

Global Efforts to Phase-Out Incandescent Lamps

An update from
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This paper comprises two parts.

Part A – My testimony to the US Senate hearing of September 12, 2007 on senate bill S.2017 the “Energy Efficient Lighting for a Brighter Tomorrow Act”. The testimony includes a chronological summary of international developments to phase out inefficient incandescent lamps.

Part B – An outline of the measures undertaken by the IEA Secretariat to support the phase-out of inefficient incandescent lamps.

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Part A

Testimony to the United States Senate Energy and Natural Resources Committee hearing on the status of energy-efficient lighting technologies and on S. 2017 the “Energy-efficient lighting for a better tomorrow act”, September 12th 2007.

Prepared by Dr Paul Waide, Senior Policy Analyst in the Energy Efficiency and Environment Division of the International Energy Agency, Paris, September 2007

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The information and views expressed in this testimony reflect the personal understanding and opinion of Dr Paul Waide. He accepts no liability for the accuracy of the information presented or any subsequent use that is made of it, but offers this testimony in good faith according to his best understanding of the topic at the time of writing.

1. Synopsis

This testimony summarises the international status of policy efforts to phase-out inefficient incandescent lighting, provides estimates of potential energy and CO₂ savings, gives a timeline of the developments to date, explains broader international policy dynamics and how they may influence the US lamp market and provides comments on some issues pertinent to the proposed US legislation.

2. Summary

Since early 2007 almost all OECD governments have begun to develop policies aimed at phasing-out inefficient incandescent lighting. The intention of the regulations already adopted or under consideration is to encourage energy savings through the usage of higher efficiency lamps and most notably the use of compact fluorescent lamps (CFLs) in place of standard incandescent lamps (known as GLS, which is an abbreviation of *general service lamps*)². The countries which are currently actively developing policy measures to phase-out incandescent lamps account for roughly half the global GLS market and consume about 6.5 billion GLS per year out of a global market volume of approximately 12.5 billion lamps. Other countries may also be poised to introduce similar initiatives in the near future, such that it is conceivable that standard GLS lamps could be phased-out globally within a decade. The USA is the largest single GLS market and accounts for almost a third of the global market by volume. The next largest markets are the European Union and China, which each account for about a sixth of the global GLS market. The global market for screw-based CFLs is estimated to have been roughly 1.6 billion lamps in 2006 of which approximately four-fifths were manufactured in China. CFL sales are growing strongly internationally, with growth in demand in almost all markets, but GLS sales are likely to remain high and even increase without policy intervention.

² On average a CFL uses a quarter of the energy of a GLS lamp for the equivalent light output and hence leads to very significant and cost effective energy savings. GLS and most CFLs have screw-base or bayonet-base caps but are collectively called “screw-based lamps”.

Incandescent lamps consume about 7% of global electricity consumption and give rise to approximately 2% of global energy-related CO₂ emissions³. First commercialised in 1879 the technology is little changed since the 1920s and has a physical energy efficiency of about 5%, which means that only 5% of the input power is converted to visible light and the rest is converted into heat. Compact fluorescent lamps are typically between four and five times more energy-efficient i.e. they convert between 20 and 25% of the input power into visible light. Were people around the world to universally stop using incandescent lamps from 2012 onwards and instead use lamps with an efficiency of CFLs it would save 5.5% of global power demand and avoid roughly 500 million metric tonnes of CO₂ emissions⁴. This magnitude of CO₂ abatement is equivalent to what would be achieved by installing one hundred times current US wind generation capacity in lieu of unsequestered coal-fired power plants, or alternatively from building 77 one-gigawatt nuclear power plants in lieu of unsequestered coal-fired power plants. To give an alternative context were these savings to be realised it would amount to abatement of CO₂ emissions equivalent to almost three-quarters of the residual 2012 reduction commitment of the Kyoto Protocol signatories⁵.

However, CFLs are not the only alternative to conventional general service incandescent lamps and there are other lamp technologies which could be used in place of GLS lamps that have higher (or slightly higher) energy efficiency but are not as efficient as CFLs. They include: halogen lamps, which can have efficiencies that are between a few percent better than GLS to up to twice as high as GLS depending on the technology used; and light emitting diodes (LEDs), which are just beginning to appear on the market. LED technology is making great advances; however, it is still unclear how viable it will eventually be as a replacement for general service incandescent lamps. There is uncertainty about the future rate of product development and the eventual market acceptance of LED costs, light level and distribution characteristics, heat dissipation and chromatic properties.

Regulations could thus be promulgated, which would phase-out conventional general service incandescent lamps but could still be met by significantly less efficient lamps than CFLs. Under such circumstances the magnitude of energy savings resulting from the regulations would depend on the relative preference expressed in the market place for the less-efficient compliant lamp options and for CFLs. In the lower extreme energy savings could be as little as 10 to 20% of GLS lamp energy consumption as compared to roughly 75% with the full adoption of CFLs. Some of the factors to be considered when developing such regulations are discussed in Section 4 of this testimony, including a summary of the issues pertaining to current screw-based lamp technology discussed in Section 5. The following section gives a chronology of international regulatory developments in relation to the phase-out of standard incandescent lamps and provides information on their current status.

