## Energy and cost savings with high quality efficient lamp technology

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Indandescent</th>
<th>Halogen</th>
<th>CFL</th>
<th>LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumen (lm)</td>
<td>660</td>
<td>700</td>
<td>740</td>
<td>810</td>
</tr>
<tr>
<td>Watt (W)</td>
<td>60</td>
<td>46</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Efficacy (lm/W)</td>
<td>11</td>
<td>15</td>
<td>52</td>
<td>67</td>
</tr>
<tr>
<td>Lifetime (hrs)</td>
<td>1000</td>
<td>2000</td>
<td>10000</td>
<td>30000</td>
</tr>
<tr>
<td>Purchase price (€)</td>
<td>10</td>
<td>20</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>10 years*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy costs (€)</td>
<td>72 €</td>
<td>55 €</td>
<td>17 €</td>
<td>14 €</td>
</tr>
<tr>
<td>10 years*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Assumption: operation time 1000 hrs/a

**Fig. 4 Energy and cost savings**
Quality of lighting for homes has become a sensitive issue since the beginning of the phase-out of the incandescent lamps in 2009. Many buyers in EU countries were annoyed about the ban of incandescent lamp technology and felt uncertain how to properly replace lamps with new LED or CFL (compact fluorescent respectively energy saving lamps) products.

The good news is that today a wide variety of high quality lamps is available already for both CFL and LED allowing the replacement of classic incandescent lamps or also halogen lamps of any kind. The second good news is that energy efficient lighting pays off. The switch from incandescent lamps to CFL and LED technology allows energy and cost savings of 50-90% which corresponds to cost savings of several hundred Euros over the lamp lifetime (see table 1).

On the other hand it has to be considered that still many low to medium quality lamps are in the market which do not meet the typical quality requirements of consumers. Consequently it is quite important for buyers to make a critical good choice and select the products meeting the specific purposes and expectations.

The purpose of this brochure is to support buyers in selecting high quality efficient products for their specific needs. Thus the information provided will assist you in answering the following questions:

- What are the advantages and limitations of the different lamp technologies?
- What lamp type should I consider for a specific lighting purpose?
- How can I help to select efficient high quality lamps?
- Where can I get more information on good lamps?

High quality and energy efficiency pays off

6

Essential recommendations for selecting appropriate lamps for your specific purposes

1. Check the specific lighting requirements:
   - What is the purpose needed for the specific lamp for and where is it to be used? See options for different lamp technologies for different lighting purposes in figure 2 (page 16).
   - What type of lamp has to be replaced and what is the appropriate replacement option (LED or Energy Saving lamp)? See typical options for replacement in figure 3 (page 17).

2. Consider current quality and efficiency criteria for lamps before purchase: see criteria in table 7 (page 18).

3. Inform about efficient high quality products based on product tests or specific information services (e.g. www.premium-light.eu and www.eurotopten.eu).

4. Consider energy and cost savings over the product life cycle: see figure 4 (page 24) for further information.

5. Consider the information provided on the lamp packaging or on web-based information sources and compare to proposed criteria: see page 19.

6. If possible check the lamp for desired light quality (especially light colour).
Choose the desired brightness for any lighting purpose – Luminous Flux

For many years incandescent light bulbs has been selected based on the number of watts indicated on the product package. However the wattage in fact only indicates the energy consumption of the lamp and does not say anything about the concrete amount of light provided. Classic light bulbs, LED-bulbs or energy saving bulbs may all provide the same amount of light but at very different wattage.

Thus the appropriate indicator for selecting lamps of a desired brightness is not the wattage but the so called “Luminous Flux” of the light source (expressed in Lumen) which is the total amount of light emitted by the lamp. Fig. 1 below shows how the Luminous Flux of energy saving lamps and LEDs compares to the brightness of incandescent light bulbs. When selecting LED replacement lamps it is advisable to choose a somewhat higher lumen value compared to the original incandescent lamp because both CFLs and LEDs loose some percentage of their brightness over time. Thus a higher initial value allows a comparable average brightness over the lamp lifetime.

