirds of this.

The energy consumed to supply lighting entails greenhouse gas emissions of an equally impressive scale: 1 900 Mt of CO_2 per year, equivalent to 70% of the emissions from the world's light passenger vehicles. Nor do all of these emissions result from electricity generation. Fuel-based lighting, used both in vehicles and areas beyond the range of electricity grids, amplifies these consumption figures and lighting's secondary effects on public health and the environment. At present, 1.6 billion people live without access to electric light, a greater number than when Thomas Edison commercialised the incandescent light bulb in the 1880s. The paraffin- and diesel-fuelled lighting they use is much less efficient than even the most inefficient incandescent lamp, is a large emitter of CO_2 and is very costly. These combined uses provide only 1% of global lighting but are responsible for 20% of lighting CO_2 emissions. In an era of tight oil markets they consume 3% of world oil supply – more than the total output of Kuwait.

1. One megalumen-hour.

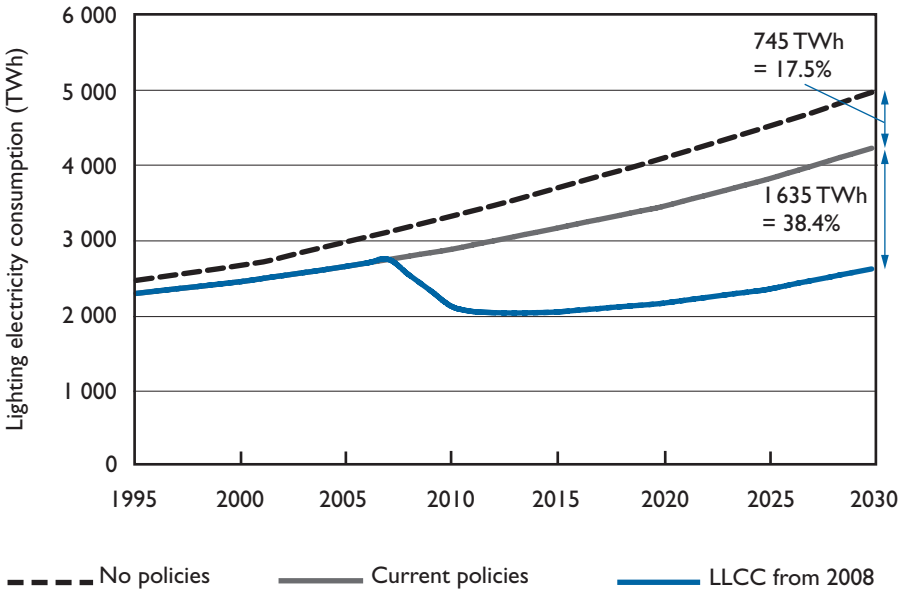
The rate at which humanity has managed to increase its use of artificial light is both striking and sobering. In the span of 200 years, the typical (English) person's annual consumption of artificial light has increased by a factor of 12 000, from 5 kilolumen-hours at the beginning of the 19th century to 60 megalumen-hours today, although no higher share of disposable income is being spent on it. Global in scale yet by no means homogeneous, the demand for artificial light is far from being saturated. While an average North American consumes 101 megalumen-hours each year the average inhabitant of India uses only 3 megalumen-hours. With current economic and energy-efficiency trends, it is projected that global demand for artificial light will be 80% higher by 2030 and still unevenly distributed. If this comes to pass and the rate of improvement of lighting technologies does not increase, global lighting electricity demand will reach 4 250 TWh: almost twice the output of all modern nuclear power plants. Furthermore, without further energy-efficiency policy measures, lighting-related annual CO_2 emissions will rise to almost 3 gigatonnes by 2030.

SOURCES OF WASTE

This energy- and carbon-intensive future need not become a reality. Simply by making better use of today's cost-effective efficient-lighting technologies and techniques, global lighting energy demand need be no higher in 2030 than it is now. In the current lighting environment there are enormous sources of waste. Light is routinely supplied to spaces where no one is present. Over-lighting occurs even though visual functions are insensitive to light levels beyond certain thresholds. There are vast differences in the efficiency of competing lighting sources and in the way lighting systems are designed to deliver light to where it is needed. Moreover, the advent of powerful and affordable artificial lighting has allowed poor architecture to prosper. Uninspired building design has taken us into dark boxes where the largest, cleanest and highest-quality source of light – daylight – often cannot reach.

Each of these areas holds major potential to reduce lighting energy needs without compromising lighting service, and the technologies to do so are widely available today. The IEA estimates that were end-users to install only efficient lamps, ballasts and controls that will save them money over the life cycle of the lighting service, global lighting electricity demand in

Figure ES.1 Global lighting electricity consumption in 1995–2030 under the No Policies, Current Policies and LLCC from 2008 scenarios*



* These scenarios are explained in Chapter 6 of the main text and also in the Extended Summary. The Current Policies scenario is the lighting component of the Reference Scenario in the IEA's *2004 World Energy Outlook* (OECD/IEA, 2004).
Abbreviation: LLCC = Least Life-Cycle Cost.

2030 would be just 2 618 TWh. This is almost unchanged from 2005 and would actually be lower between 2010 and 2030 (see the LLCC from 2008 scenario in Figure ES.1).