³ This is just their direct electricity use and does not take account of any additional energy that may be used or saved for space conditioning purposes as a result of the heat emitted by these lamps.

⁴ These figures are IEA estimates derived from projections made in a global lighting model developed for the 2006 publication, *Light's Labour's Lost: Policies for Energy Efficient Lighting*, IEA, Paris.

⁵ The IEA has estimated that Annex I Kyoto protocol signatory countries, with projected emissions above targets, need to abate an additional 700Mt of CO₂ in 2012 if they are to meet their domestic targets under the treaty. Reference: *Act Locally, Trade Globally*, IEA, Paris 2005.

3. Chronology of international regulatory developments⁶

Regulations in place in 2006

In 2006 the only economies that had adopted any kind of regulation to influence the efficiency of general purpose standard incandescent lamps with screw-caps were the Republic of Korea and California. In both cases the regulations are set at a level of stringency that continues to allow conventional GLS lamps to be sold but excludes the least efficient varieties. These measures are expected to result in energy savings for screw-based lamps of a few percent which reflects the narrow spread in energy efficiency of currently available GLS lamps.

With current commercially available lamps designed to use existing screw-base sockets it is only possible to get much larger energy savings by the use of fundamentally different lamp technologies⁷. Energy savings of 75-80% can be achieved through the use of compact fluorescent lamps (CFLs) in place of GLS and lesser savings of from 0-50% can be realised through the use of halogen lamp technology.

Policy developments from 2006 to the present

Light's Labour's Lost

In June 2006, as part of its work for the G8 Plan of Action on a *Clean, Clever and Competitive Energy Future* the IEA released a 558 page publication on lighting energy use and energy efficiency issues around the world, entitled *Light's Labour's Lost: Policies for Energy Efficient Lighting*.⁸ The book's findings received widespread media attention and were widely circulated among lamp manufacturers and policy makers. The key findings are:

- Some 19% of global power consumption and some 3% of global oil demand is attributable to lighting⁹
- Overall lighting gives rise to 1900 million metric tonnes of CO₂ emissions, which is roughly 70% of the CO₂ emitted by light duty vehicles (cars, SUVs, motorcycles etc.)
- Without new policy measures global energy consumption for lighting is projected to grow by 60% from 2005 to 2030
- Over 38% of future global lighting energy demand could be avoided by the use of more efficient lamps and ballasts¹⁰ which are routinely available on today's market.

⁶ Note: this chronology has been amended from the original delivered at the Senate hearing to include a more detailed summary of the US federal regulatory developments which did not need to be explained to the US policy audience.

⁷ Note this does not preclude the possibility of more efficient incandescent lamps being commercialized in the future

⁸ *Light's Labour's Lost: Policies for Energy Efficient Lighting*, IEA, Paris, 2006.

http://www.iea.org/Textbase/publications/free_new_Desc.asp?PUBS_ID=1695

⁹ About 1.1 million barrels of oil a day are used in road vehicles to power their lights and some 1.3 mb/d is used in liquid petroleum products, such as kerosene, to provide lighting in households without access to the electricity grid. Approximately 1/5th of the world's population rely on fuel-based lighting in their homes.

¹⁰ Ballasts are devices used by some types of lamps to regulate the input current and voltage so that the lamp operates properly. Ballasts consume power to operate and some types are more efficient than others.

- Were the global phase-in of such high-efficiency lamps and ballasts to start in 2008 following natural equipment replacement cycles it would give rise to 16.6 billion metric tonnes of CO₂ savings globally by 2030 and reduce the total cost of lighting over the same period by some 2.6 trillion US\$ due to reduced energy costs.
- Each metric tonne of CO₂ abated would provide a net economic benefit of US\$156.

The key findings regarding phasing-out inefficient incandescent lamps in favour of more efficient technologies, such as CFLs, are:

- Globally incandescent lamps are estimated to have accounted for 970 TWh of final electricity consumption in 2005 and given rise to about 560 million metric tonnes of CO₂ emissions.
- About 61% of this consumption is in the residential sector with most of the rest in commercial and public buildings.
- The IEA estimates that incandescent lamps used in the USA and Canada jointly consumed about 350 TWh of delivered electricity in 2005 and gave rise to about 217 million metric tonnes of CO₂ emissions.
- If current trends continue incandescent lamps could use 1610 TWh of final electricity globally by 2030.
- In the hypothetical case that all standard incandescent lamps were to be replaced by CFLs it would save roughly 800 TWh and 470 million metric tonnes of CO₂ emissions in 2010 rising to 1200 TWh and 700 million metric tonnes of CO₂ in 2030.
- Cumulatively this would reduce global net lighting costs by US\$1.3 trillion from 2008 to 2030, and avoid 6.4 billion metric tonnes of CO₂ emissions at a negative abatement cost of -US\$205 per tonne.
- The typical rate of return on investment¹¹ in a CFL compared with a standard GLS lamp is in excess of 180%.