**Fig. 1 Typical luminous flux of energy saving lamps (CFLs and LEDs) corresponding with wattages of classic incandescent light bulbs.**

<table>
<thead>
<tr>
<th>Incandescent bulb</th>
<th>LED lamp</th>
<th>CFL lamp</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 watt</td>
<td>140 lumen</td>
<td></td>
</tr>
<tr>
<td>25 watt</td>
<td>250 lumen</td>
<td></td>
</tr>
<tr>
<td>40 watt</td>
<td>470 lumen</td>
<td></td>
</tr>
<tr>
<td>60 watt</td>
<td>800 lumen</td>
<td></td>
</tr>
<tr>
<td>75 watt</td>
<td>1,050 lumen</td>
<td></td>
</tr>
<tr>
<td>100 watt</td>
<td>1,520 lumen</td>
<td></td>
</tr>
</tbody>
</table>

**Candela** Indicates how much light a directional lamp emits in one direction.

**Lumen** is the unit of light output. It tells you how much light the lamp will produce.
Lamps for domestic lighting are expected to meet certain quality requirements regarding light colour and the representation of colours of lighted objects.

Regarding “light colour” of white light, consumers can typically choose between so-called warm-white, neutral white and cold-white lamps. The light colour is declared by the colour temperature of the lamp expressed in Kelvin (K declared on the lamp package). A warm white light colour (more yellowish) is 2600–3200K and cool-white (clear white to bluish) is 4000–5000K. Table 1 shows the available and recommended colour temperatures respectively light colours for different lamp technologies.

Besides the light colour also the ability of a light source to represent the various colours of lighted objects in a room is an essential quality criterion. It is typically expected that colours of lighted objects should appear as natural as possible. The quality of colour representation is measured with the so-called colour rendering index (Ra). This index indicates how well 8 test colours are represented by a specific light source (see Tab 2.). Table 2 shows available levels of colour rendering for the different lamp technologies. Classic light bulbs and halogen lamps provide the maximum colour rendering which is Ra=100. Colour rendering above 80 is good, above 90 is very good.

**Tab. 1 Available and recommended colour temperature for different lamp types**

<table>
<thead>
<tr>
<th>Lamp type</th>
<th>Colour temperature (Kelvin)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent</td>
<td>2,500 warm white (K)</td>
</tr>
<tr>
<td>Halogen</td>
<td>3,000 warm white (K)</td>
</tr>
<tr>
<td>Energy saving (CFL)</td>
<td>4,000 neutral/cold white (K)</td>
</tr>
<tr>
<td>Fluorescent tube</td>
<td>6,000 cold white (K)</td>
</tr>
<tr>
<td>LED</td>
<td>7,000 cool white (K)</td>
</tr>
</tbody>
</table>

**Tab. 2 Available colour rendering of different lamp types**

<table>
<thead>
<tr>
<th>Lamp type</th>
<th>Colour rendering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent</td>
<td>100</td>
</tr>
<tr>
<td>Halogen</td>
<td>95</td>
</tr>
<tr>
<td>Energy saving (CFL)</td>
<td>90</td>
</tr>
<tr>
<td>Fluorescent tube</td>
<td>85</td>
</tr>
<tr>
<td>LED</td>
<td>80</td>
</tr>
</tbody>
</table>

-get familiar with lighting basics-
Spend a thought on durability of products – Lamp lifetime and switching cycles

Besides brightness and light colour also lamp lifetime is an essential quality criterion typically considered by the consumers. Many consumers already have made the experience that some energy saving lamps died away long before they reached the operating hours indicated on the lamp packages. This disappointment however is not due to wrong declaration by the manufacturer or a specific problem of the lamp. It is in fact due to a common misunderstanding caused by the specific type of declaration. The average lamp life time indicated on lamp packages only indicates the minimum operation time of lamps after which at least 50% of the lamps have to be still functioning. Thus it is quite legal that 50% of the lamps already are damaged before the specific lifetime indicated on the package. In concrete terms: if for a specific lamp an average lifetime of 10000hrs is indicated on the package only every second lamp is expected to meet this value in practice.

