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Accounting for Durability in Least Life Cycle Cost Methods

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Circular Economy

- More than efficiency
- Resource recovery and closed loops
- Durable products

Current Ecodesign Requirements for Lighting

Requirements of EU Ecodesign regulations	Directional and LEDs	Non-directional lamps (italics for lamps excluding CFL and LEDs)
lamp survival factor at 6,000 hours	≥ 70% except LEDs ≥ 90% LEDs	≥ 70% ≥ 85 % at 75 % of rated average lifetime and 2000 hour minimum rated lifetime for lamps
lumen maintenance' at 6,000 hours	≥ 70 CFLs ≥ 80 LEDs	≥ 85 % at 75 % of rated average lifetime
number of switching cycles before failure	≥ 15,000 if rated lamp life ≥ 30,000 hours, otherwise ≥ half the rated lamp life expressed in hours	≥ lamp lifetime expressed in hours ≥ 30 000 if lamp starting time > 0.3 s ≥ four times the rated lamp life expressed in hours
premature failure rate (maximum number of failure products in %)	≤ 5 % at 1 000 h	≤ 2 % at 400 h ≤ 5 % at 200 h
'colour rendering' requirements for various applications	≥ 80	≥ 80

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The data : webcrawled (Big2Great)

Lifetime	≤15000 h (n = 130)	20000 h (n=44)	25000 h (n=139)	≥30000 (n=30)
Price	AVG: 13 € Range: 28-959 SEK	AVG: 15 € Range: 9-659 SEK	AVG: 14.4 € Range: 19-720 SEK	AVG: 15.2 € Range: 19-390 SEK
Lumens (lm)	AVG: 475 Range: 8-1800	AVG: 489 Range: 110-2200	AVG: 573 Range: 136-1522	AVG: 455 Range: 82-1500
Efficiency (lm/W)	AVG: 83 Range: 16-128	AVG: 72 Range: 37-100	AVG: 79 Range: 46-125	AVG: 68 Range: 27-120
Temperature (K)	AVG: 2700 Range: 1900-6500	AVG: 2850 Range: 1800-6500	AVG: 2700 Range: 2100-6500	AVG: 3000 Range: 2700-6000

The modelling

- Least lifecycle costs (LCC) is defined as:

$$LCC = P_A + PWF \cdot P_E \cdot UEC + EoL$$

where P_A is the appliance price, *PWF* is the present worth factor, P_E is the price of electricity, and *UEC* is the annual unit energy use and EoL is end of life costs.

- The durability of a product determines the lifetime, which in turn determines the present worth factor. The present worth factor can be defined as:

$$PWF = 1 - (1+i)^{-L} / i$$

Where *i* is the interest or discount rate and *L* is the product lifetime.

- Dividing by the present worth factor (which takes into account the influence of inflation and discount rates) gives an annualized LCC:

$$LCC/PWF = P_A/PWF + P_E \cdot UEC + EoL/PWF$$

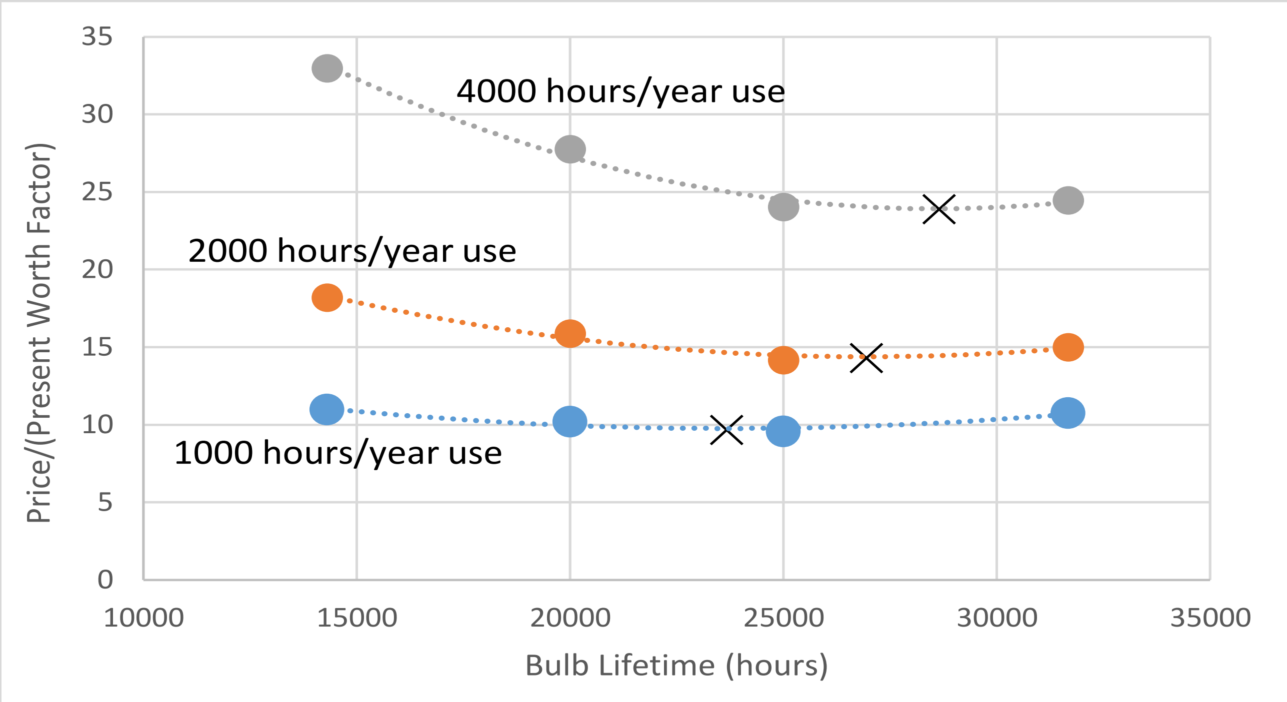
Modelling durability

- LED models in the data were binned into four categories: <15K hours, 20K hours, 25K hours and >30K hours and the price regression coefficients for each bin were calculated for a selected subset of LED bulbs.

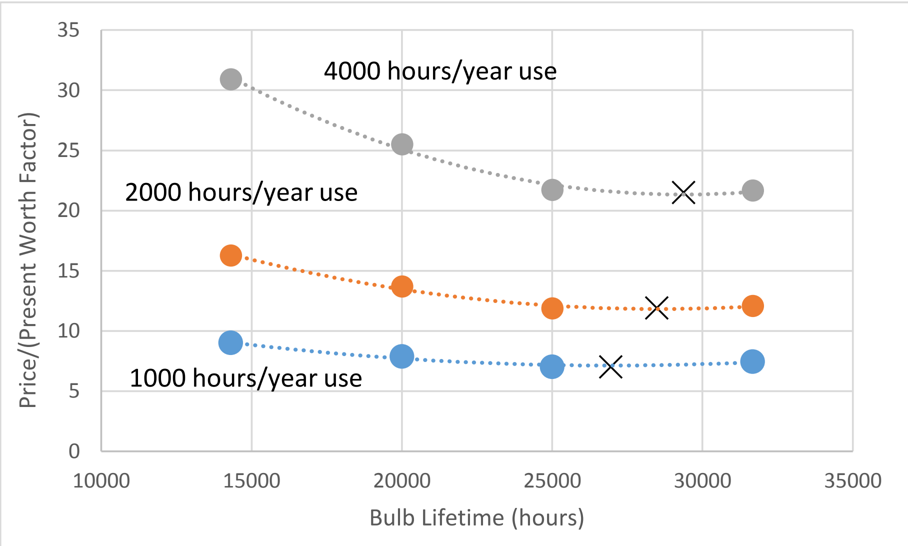
- The regression results were used to calculate price as a function of lifetime

- As PWF depends on the number of intensity of use, PWFs for three different scenarios of years, based on hours of operation per year - 1000, 2000 and 4000 lifetime hours.

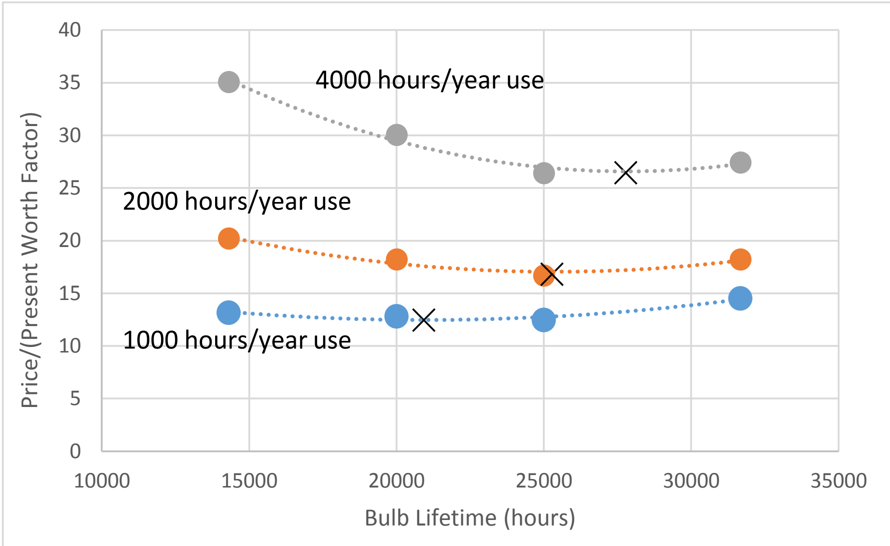
Analysis


4000 hours/year use
2000 hours/year use
1000 hours/year use
Price/(Present Worth Factor)
Bulb Lifetime (hours)
0
5
10
15
20
25
30
35
10000
15000
20000
25000
30000
35000