Time line of international policy developments since 2006

In May 2006, under the terms of the 1992 Energy Policy Act the US DOE initiated a rulemaking process to determine the case for Federal standards applicable to general service incandescent lamps, incandescent reflector lamps and general service fluorescent lamps. Under the original timetable it was expected that an advance notice of proposed rulemaking would be issued by November 2007 and a final rule by June 2009, to take effect by June 2012.

Also in May 2006 and within the rubric of the G8 Plan of Action, which was launched following the 2005 Summit of the G8 in Gleneagles, the IEA made four concrete policy recommendations on energy efficiency for consideration by the G8 at the St Petersburg summit in July. The recommendation regarding lighting encouraged G8 and plus-5¹² leaders to enact policies to raise

¹¹ The Internal Rate of Return

¹² The "Plus 5" are Brazil, China, India, Mexico and South Africa

the energy efficiency of lighting in line with international best practice. The G8 welcomed the recommendations and asked the IEA to elaborate on them with more explicit proposals.

In the USA, Wal-Mart and Home Depot launched programmes to dramatically increase the sale of CFLs in their retail outlets.

Cuba banned the sale of incandescent lamps and implemented a programme of direct substitution of GLS with CFLs in households. It is understood that this was completed sometime in 2007 making Cuba the first country in the world to have phased-out incandescent lighting. Another 10 Caribbean countries and Venezuela are reported to be implementing similar measures.

In December 2006 Philips Lighting, the worlds largest lamp manufacturer, held a press conference in Brussels at which they announced they would welcome the global phase-out of general service incandescent lamps over a 10 year period under proviso that the same regulatory conditions apply to all market actors.

On January 30, 2007, California Assemblyman Lloyd Levine proposed a bill to ban the sale of general service incandescent lamps in the state by 2012.

On February 26th 2007 the IEA and European Commission held a joint workshop in Paris on *CFL Quality and Strategies to Phase-out Incandescent Lighting* which was attended by energy efficiency policy makers and industry. At this workshop the other major international lamp producers¹³, who supply the majority of lamps sold within the economies of the OECD, announced their support for the objective of phasing-out of inefficient incandescent lamps within a reasonable timeframe.

In the week preceding the IEA workshop (on February 20th) the government of Australia held a press conference announcing their intention to phase-out inefficient incandescent lighting by 2011. The Government of New Zealand has since confirmed that they support the policy and will harmonise their requirements with Australia. The final details of the regulation are still being settled but as of the end of August 2007 the structure of the regulations appeared to be as follows. From 1 October 2008 the majority of screw-based lamps imported into Australia would need to have an efficacy¹⁴ of 20 lumens per Watt (denoted (lm/W)).¹⁵ The intended result of these regulations is that conventional GLS lamps will effectively be eliminated from the Australian marketplace and that CFLs will dominate screw-based lamp sales afterwards, although some mains voltage halogen lamps would remain. From 2010 the scope will be expanded so that decorative screw-based lamps such as candle-shaped, “fancy rounds”, etc. have to meet the 20 lm/W requirement. From 2012 mains voltage halogen lamps and incandescent reflector lamps

¹³ The major international lamp companies who jointly supply the majority of lamps currently sold in the economies of the OECD are: Philips, Osram-Sylvania and General Electric – note in Europe Osram and Sylvania are separate companies whereas in North America they are a joint company.

¹⁴ The efficacy of a lamp is the standard metric denoting its functional efficiency and is the amount of visible light it emits (expressed in lumens (lm)) divided by the power it consumes (expressed in watts (W)).

¹⁵ Note that 20 lm/w is for 1200 lm (60w) lamp. The precise efficacy requirement is expected to be a curve based on lamp light output. Lamps required to meet this requirement would include IEC bulb designations A55-A60-PS60, M50 and M60 (& possibly others) designed to operate at >220V and with screw-caps of E26, E27 or B22d. When comparing these proposals with those under consideration in the USA account needs to be taken of the difference in operating voltage. Due to physical laws incandescent lamps operating at higher voltages are less efficient than when operating at lower voltages. Incandescent lamps designed to operate at 220-240V electricity networks, such as in Europe and Australia, are roughly 15 to 20% less efficient than comparable products designed for 120V systems such as those used in North America.

(PAR, R, ER, etc.) will also be required to attain 20 lm/W. From 2014 pilot lamps, refrigerator and oven lamps will need to satisfy 20 lm/W.¹⁶

In the same week (on February 22) the “How Many Legislators Does it Take to Change a Light Bulb Act (AB 722)”, was introduced in the California State Legislature. This proposed that GLS lamps would not be sold after 2012.