For the more recent lamp technologies CFL and LED it furthermore has to be taken into account that the amount of light provided is decreasing over time. Thus after several thousand hours the luminous flux may decrease by 50 or more percent of the original value before the lamp finally fails completely. Thus for LEDs a so called useful lifetime is defined, indicating an operation period after which at least 70% of the original light-output is maintained and at least 50% of the lamps are functioning (so called L70F50 value).

As a general recommendation the average lifetime of good compact fluorescent lamps should be higher than 10 000hrs and higher than 25 000hrs for good LEDs (see also table 3 for available and recommended minimum lifetime).

Select energy efficient products

The energy efficiency of lamps (also called efficacy) is expressed as luminous flux (lm) produced per power demand (watt). The available lamp technologies differ markedly in terms of amount of light provided per power draw. Efficient fluorescent lamps and LED lamps are 5-10 times more efficient than classic incandescent lamps and still 2-5 times more efficient than halogen lamps. Thus LEDs and CFLs allow 50-90% of energy and energy cost savings depending on the previously used lamp type.

**Tab. 3 Available and recommended levels for average lamp lifetime (h)**

<table>
<thead>
<tr>
<th>Lamp type</th>
<th>Average lamp life time (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent</td>
<td>10000</td>
</tr>
<tr>
<td>Halogen</td>
<td>20000</td>
</tr>
<tr>
<td>Energy saving</td>
<td>30000</td>
</tr>
<tr>
<td>Fluorescent tube</td>
<td>40000</td>
</tr>
<tr>
<td>LED</td>
<td>50000</td>
</tr>
</tbody>
</table>

**Tab. 4 Available and recommended levels for lamp efficacy (lm/W)**

<table>
<thead>
<tr>
<th>Lamp type</th>
<th>Efficacy (lm/W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incandescent</td>
<td>10</td>
</tr>
<tr>
<td>Halogen</td>
<td>20</td>
</tr>
<tr>
<td>Energy saving</td>
<td>40</td>
</tr>
<tr>
<td>Fluorescent tube</td>
<td>50</td>
</tr>
<tr>
<td>LED</td>
<td>80</td>
</tr>
</tbody>
</table>
LED technology has rapidly developed during the last years and various lamp designs are already available for any type of lighting purpose in households. Thus besides the well-known fluorescent lamps LED is the most promising technology for which further extensive development is expected for the upcoming years.

What is a LED lamp?
LED stands for “light emitting diode”. In contrast to classic incandescent lamps LEDs do not emit light from a heated filament but by transfer of electrons in a diode respectively a semiconductor material. Semiconductor materials are used in many electronic devices. The UV-radiation emitted due to electron transfer is transformed to white light by a specific coating of the LED (similar to energy saving lamps):

What types of LEDs are available and recommended for lighting in households?
Besides a large number of specific LED designs used for the professional lighting sector mainly the following three lamp design types are available for use in households.

• LED-Bulbs: Are partly recommended as replacement for incandescent and halogen lamps but depending on type of use not always the better solution than compact fluorescent lamps (see on page 17).
  • LED Bulbs are the better choice than CFLs when:
    › immediate full light output is required
    › mercury shall be avoided for safety reasons (e.g. nursery)
    › better colour rendering is needed (check for high quality LED with Ra>90)

• LED-Spots: Are generally highly recommended as replacement for halogen spots. LED spots provide several times the lifetime and energy efficiency compared to halogen lamps at comparable light quality.

