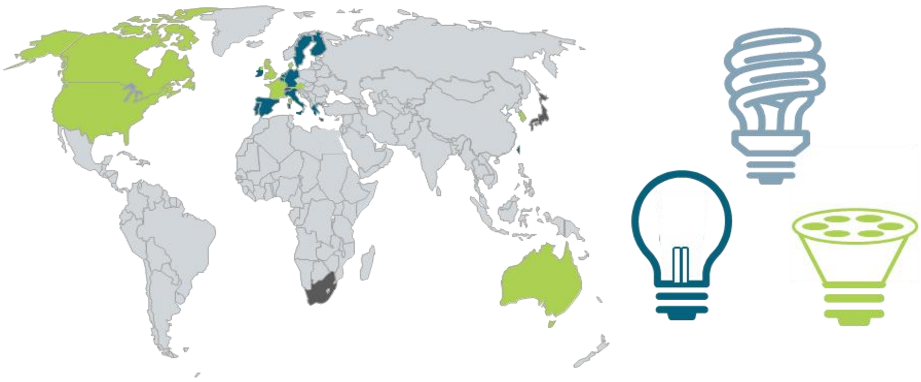
Benchmarking Document

Technology: Lighting: Market Impact of 'Phase-out' Regulations



Participating countries: Australia, Austria, Canada, Denmark, France, Republic of Korea, UK, USA

Other funding countries: Netherlands, Japan, South Africa, Switzerland, Sweden

Other regions covered: EU, Taiwan

Supporting assumptions
Impact of 'Phase-Out' Regulations on Lighting Markets

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In order to undertake the mapping and benchmarking analysis for this study a number of assumptions had to made about the average efficacy and assumed lifetimes of each lamp type for a range of wattages over the years 1995-2010. These assumptions were made in consultation with a panel of experts in the field of lighting technology. A full explanation of these assumptions and how they are sued in the analysis can be found in Annex 2 of the Benchmarking report: ***Wattage buckets, standard efficacy tables, standard lifetimes and normalisation of lamps on differing voltages .***

For further information refer to **http://mappingandbenchmarking.iea-4e.org/matrix**
or email **operating.agent@mapping.iea-4e.org**

Supporting assumptions

Wattage buckets and assumed average wattage per bucket

Globally, the majority of lamps are rated by wattage. For specific lamp types, the majority of lamps sold are from a number of discrete wattages, e.g. in Europe, traditional GLS incandescent lamps have normally been sold at 25 W, 40 W, 60 W, 75 W and 100 W. These discrete wattages vary between lamp types and between countries. Further, these discrete wattages account for the majority of, but not all, sales; some lamps are sold at intermediate wattages. However, it is possible to capture sales of all lamps by using these discrete wattages to create ‘wattage buckets’. Typically these buckets have the discrete wattages for a particular lamp type as their upper limit, with the lower limit set immediately above the preceding discrete wattage (using our European example above, the wattage range for incandescent lamps may be set at *x* ≥25 W; 25 W>*x* ≥40 W; 40 W>*x*≥60 W; etc). This has been the approach adopted by the mapping and benchmarking annex, with the discrete wattages agreed at the product definition stage.

The wattage buckets used to collect sales data and for subsequent analysis are shown below:

Lamp Type	**Wattage Ranges**									
Main Voltage Incadescents	0-25	26-40	41-60	61-75	76-100	>100				
Mains Voltage Halogens (single ended)	0-17	18-20	21-28	29-43	44-53	54-73	>73			
Mains Voltage Halogens (double ended)	0-100	101-150	151-200	201-250	>250					
Low Voltage (12V) Halogens	0-34	35-38	39-50	51-100	>100					
Mains Voltage Pin Based CFLs	0-3	4-5	6-7	8	9-11	12-13	14-15	16-20	21-25	>25
Mains Voltage Self-Ballasted CFLs	0-3	4-5	6-7	8	9-11	12-13	14-15	16-20	21-25	>25
Mains Voltage Linear Flourescent Tubes (T5)	0-28	29-50	>50							
Mains Voltage Linear Flourescent Tubes (T8)	0-24	25-27	28-31	>31						
Mains Voltage Linear Flourescent Tubes (T12)	0-33	34-40	>40							
Retrofit LED Lamps	0-1	1-2	2-4	4-8	8-11	12-14	15-20	>20		
Dedicated LED Lamps	0-1	1-2	2-4	4-8	8-11	12-14	15-20	>20		

The *average* wattages of all lamps sold within a bucket is assumed to be the top of the range (the discrete wattage), less 5% of the range.[1] This 5% reduction recognises that the majority of lamp sales will be at the discrete wattage, whilst taking into account the significantly lower wattage lamp sales of wattages across the remainder of the bucket range.

Lamp efficacies (Efficacies of 220-240 V lamps)

To analyse the information received on lamps, it is necessary to know the efficacy of lamps (lumens/watt). For a specific wattage, these efficacies will vary between lamps within the same market, and potentially more so between markets. Further, given wattage buckets are being used, the efficacies of lamps at the lower end of the wattage range of the bucket will typically be lower than the efficacy of lamps at the higher wattage range of the bucket.[2] However, the efficacy variation between individual lamps and of lamps of the same voltage

[1] For example, for a wattage rage 40 W> *x* ≥60 W, the assumed *average* wattage of all lamp sales in that bucket will be 60 W – ((60-40) * 5%) = 59 W.
[2] Lamp of lower wattages are typically of lower efficacy than lamps of the same type with higher wattages.

within a bucket is far outweighed by the differences between lamp types. Hence it is reasonable to use an average efficacy for each wattage bucket.