On March 9th, 2007, the EU Council of Ministers¹⁷ called on the European Commission to establish a regulation addressing incandescent lighting by 2009 within the framework of the already existing Eco-design for Energy Using Products Directive 2005/32/EC. This Directive is a regulatory framework which grants the European Commission authority to set mandatory (or voluntary) energy performance standards for tradable goods sold across the EU.

On March 12th, 2007, the UK government announced a plan to complete the phase-out of inefficient incandescent lamps within the UK by 2011, even if this is in advance of the provisions that are ultimately set in the EU Eco-Design Directive. Under the terms of the European Single Market individual EU member states do not have the authority to set non-EU harmonised performance requirements for tradable goods. Accordingly it is understood that the UK government are considering a mixture of: voluntary agreements with lamp suppliers and retailers; subsidies to encourage the sale of high quality compact fluorescent lamps; and fiscal measures to discourage the sale of low efficiency incandescent lamps. Some major UK retailers have already announced that they will stop stocking GLS lamps.

During the period of March to May 2007 the governments of the Republic of Ireland, Portugal, Belgium and the Netherlands announced similar policies and initiatives to the UK.

On March 14, 2007, Philips Lighting in North America and several US energy efficiency advocacy agencies including the Alliance to Save Energy, the Natural Resources Defence Council and the American Council for an Energy-Efficient Economy issue a public call to phase out inefficient incandescent light bulbs and replace them with a new generation of lighting technologies that meet advanced efficiency performance standards by 2016.

On March 15, 2007, US Representative Jane Harman proposed a bill (HR1547) in the House of Congress that would impose efficacy standards for general service lamps sold within the USA. This has since been modified and entered within the House energy bill (S. 3221 – Sec 109).

On March 28th, 2007, a cross-party group of members of the European Parliament urged EU governments and the European Commission to quickly introduce new energy efficiency standards for lighting and to introduce market surveillance measures to prevent existing product quality standards from being flouted by importers

Also in March 2007 California assemblyman Jared Huffman submitted a competing bill (AB 1109) to the Levine bill (AB 722) based-on technology-neutral performance standards for various categories of lighting.

Shortly afterwards several other bills were introduced in other US states. These include: bills in Rhode Island (SB 806), Nevada (AB 178), New York (#A07944 and AB 6190) and North

¹⁶ Source: *Australian Phase-out of Incandescent Lamps*, presentation by Shane Holt, Australian Greenhouse Gas Office, Government of Australia.

¹⁷ The regular meeting of EU heads of state.

Carolina (DRH30218-RT-5) of a similar nature to the CA Levine bill; a bill introduced in Minnesota (SB 1442) which proposed to tax the sale or transfer of incandescent lamps by a wholesaler at \$0.25 per lamp; a bill entitled, “Act Concerning Inefficient Incandescent Lamps” in Connecticut (HB 6550); bills that would require all state buildings to switch to CFLs over the next three years were introduced in New Jersey (A 3983), South Carolina (SB 97), Illinois (HB 1460), Hawaii (SCR 53 and SR 28) and Arkansas (HB 2551). The Nevada bill AB178 was approved by the Governor in June and requires lamps sold in the state from 2012 to attain an efficacy of 25 lm/W or higher.

April 18th, 2007, the government of Ontario announced a policy to phase-out the sale of incandescent lamps within the province by 2012.

April 25th, 2007, the government of Canada announced a policy to set performance standards for all lighting to phase-out the use of inefficient light bulbs in common applications by 2012. The intention is to have defined details of the requirements by the end of 2007. At a workshop held in Toronto on June 26th staff from the Office of Energy Efficiency in Natural Resources Canada set out a provisional rulemaking proposal containing the following elements. The standard is expressed by an equation that represents the shape of a curve of lamp efficacy (lumens per watt) to lumen output (lumens) where E (expressed in lumens per watt) = $4.2375 * \ln(\text{Lumens}) - 13.7912$. This equation is intended to be approximately 50% higher than the best fit curve through existing general service lighting products. The proposal also includes a lower standard (at 30% higher than best fit) for “enhanced spectrum lamps”. A second Tier was proposed that would be approximately 100% higher than current efficacy levels to come into effect in 2015. The following table summarises the required efficacy thresholds that would apply were this proposal to be adopted.