In the intervening years, staggering cumulative savings of almost 28 000 TWh of final electricity and over 16 000 Mt of CO_2 emissions would be made beyond what is expected with the continuation of current policies. Moreover, these savings are realised just by making good use of today's routinely available efficient-lighting technologies. Nor are these technologies expensive when the operating costs are also considered, because they save far more money in avoided energy bills than they cost. Using these life cycle cost optimised lighting choices would save end-users

cumulative net costs worth USD 2.6 trillion to 2030. As the efficient-lighting technologies are more cost-effective than the standard technologies, the net cost of CO_2 abatement is negative. Cutting CO_2 emissions through cost-optimised lighting technologies saves end-users USD 161 of expenditure for each tonne of CO_2 avoided. However, achieving these gains will require strong additional action by governments as current market conditions are far from these energy- and cost-optimised circumstances.

SO WHY DOESN'T EFFICIENT LIGHTING HAPPEN BY ITSELF?

If efficient lighting is so economical, why does the market not deliver it automatically? The explanation can be found in a number of barriers that limit deployment of cost-effective lighting technologies. End-users and market actors are often unaware of the savings potentials and lighting-quality advantages and without information are inclined to use the technologies that they have always used. Some efficient lighting has higher initial costs and thus users are less likely to invest in it unless they are aware of the future savings. Most lighting is not installed and directly paid for by the end-user, thus different cost incentives exist for installers and users. Furthermore, most public and private organisations manage their equipment and operations budget separately and thereby create an incentive to minimise equipment costs at the possible consequence of higher operating costs. These and similar obstacles all slow the rate at which markets learn about and adopt cost-effective choices.

Policy makers in many countries have long understood these difficulties and have been implementing measures to encourage more efficient lighting since the 1970s. Moreover, these measures have resulted in impressive returns. In cumulative terms the policies implemented since 1990 saved almost 8% (2 960 TWh) of cumulative lighting electricity consumption to 2005 and 1 670 Mt of CO_2 emissions; they are also forecast to save another 14 500 TWh and 8 500 Mt of CO_2 (17% of the total) from 2006 to 2030 without being strengthened. In addition they have been remarkably cost-effective in avoiding net costs of USD 253 billion by 2005 and are on course to save USD 1.5 trillion by 2030.

Nonetheless, the broader goal of stabilising global lighting electricity demand at or below 2005 levels will only be achieved by substantially strengthening and expanding current policy settings.

BEACONS OF HOPE

A number of technologies are profiled in this book. All of them exist and are fully commercialised. They include incandescent, fluorescent and high-intensity discharge lamps; the ballasts and transformers that drive them; the luminaires in which they are housed; and the controls that operate them. Incandescent lamps have been with us since the 19th century and still have an energy-to-light conversion efficiency of just 5%, which is five times lower than that of equivalent good-quality compact fluorescent lamps (CFLs). Without a palpable change in lighting quality, a market shift from inefficient incandescent lamps to CFLs would cut world lighting electricity demand by 18%. In the service sector, the use of high-efficiency ballasts, slimmer fluorescent tubes with efficient phosphors and high-quality luminaires produces savings that are just as impressive. For street and industrial lighting there are great savings to be had from discontinuing the use of inefficient mercury vapour lamps and low-efficiency ballasts in favour of higher-efficiency alternatives. The waste of light can also be readily reduced by the use of time-scheduled switching, occupancy sensors and daylight-responsive dimming technologies, all of which are mature and fully proven techniques with high savings returns.

For the near future solid-state lighting is emerging as a promising lighting technology. Over the last 25 years it has undergone sustained and dramatic improvements in efficiency that hold the prospect of it outperforming today's mainstream lighting technologies in a growing number of applications. If current progress is maintained, solid-state lighting may soon make inroads into general lighting. Moreover, solar-powered solid-state lighting already offers a robust, low-energy and economic solution to the needs of households reliant on fuel-based lighting.

MAKING IT HAPPEN

Governments have a key role to play in accelerating the adoption of energy-efficient lighting. They can set standards to prohibit the sale of the

least efficient lighting technologies where high-efficiency, good-quality and cost-effective alternatives exist. They can institute regulations applying to the energy performance and quality of lighting systems installed in major applications: commercial buildings, new residential construction, outdoor lighting, industrial lighting and vehicle lighting. They can help develop innovative financing and fiscal schemes to overcome first-cost barriers and provide information and training to lighting specifiers, designers and installers. They can educate the public at large about the benefits of efficient lighting. They can ensure that the energy costs and performance of lighting are visible in the market by labelling the energy performance of equipment and certifying the performance of entire light-using systems such as buildings and outdoor lighting. They can encourage better building design with more effective use of daylight through education, training and incentives. They can lead by example through pioneering efficient-lighting technologies and practices in their own buildings and by setting appropriately ambitious targets. And they can establish programmes and provide support to bring more sustainable, affordable and high-quality lighting to the world's light-poor.

All these measures will bring results but need careful design and targeting. They also need to be ambitious, broadly based and effectively implemented to realise their potential. Many governments have found that comprehensive and broad-ranging programmes with a clearly defined mandate and adequate resources enable the most effective response, but so far not one has done enough to attain the full cost-effective savings potential and some have not yet begun to try. Taken as a whole, the rapid adoption of such measures will produce a brighter future and help prevent light's labour's from being lost.