WITH THESE RECOMMENDATIONS YOU WILL FIND TOP QUALITY LED BULBS AND SPOTS:
• Energy efficiency class is A+
• Their average life-time is 25 000 hours which equals to 25 years
• Colour rendering index (CRI) is at least 80 Ra, preferably > 90 Ra
• And they will last at least 25 000 switching cycles
**LED-Tubes:** Are not recommended as replacement for fluorescent tubes. LED is not the appropriate technology for tube design lamps, fluorescent tubes are still the better alternative.

- LED tubes provide only slight advantages regarding efficiency
- LED tubes show asymmetric light distribution not suitable for standard luminaires
- Replacement of fluorescent tubes by LED tubes in existing luminaires by means of adapters may cause problems regarding warranty and safety issues.

**LEDs integrated in LED-luminaires:** Integrated LED luminaire designs where the LED-lamp is fixed in a specific luminaire are already quite common and of high quality for the professional sector. For the household sector products have to be checked with care as quite different quality may be offered.

**What are the specific benefits of LEDs**

LED-technology provides a number of advantages which makes it a primary choice for different applications. However it also has some limitations and consequently there are some types of use where other lamp technologies are preferable. The current benefits are:

- ✓ High efficiency
- ✓ Long lifetime
- ✓ Full light at lamp start
- ✓ Good colour rendering (for high quality lamps)
- ✓ Good dimmability (however consider, that an adequate dimmer is necessary)
- ✓ No heat emission in the light beam
- ✓ Optimum technology for directional lighting (e.g. spots)
- ✓ No mercury
What are the current limitations of LEDs?

Besides several advantages there are also some limitations of the LED technology which makes LED lamps not necessarily the best choice for every type of lighting task.

- The purchasing price of LEDs is still 2-3 times the price for CFLs. Thus the investment only pays-off if the lamps meet an indicated lifetime of >25-30000hrs, which is not generally offered for LEDs. Low lifetimes of 15000hrs are only acceptable at considerably lower price levels.
- The light distribution of bulbs is not always comparable to typical classic bulbs but more comparable to wide angle spot lamps.
- LEDs are temperature sensitive. Efficacy and lifetime is strongly reduced if lamps are overheated. Thus good lamp design and proper lamp placement is essential for long lifetime and efficiency.
- LEDs use semiconductor materials which are currently attained mainly in China under circumstances of significant environmental destruction. A comprehensive Eco-Rating also has to consider such negative impacts.

Find out tested high quality LED lamps listed at www.premiumlight.eu > test
What to consider for top quality PremiumLight lamps?

Table 5 provides recommendations for the selection of top quality LED lamps. For mid European and northern countries typically warm white colour temperature (2700–3200K) is requested whereas southern countries have some preference for cool-white (4000–5000K). Colour rendering should be at least Ra>80 for adequate and at least >90 for very good representation of light colours of objects in the lit room. Number of lifetime in hours should be at least 25 000 and efficiency should be class A+ for bulbs and at least 55lm/W or A+ for spots.

**Tab. 5 PremiumLight criteria for high quality efficient lamps (preliminary)**

<table>
<thead>
<tr>
<th>CRITERION</th>
<th>LED BULB</th>
<th>LED-SPOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour temperature (K)</td>
<td>2700–3200</td>
<td>2700–3200</td>
</tr>
<tr>
<td>Colour rendering</td>
<td>80 (&gt;90)</td>
<td></td>
</tr>
<tr>
<td>Average lamp life-time (h)</td>
<td>&gt;25000</td>
<td></td>
</tr>
<tr>
<td>Switching cycles</td>
<td>&gt;25000</td>
<td></td>
</tr>
<tr>
<td>Effeciency class: basic efficiency criterion according to label</td>
<td>A+</td>
<td>Min. 55 lm/w (a+)</td>
</tr>
</tbody>
</table>
In December 2008 the EU decided to phase out incandescent bulbs because of their high energy consumption respectively very low efficiency. Subsequently all incandescent lamps used in domestic lighting have been removed from the market in a staged process between 2009 and 2012. Many consumers were annoyed by this new legal restriction. During the phase-out period campaigns have been launched accusing compact fluorescent lamps to be of low quality and harmful for health and the environment.