Provisional Canadian government regulatory proposals for minimum efficacy levels applicable to screw-based lamps sold in Canada¹⁸

Current			Proposed		Current
Typical Wattages	Typical Lumen Level	Efficacy (best fit)	Tier 1	Tier 2	ENERGY STAR Qualified CFL (equivalent lumens)
Effective			2012	2015	
25	210	8.4	12.7	21.1	45
40	490	12.3	17.8	29.7	45
60	840	14	21.1	35.1	45
75	1170	15.6	23.1	38.4	60
100	1690	16.9	25.3	42.2	60
>100	2850	19	28.5	47.4	60

On 5th June 2007 the European Lamp Companies Federation, an industry association which includes Philips, Osram, GE and Havells Sylvania, issued a press release setting out a voluntary proposal to phase-out the sale of GLS lamps in Europe. Under the proposal, by 2015, 85% of the total EU traditional incandescent lamp market of 2.1 billion lamps would need to meet new

¹⁸ Source: minutes of the *National Lighting Summit: Summary of the first consultation on the Government of Canada’s proposed national performance standard for general service incandescent light bulbs* – Toronto, June 27, 2007. Natural Resources Canada

efficiency requirements. The proposal envisages a staggered phase-out of GLS lamps such that lamps above 100W would have to meet an initial efficacy limit of 18 lm/W by 2009 and a more stringent one of 20 lm/W by 2011, lamps of 100W to 75W power would have to meet a first efficacy requirement of 14 lm/W by 2011 and of 17 lm/W by 2013, lamps of 60W to 75W would have to meet a first efficacy requirement of 13 lm/W by 2013 and one of 15 lm/W by 2015, lamps of 40W to 25W would need to satisfy a first efficacy requirement of 11 lm/W by 2015 and 14 lm/W by 2017 and lamps of less than 25W would need to satisfy a first efficacy requirement of 10 lm/W by 2015 and 12 lm/W by 2017¹⁹. There has yet to be any consideration of this proposal within the European Commission's rulemaking process under the rubric of the Eco-design of Energy Using Products Directive, 2005/32/EC. To date the Commission has hired consultants to examine all the technical issues pertinent to the preparation of a rule-making and they are planning to report their first results in November 2007. The Commission has been instructed by the EU Council of Ministers to issue a final rulemaking on the topic before 2009 and is expected to begin a consultation process with representatives of EU Member States in early 2008.

On 6-8 June 2007 the G8 Summit met at Heiligendamm in Germany and endorsed twelve concrete energy efficiency policy recommendations from the IEA. In the case of lighting the IEA recommended that:

- Governments should move to phase-out the most inefficient incandescent bulbs as soon as commercially and economically viable

These recommendations were also circulated to the 26 IEA energy ministers for consideration at the 2007 IEA Ministerial held in Paris on May 15th 2007 and were strongly supported.

On June 12th US Senator Bingaman introduced a Senate Bill 1115 the *Energy Efficiency Promotion Act* that is subsequently renumbered as S1419 and then S.2017 (the subject of the current hearing). The bill includes measures aimed at phasing-out inefficient general purpose lighting.

In August 2007 the Government of Switzerland published an Energy Efficiency Action Plan which included a proposal for regulations to phase-out inefficient incandescent lamps. Under the proposal all incandescent lamps sold from 2008 onwards will need to be of an efficiency of class E or higher according to the EU household lamps energy label²⁰ (e.g. requires a minimum efficacy of 11.2 lm/W for a 750 lm lamp), from 2010 onwards to be class D or higher (e.g. requires a minimum efficacy of 13.0 lm/W for a 750 lm lamp) and from 2012 to be class B or higher (e.g. requires a minimum efficacy of 20.5 lm/W for a 750 lm lamp). Fluorescent lamps must perform to level A from 2010 onwards (e.g. requires a minimum efficacy of 65.9 lm/W for a 750 lm lamp). This proposal is currently entering into a consultation process.

In September 12th the US Senate held a hearing on the Senate bill S.2017 "Energy Efficient Lighting for a Brighter Tomorrow Act". The hearing was addressed by Representative Jane Harman who has backed a similar bill S.3221 Sec – 109 in the US House of Representatives. S.2017 proposes that screw-based lamps sold in the USA will be required to meet energy

¹⁹ When comparing these proposals with those under consideration in the USA account needs to be taken of the difference in operating voltage. Due to physical laws incandescent lamps operating at higher voltages are less efficient than when operating at lower voltages. Incandescent lamps designed to operate at 220-240V electricity networks, such as in Europe and Australia, are roughly 15 to 20% less efficient than comparable products designed for 120V systems such as those used in North America.

²⁰ Commission Directive 98/11/EC, OJ L 71 10.3.1998, p. 1-8

performance levels that are roughly 28% higher than current GLS lamps in the timeframe of 2012-2014 (with the implementation date phased by lamp wattage class) and that from 2020 all common types of screw-based lamp would be required to meet an efficacy level of 45 lumens per watt (roughly 3 times higher than current GLS). Both bills have already passed votes in the House and Senate.

Beyond the economies of the OECD the governments of Thailand and of Ghana have recently announced policies to phase-out incandescent lamps. Government and utilities in Egypt, India, Indonesia, South Africa and Vietnam are all strengthening existing major CFL promotional programmes. Several other countries including Brazil and Mexico have previously launched successful large scale programmes to promote the use of CFLs in place of incandescent lamps.

The Government of China is understood to be in the process of initiating a project to investigate the issues associated with phasing-out incandescent lamps to help them to determine whether to introduce new policy measures to that effect.