For the year 2010, average efficacies of lamps in each wattage bucket (at 220-240 V) have been created based on a combination of actual test data of lamps purchased in Australia, China and Europe, and where test data is not available, by a review of manufacturer declared efficacies for a range of lamps in those buckets. The efficacies used in 2010 are shown below:

Main voltage incandescent (W)	0-25	26-40	41-60	61-75	76-100	>100
2010 (efficacy)	*8.7*	*10.2*	*11.8*	*12.5*	*13.5*	*14.8*

Mains voltage halogens (single ended) (W)	0-17	18-20	21-28	29-43	44-53	54-73	>73
2010 (efficacy)	*11.5*	*11.9*	*12.0*	*13.5*	*15.0*	*17.3*	*18.5*

Mains voltage halogens (double ended) (W)	0-100	101-150	151-200	201-250	>250
2010 (efficacy)	*16.0*	*17.5*	*17.8*	*19.0*	*20.0*

Low voltage (12 V) halogens (W)	0-34	35-38	39-50	51-100	>100
2010 (efficacy)	*17.0*	*18.2*	*18.8*	*21.7*	*23.0*

Mains voltage pin based CFLs (W)	0-3	4-5	6-7	8.0	9-11	12-13	14-15	16-20	21-25
2010 (efficacy)	*50.0*	*51.5*	*59.0*	*62.0*	*65.2*	*69.0*	*72.0*	*66.9*	*74.2*

Mains voltage self-ballasted CFLs (W)	0-3	4-5	6-7	8.0	9-11	12-13	14-15	16-20	21-25
2010 (efficacy)	*40.0*	*50.0*	*51.1*	*52.2*	*56.4*	*56.0*	*57.5*	*62.5*	*61.4*

Mains voltage linear fluorescent tubes (T5) (W)	0-28	29-50	>50
2010 (efficacy)	*87.8*	*94.0*	*94.0*

Mains voltage linear fluorescent tubes (T8) (W)	0-24	25-27	28-31	>31
2010 (efficacy)	*67.2*	*73.0*	*79.1*	*84.4*

Mains voltage linear fluorescent tubes (T12) (W)	0-33	34-40	>40
2010 (efficacy)	*73.0*	*74.0*	*75.0*

Retrofit LED lamps (W)	0-1	1-2	2-4	4-8	8-11	12-14	15-20	>20
2010 (efficacy)	*48.0*	*49.6*	*51.2*	*54.4*	*56.0*	*57.6*	*60.0*	*64.0*

Dedicated LED lamps (W)	0-1	1-2	2-4	4-8	8-11	12-14	15-20	>20
2010 (efficacy)	*60.0*	*62.0*	*64.0*	*68.0*	*70.0*	*72.0*	*75.0*	*80.0*

For almost all lamps, efficacy has been improving over time. This improvement varies significantly between lamps. For example, the improvement in LED efficacies has been rapid in recent years, while incandescent lamps have improved very slowly. This improvement in efficacy over time has been accounted for by assuming an average annual improvement in efficacy for each lamp type as detailed overleaf:

Lamp type	Annual improvement in efficacy
Main voltage incandescent	**0.1%**
Mains voltage halogens (single ended)	**0.3%**
Mains voltage halogens (double ended)	**0.3%**
Low voltage (12V) halogens	**0.3%**
Mains voltage pin based CFLs	**0.6%**
Mains voltage self-ballasted CFLs	**0.6%**
Mains voltage linear fluorescent tubes (T5)	**0.3%**
Mains voltage linear fluorescent tubes (T8)	**0.2%**
Mains voltage linear fluorescent tubes (T12)	**0.1%**
Retrofit LED lamps	**10.0%**
Dedicated LED lamps	**10.0%**

Efficacies for each wattage bucket over time have then been calculated by the formula:

Efficacy in year n-1 = Efficacy in year n x [1/(1+annual improvement in efficacy)]

Thus the efficacies for all lamps in previous years can be deduced from the efficacies of lamps in 2010.

Efficacies of 110-120 V lamps

For lamps with an integral or external electromagnetic/electronic control unit (e.g. CFLs, LEDs fluorescent lamps with ballasts, etc), there is very little difference in efficacies between 220-240 V lamps and 110-120 V lamps. For lamps that use a filament to produce light (incandescent and halogen lamps) there is an inherent improvement in efficiency for lamps operating on lower voltages. These differences are adjusted in the analysis as described in Annex 2 of the Benchmarking report.

Lamp lifetimes

The individual lifetimes of lamps vary considerably between models of a particular type. Similarly there are variations in average lifetimes of lamps between geographical regions and over time. However, for the mapping and benchmarking analysis, 'standard lifetimes' have been used for each lamp types in all markets for all years.[3] These standard lifetimes used are given below.

Lamp type	Assumed lifetime (hours)
Main voltage incandescents	1000
Mains voltage halogens (single ended)	1300
Mains voltage halogens (double ended)	1300
Low voltage (12V) halogens	1300
Mains voltage pin based CFLs	6000
Mains voltage self-ballasted CFLs	6000
Mains voltage linear fluorescent tubes (T5)	15000
Mains voltage linear fluorescent tubes (T8)	10000
Mains voltage linear fluorescent tubes (T12)	10000
Retrofit LED lamps	20000
Dedicated LED lamps	20000

[3] Note that 'standard' lamp lifetimes are based on an average of the lifetimes of lamps sold in 2010 as estimated by experts in the USA, Europe and Australia. Lamps in preceding years are *likely* to have shorter lifetimes and this has not been accounted for in the benchmarking.