Discount factors - sensitivity



3% Discount factor



9% Discount factor

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Lifetime claims versus lifetime testing

- Standard testing methods focus on the lifetime of the LED components rather than the whole system.
- Often focus on lumen depreciation over catastrophic failure, though both are of concern (Narendran et al., 2016).
- Promising developments in accelerated testing procedures (Narendran, personal communication 3 March 2017)

Policy options for durability

Policy choice	Advantages	Disadvantages
Mandatory requirements	• Allows policymakers to make the appropriate trade-offs between different functions • The complexity of establishing 'durability' for lighting implies that mandatory requirements can be helpful	• Policymakers may interfere with decisions that are best taken by designers • Customers could use labelling to differentiate product lifetime according to their preferences
Mandatory labelling	• Allows consumers to choose products according to preferences, and provides for competition • Less intrusive for producers than mandatory	• Difficult for consumers to interpret information • Risk of cheating • The broad range of LED products and applications can lead to varying lifetimes in practice.
Voluntary extended warranties	• Useful in B2B applications where buyers can interpret technical information and enter into relevant contracts suitable for the purpose in which LED used	• Less useful for private buyers as the information is complex and the limited price of many LED products may mean that buyers are not very interested
Mandatory extended warranties	• Could be useful for consumers and increase confidence in LED products	• Not so useful in B2B relations

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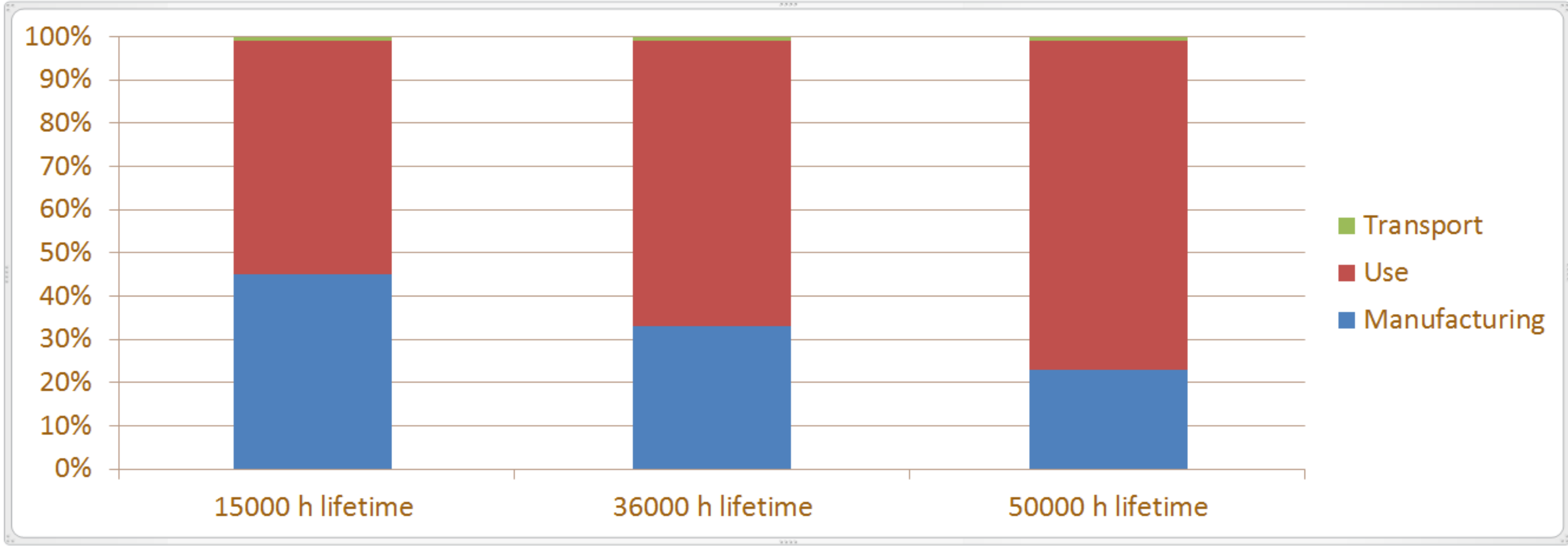
Moving forward



based on (Tähkämö et al., 2013)

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