The Global Environment Facility of the UNFCCC is currently in the process of developing a global project to support non-OECD economies to phase-out incandescent lighting. It is anticipated this project will be formally launched before the end of 2007.

4. Issues being considered by legislators:

Legislators around the world considering the adoption of regulations to phase-out inefficient incandescent lighting are facing similar issues. They need to weigh in the balance the potential for energy performance requirements to deliver significant energy savings, and their associated environmental and economic benefits, with the desire to ensure there is an on-going supply of lamps that satisfy consumer needs. Setting general energy performance requirements in a manner that facilitates the required industrial and commercial transition but doesn't result in unintended consequences is a challenge. In particular, determining appropriate treatment for niche applications without creating substantive loopholes is one of the biggest technical issues to be addressed and reaching a satisfactory resolution will require careful attention to detail during the policy making process.

A recurrent issue is whether to set requirements that allow more than one type of currently-available screw-based lamp technology to be deployed, or whether to set them at a level which guarantees maximum energy savings but may exclude some genres of lamp technologies. The response will depend on how regulators and the market view the suitability of the various higher-efficiency alternatives to standard incandescent lamps and on the relative importance given to the trade-offs implied. To provide some sense of what these are the main characteristics of the principal alternative technologies to general service incandescent lamps are briefly described in section 5. Some thoughts are also offered about complementary measures which can help to minimise some of the trade-offs.

When developing regulations care needs to be taken to ensure that regulatory lead times and market rewards are sufficient for industry to adjust their manufacturing base to produce compliant lamps in the required volumes. At present, most regulatory discussions have been taking place independently of those in other jurisdictions and there has been relatively limited discussion between regulatory authorities about the combined impact of their measures on global lamp supply. As lamps are internationally traded products and a large proportion of lamps sold in any one jurisdiction are often sourced from elsewhere there may be a need to ensure that international regulatory developments are coordinated to minimise the risk of lamp shortages once the

regulations come into effect. Specifically the risk of a shortage in regulatory-compliant lamps arises from the following concerns:

a) The substantially different average lifetimes of CFLs compared to incandescent lamps means that, dependent on the rate of transition to CFLs, there is a possibility of the development of a short-lived peak in global demand for CFLs followed by a depression as lamp markets move to significantly longer replacement cycles²¹. Were this to occur it would create a risk of those manufacturers investing in new CFL production capacity being left with stranded assets. From a regulators perspective the concern is that industry might not invest sufficiently in meeting the peak in global CFL demand and thus bring about a shortfall in lamps at the moment of inflection in global compliant-lamp demand.




b) There are technical limits to the rate at which the global lamp industry is capable of increasing CFL production capacity mostly due to the time it takes to increase production and supply of key materials and components (notably glass of an appropriate grade, phosphors and electronics). This is a particular concern for the supply of higher quality CFLs, such as currently sold in the economies of the OECD.

Performing simulations of the potential impacts of current global regulatory developments on demand for CFLs and other regulatory-compliant lamp types would be one means of assessing the seriousness of these risks and determining if greater coordination in policy setting may be required. The IEA is developing a project to examine this issue.

Lastly, not only do near-term regulatory performance thresholds need to be achievable with current technology but regulators must also be mindful about the signals they send regarding investment in future technology. It is appropriate to consider the degree to which the regulatory framework put in place in the short-term may influence near and medium-term investment decisions in lamp production capacity and the extent to which this is consistent with longer-term public policy objectives. To this end regulators will need to decide whether to specify longer-term performance objectives at the same time as announcing near-term regulatory requirements or not.

²¹ The average GLS lasts for 1000 hours and the average CFL for 6000 hours, therefore the lamp sockets currently supplied by global sales of 12.5 billion GLS per annum could be supplied by sales of 2.1 billion CFLs per annum once all GLS had been replaced by CFLs and a CFL replacement market were operational; however, during the transition period much higher volumes of CFLs could be required depending on how short the transition period were to be.

5. Suitability of replacement lamps

	<p>Common types of screw-based CFLs having 4 to 5 times the energy efficiency of conventional GLS lamps and lasting from 5 to 15 times longer. Smaller CFLs are also available on the market including those in the form of spirals, golf-balls, reflector lamps and candle-shapes.</p>
	<p>Examples of new advanced halogen lamps having roughly twice the energy efficiency of comparable conventional GLS lamps.</p>
	<p>Examples of substitute GLS and reflector lamps using LEDs (currently designed for decorative lighting applications)</p>

Photos courtesy of Philips Lighting

CFLs

The suitability of CFLs as replacements for incandescent lamps has increased significantly in the last decade due to on-going improvements in the lamp technology and their production. CFLs are now available at much lower prices than hitherto, they come in a much larger range of dimensions and thus models can be found which will fit into almost all light fixtures using a screw-based socket, and their light quality has improved substantially. Because they require only a quarter to a fifth of the energy of conventional GLS lamps CFLs are far more economical to operate and hence are more cost-effective for the end-user. They also last between five and fifteen times as long as a standard GLS lamp (5000 to 15000 hours for CFLs compared with 750-1500 hours for GLS). The limitations of CFLs compared with GLS lamps are as follows:

- Good CFLs give out light with a colour-rendering index (CRI) of about 85 as compared with that from an incandescent or halogen lamp of 100. This means that they are not quite as good at producing a faithful rendering of colour as are incandescent lamps. For most

applications a CRI of 85 is perfectly adequate for end-users but there may be some cases where end-users would prefer a higher CRI.