However such simplified prejudices at best may be true for some still existing low quality lamp products. High quality CFL and LFL products however provide good light with negligible impact on health and environment. The following section shows for what types of lighting applications CFL and LFL are still a good choice and what is to be considered for the selection of quality products.

What is a fluorescent lamp?
Compact fluorescent lamps and fluorescent tubes both are glass tubes filled with mercury gas. For the compact lamps the tube typically is bent to achieve a compact design (e.g. typical stick or spiral or bulb design). If a voltage is applied to the mercury gas UV-light is emitted and transformed to white light by the fluorescent coating of the lamp tube. Various types of phosphorus are used for the lamp coating. The specific colour of the light depends on both the coating and the gas filling. Fluorescent lamps typically need an electronic device that starts the lamp and limits the current in the lamp. This device (also called ballast) is either integrated into the lamp or an external part attached to the luminaire.

Find out tested high quality CFL lamps in www.premiumlight.eu
What types of CFLs and LFLs are available and recommended for lighting in households?

Fluorescent lamps are available in different designs which are partly only used in office environments:

• Compact fluorescent lamps with integrated ballast (also called CFL or Energy Saving Lamps):
  
  This type of lamp is available in four typical designs including candle-type, stick-type, spiral-type and bulb-type. Bulb type lamps have the same design as classic incandescent bulbs. However they need two glass covers and are therefore slightly less efficient than stick and spiral type designs. Energy saving lamps are still recommended for applications where:

  • the typical warm-up time of the lamps is not relevant
  • a very efficient and relatively cheap lamp is required
  • dimming is not required
  • colour rendering does not need to be excellent
  • no brilliant light is required but diffuse light is acceptable

  • Compact fluorescent lamps with external ballast
  
  For this lamp type the electronic device is not integrated into the lamp but typically attached to the luminaire. This type of lamps is common for offices but rarely used in domestic environments.

WITH THESE RECOMMENDATIONS YOU WILL FIND TOP QUALITY CFLs

  • Energy efficiency class is A
  • Their average life-time is 10 000 hours which equals to 10 years
  • Colour rendering index (CRI) is at least 80 Ra, also found in 90 Ra
  • And they will last at least 10 000 switching cycles
• **Fluorescent tubes (LFL)**

Linear tube type lamps are the oldest design of fluorescent lamp technology that has been used in office buildings for several decades already. This lamp type is typically available with high luminous flux, therefore also recommended as a good alternative for locations where bright light is needed e.g.

- in kitchens (e.g. above stove)
- in bathrooms (e.g. above basin or mirror).

Modern highly efficient lamps are the so called T5 tubes, which are also available with high colour rendering. Fluorescent tubes require external electronic devices (ballasts) for the lamp start and current limitation. Only luminaires with so called electronic ballasts should be bought, as these allow better energy efficiency and better light quality compared to old magnetic ballast technology.

• **Fluorescent reflector lamps**

Alternatively to halogen spot lamps so called fluorescent reflector lamps are also offered on the market which have a typical mushroom-type design. However in consideration of the fast developing LED spot lamp technology fluorescent reflector lamps are a minor product segment and not specifically recommended anymore.

**What are the current limitations of LFLs?**

The following limitations indicate for which situations fluorescent lamps are not the best choice:

- Warm-up-time until full light output (not suitable for rooms with very short use, e.g. toilets)
- Limited dimmability of CFLs (limited number of dimmable lamps, appropriate dimmer required)
- Mercury content (proper recycling as special waste required)
- Only diffuse light (no clear lamps available)
What are the specific benefits of CFLs and LFLs?