- While an incandescent lamp produces light as soon as they are switched on there is a very short delay for CFLs and the lamps take slightly longer to produce their full light output.
- While CFLs are available in much smaller sizes than was previously the case there is a limit to how small they can be made. Incandescent lamps and halogen capsules can be produced that are even smaller still and these may be better suited to certain kinds of lamp fixtures.
- CFLs contain trace levels of mercury. The levels included in modern lamps are much less than was previously the case but some economies, most notably the EU, are introducing requirements for their safe disposal at end of life. The corollary to this issue is that in economies that use a significant amount of coal-fired generation in the electricity mix there is likely to be a significant overall reduction in mercury release to the environment from the use of CFLs. This is because the avoided power demand reduces coal-derived airborne mercury emissions by levels that significantly exceed the amount of mercury used in the lamp.
- CFLs can be produced to have a light colour (referred to as the colour temperature) which matches that of GLS lamps but they can also be produced to emit light of a different colour temperature. To avoid confusion among consumers, many of whom will be seeking to have lamps with identical colour temperature characteristics to the GLS lamps they have always used, some additional effort may be required to communicate the colour temperature characteristics in a user-friendly way at the point of sale.
- CFLs are not as well-suited to provide well directed beams of light as are certain types of incandescent lamps (most notably halogen reflector lamps) and hence are not adapted to provide some types of reflector lamp applications.

Halogen lamps

Halogen lamps are a type of improved incandescent lamp which can have higher energy efficiency than conventional GLS lamps but cannot attain the levels of CFLs with today's technology. The most efficient halogen lamps, which are just in the process of being commercialised on OECD markets, have an efficiency that is roughly twice as high as for a comparable GLS lamp. They have the same high colour rendering (i.e. a CRI of 100) and last two to three times as long as a GLS (2000 to 3000 hours compared with 750-1500 hours for GLS lamps). With today's lamp technology it is possible to produce halogen lamps that could substitute for almost all conventional GLS applications and that would give energy-savings of from 0 to 50% depending on the explicit halogen technology used. It is expected that the most efficient varieties will be significantly more expensive than GLS and even CFLs when first entered on the market and that their price will decline as and when their market volumes increase. It is not easy to estimate whether halogen or CFL lamps would be the cheapest in a market where no conventional GLS lamps were permitted to be sold, but it seems likely that CFLs would be cheaper than the most efficient halogen lamps at least in the short term.

Light emitting diodes (LEDs)

Light emitting diodes are rapidly evolving but are not yet widely available as substitutes for screw-based GLS lamps. Current lamps can be produced with a higher efficacy than GLS lamps and with very long lifespans (tens of thousands of hours) but the lamp costs are very high and there appear to be ongoing problems with:

- providing adequate amounts of light
- providing light distribution in a manner which satisfies consumer needs
- ensuring chromatic properties are sufficiently stable from batch to batch and that the light colour matches consumer requirements
- adequately addressing heat dissipation

The pace of development of the technology is such that many, if not all, of these issues may be overcome in the next few years but the outlook is still somewhat uncertain.

Ensuring and communicating the quality of compliant lamps

Some of the lamp characteristic issues raised above can be addressed by taking steps to ensure the quality of high efficiency lamps sold in a market is sufficiently high for most consumer needs to be met. This can be done by setting and enforcing minimum lamp quality requirements and by encouraging higher quality requirements be met through endorsement schemes such as Energy Star. Where lamp quality characteristics may vary but are not universally important to consumers the relevant information could be made available through improved lamp labelling designed to communicate pertinent factors in an accessible manner.

Part B. IEA Secretariat activities in support of GLS phase-out

Activities already undertaken

Since the release of *Light's Labour's Lost: Policies for Energy-Efficient Lighting* in June 2006 the IEA has been engaged in numerous activities to support the move away from inefficient incandescent lighting. A chronology of actions undertaken by the Secretariat is described below.

In May 2006 within the rubric of the G8 Plan of Action the IEA made four concrete policy recommendations on energy efficiency for consideration by the G8 at the St Petersburg summit in July. The recommendation regarding lighting encouraged G8 and plus-5²² leaders to enact policies to raise the energy efficiency of lighting in line with international best practice. The G8 welcomed the recommendations and asked the IEA to elaborate on them with more explicit proposals.

In December 2006 Philips Lighting, the worlds largest lamp manufacturer, held a press conference in Brussels at which they announced they would welcome the global phase-out of general service incandescent lamps over a 10 year period under proviso that the same regulatory conditions apply to all market actors. The IEA participated in the Energy-Efficiency Round Table during which the press conference was held and IEA analytical results from *Light's Labour's Lost* were quoted by Philips.

On February 26th 2007 the IEA and European Commission held a joint international workshop in Paris on *CFL Quality and Strategies to Phase-out Incandescent Lighting*, which was attended by energy efficiency policy makers and industry from around the world. At this workshop the major international lamp producers²³, who supply the majority of lamps sold within the economies of the OECD, announced their support for the objective of phasing-out of inefficient incandescent lamps within a reasonable timeframe. Support for this objective was also publicly articulated by government representatives from Australia, Portugal, Belgium, California and the Province of Ontario. All these economies have now made the objective public policy.

On 3-4th April the IEA Secretariat briefed EU energy efficiency policy makers about the issues involved with the phase-out of inefficient incandescent lighting at the 4th Amsterdam Sustainable Energy Forum.

On 5th June 2007 the European Lamp Companies Federation, an industry association which includes Philips, Osram, GE and Havells Sylvania, issued a press release setting out a voluntary proposal to phase-out the sale of GLS lamps in Europe. Under the proposal, by 2015, 85% of the total EU traditional incandescent lamp market of 2.1 billion lamps would need to meet new efficiency requirements. The proposal envisages a staggered phase-out of GLS lamps based on four lamp wattage classes to occur in a first tier phased by wattage class from 2009 to 2015 and a second tier phased from 2011 to 2017 set at more demanding efficiency thresholds. The IEA welcomed this initiative and was directly quoted in the press release.

²² The "Plus 5" are Brazil, China, India, Mexico and South Africa

²³ The major international lamp companies who jointly supply the majority of lamps currently sold in the economies of the OECD are: Philips, Osram-Sylvania and General Electric – note in Europe Osram and Sylvania are separate companies whereas in North America they are a joint company.

On 6-8 June 2007 the G8 Summit met at Heiligendamm in Germany and endorsed twelve concrete energy efficiency policy recommendations from the IEA. In the case of lighting the IEA recommended that:

- Governments should move to phase-out the most inefficient incandescent bulbs as soon as commercially and economically viable

These recommendations were also circulated to the 26 IEA energy ministers for consideration at the 2007 IEA Ministerial held in Paris on May 15th 2007 and were strongly supported.

On the 19th of June the IEA Secretariat participated in a workshop organised by the Californian Energy Commission in Sacramento to consider policy options towards the phase-out of incandescent lamps. The workshop was jointly staged by the California Energy Commission's Integrated Energy Policy Report (IEPR) Committee and the Energy Efficiency Committee to obtain input from all interested parties on issues and opportunities to improve residential lighting efficiency in California as part of the 2007 IEPR proceeding. The context for the meeting was the response to recently adopted legislation in California which requires the energy used for residential lighting to be halved within a decade. In addition two bills have been under discussion in CA regarding the phase-out of incandescent lighting, the Levine Bill which was withdrawn just prior to the meeting on June 8th and Jared Huffman's Bill AB1099, passed in the assembly on June 7th, which proposes to set a general performance standard for household lamps and passes over authority to the California Energy Commission to develop the bill. This bill has the broad support of the lighting industry although they would prefer a common US federal approach.

On June 20th the IEA met with representatives from the North American lighting industry and the Californian Energy Commission to discuss issues related to the phase-out of incandescent lighting in North America.

On June 27th the IEA spoke at the National Lighting Summit workshop held in Toronto on June 27th organised by staff from the Office of Energy Efficiency in Natural Resources Canada. At this workshop NRCan set out a provisional rulemaking proposal on how they intend to phase-out inefficient incandescent lamps.

On July 18th the IEA Secretariat met with Philips Lighting in Eindhoven to compare and review the Philips's and IEA models for international lamp demand and energy use.

On September 12, Paul Waide from the IEA Secretariat testified to the US Senate hearing on Senate bill S.2017 the "Energy Efficient Lighting for a Brighter Tomorrow Act". The testimony is provided in Part A above.

In addition to the above findings from *Light's Labour's Lost* have presented at numerous fora, including: the UNFCCC COP, Buy-Bright Forum, Right Light Conference, The Carbon Expo, the EEDAL conference, the ENDS energy efficiency forum, the Asia-Europe Business Forum, the AUDIT 06 conference, the ACEEE Summer study on Energy-Efficiency in Buildings, the Energy Charter PEERA forum, The Global Environmental Facility General Assembly, the International Centre for Trade and Sustainable Development, the International Conference for Improving Energy Efficiency in Commercial Buildings, the CEI Summit Economic Forum, Wilton Park conference on Energy Efficiency, The Energy Efficiency in Buildings EU forum, the Commission for Sustainable Development and The European Dialogue on Energy & Climate.