High quality fluorescent lamps provide a good option for many lighting applications in households. The typical benefits of the technology are:

- High efficiency (3-4 times more efficient than halogen lamps)
- Long lifetime (5-10 times of halogen lamps)
- Good light quality for many general lighting purposes which do not require brilliant light
- Low purchasing prize compared to LED
- Good switching capability of lamps specifically designed for frequent switching

What to consider for top quality PremiumLight lamps?

The following table provides recommendations for quality requirements of fluorescent lamps. Criteria for colour temperature and colour rendering are basically the same as for LEDs. Average lamp lifetime and switching cycles should be higher than 10000 for CFLs and 20000 for LFLs. Efficiency criteria a for CFLs and for LFLs.

Tab. 6 PremiumLight criteria for efficient high quality lamps

<table>
<thead>
<tr>
<th>CRITERION</th>
<th>COMPACT FLUORESCENT LAMP</th>
<th>FLUORESCENT TUBE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour temperature (K)</td>
<td>2700–3200 K</td>
<td>2700–3200 K</td>
</tr>
<tr>
<td>Colour rendering</td>
<td>&gt;80 (&gt;90 only special high quality lamps)</td>
<td></td>
</tr>
<tr>
<td>Average lamp life-time (h)</td>
<td>&gt;10000</td>
<td>&gt;20000</td>
</tr>
<tr>
<td>Switching capability (Switching cycles)</td>
<td>&gt;10000 (&gt;500000²)</td>
<td>&gt;20000</td>
</tr>
<tr>
<td>Energy efficiency (Efficacy based on EU- label)</td>
<td>A</td>
<td>A+ Min. 90 lm/W</td>
</tr>
</tbody>
</table>
Halogen lamps – the remaining option for special purposes

Halogen lamps have been popular for many years especially for use in spot design luminaires and uplighters. Since the phase-out of the incandescent lamp, halogen lamps have been offered in many retro design types which allow direct replacement of classic light bulbs with lamps.

The halogen technology is based on the same technological principle as classic incandescent lamps and therefore provides basically the same advantages regarding light quality. Nevertheless halogen lamps are among the least efficient technologies and provide only short lamp lifetime. The use of the technology therefore should be restricted to applications where no other technology provides the required benefits. According to EU legislation all halogen lamps below efficiency B shall be removed from the EU market after 2016.

What is a halogen lamp?

Halogen lamps are basically advanced incandescent lamps. The technological principle of the halogen lamp is also a heated filament which emits light. In contrast to the classic incandescent lamp the halogen lamp bulb contains a halogenated gas. This allows a higher filament temperature and lifetime. The compact lamp design allows a higher pressure in the bulb. Overall the technology provides a longer lamp lifetime, a higher colour temperature and a better energy efficiency compared to classic light bulbs.

What types of halogen lamps are available and recommended for lighting in households?

The main halogen lamp designs currently sold on the EU market are:

- **Spot lamps**
  
  Spot lamps are either sold for standard high voltage applications (with so called GU10 socket) or as low voltage lamps (GU5.3 socket). The use of halogen spots is not recommended anymore since the lamps can already be replaced by LED spots with 10-20 times higher lifetime and 3-4 times higher efficiency. Low voltage halogen lamps are somewhat more efficient than high voltage lamps reaching efficiency class B (respectively a little more than 20 lm/W).

- **Retro design replacement bulbs**
  
  This type of lamps provides almost identical light quality as classic incandescent lamps however at very low efficiency and lamp lifetime. Thus such lamps should only be used where really needed, thus where brilliant light is required and replacement by CFL or LED is not possible.

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**WHAT ARE THE SPECIFIC BENEFITS OF HALOGEN LAMPS?**

Halogen lamps should only be used for applications where really needed due to specific lighting requirements. The typical benefits of the technology are:

- **Brillant light**
- **Optimum colour rendering near 100%**
- **No warm-up time**
- **No mercury (can be disposed in normal waste)**
- **Low purchasing prize**
What are the current limitations of halogen lamps?

The following disadvantages will limit the application of halogen lamps in the future:

× Very low efficiency respectively high energy consumption (CFL and LED is 2-4 times more efficient)
× Low lifetime (mostly only 2000-3000hrs)
× High surface temperature of lamps

What to consider for top quality PremiumLight lamps?

There are no PremiumLight criteria for halogen lamps because there are no energy efficient products on the market. This is due to the specific limitations of the filament lamp technology. However if the choice is focused on halogen lamps for certain reasons it can generally be recommended to select:

• lamps with at least 3000hrs lamp lifetime
• low voltage lamps (especially for spots)
How to select a good lamp?

Many consumers have made the bad experience that some lamps quickly chosen at some grocery store or retail market do not fulfill the expectations when installed at home. Selecting an efficient high quality lamp can be a demanding challenge if you are not prepared with some essential information.

The following section provides you with an easy 3-step approach how to select a good lamp for your specific need:

**STEP I: CHECK THE SPECIFIC PURPOSE AND LOCATION WHERE THE LAMP WILL BE INSTALLED**

The figure 2. below shows you typical lighting purposes in different rooms and appropriate lamp types to choose from.

- Consider what lamp types are appropriate for specific rooms and lighting purposes > Fig 2
- Consider the typical options how you can replace old inefficient lamps by efficient energy CFL and LED lamps > Fig.3
- Select the desired lamp type

- Check the appropriate lamp brightness, respectively the luminous flux desired for the lamp type you have selected > Fig.1 (the light-output should correspond with the original lamp, see page 3).

*Fig. 2 Consider your specific lighting purpose and the appropriate lamp technology*
Check the replacement options from old incandescent and halogen to LED and CFL technology.

**Bulb type lamps**

- **Incandescent Bulb**
  - Efficiency class: E - G
  - + 75-80% reduced energy consumption
  - + 10-15 times longer lifetime
  - + Comparably low purchasing price
  - + Significant cost savings over lamp lifetime
  - - High purchasing price
  - - Light distribution different from classic CFL

- **CFL Bulb E27/E14**
  - Efficiency class: A
  - + 75-80% reduced energy consumption
  - + 10-15 times longer lifetime
  - + Significant cost savings over lamp lifetime
  - - Significant warm up time
  - - Mercury content

- **LED Bulb E27/E14**
  - Efficiency class: A+
  - + 75-80% reduced energy consumption
  - + 10-30 times longer lifetime
  - + Significant cost savings over lamp lifetime
  - - High purchasing price

**Spot type lamps**

- **Halogen Bulb**
  - Efficiency class: C
  - + 85-90% reduced energy consumption
  - + 10-30 times longer lifetime
  - + Significant cost savings over lamp lifetime
  - - High purchasing price
  - - Mercury content

- **LED Pin Lamp G4**
  - Efficiency class: A
  - + 75-85% reduced energy consumption
  - + 10-30 times longer lifetime
  - + Significant cost savings over lamp lifetime
  - - High purchasing price

- **LED Spot GU5.3**
  - Efficiency class: A+
  - + 75-85% reduced energy consumption
  - + 10-30 times longer lifetime
  - + Significant cost savings over lamp lifetime
  - - High purchasing price

- **LED Spot GU10**
  - Efficiency class: A
  - + 75-85% reduced energy consumption
  - + 10-30 times longer lifetime
  - + Significant cost savings over lamp lifetime
  - - High purchasing price

*Fig. 3 How to replace old inefficient lamps to CLF and LED technology*
**STEP II. BE INFORMED ABOUT THE ESSENTIAL QUALITY AND EFFICIENCY CRITERIA FOR YOUR LAMP TYPES**

It is essential to get informed about the most important quality and efficiency criteria you have to consider. These are the

- Light colour (colour temperature)
- Lamp life time
- Colour rendering
- Efficacy (energy efficiency)

Table 7 shows you recommended levels for these criteria for efficient high quality lamps proposed by the PremiumLight project.

**Tab. 7 General quality and efficiency criteria recommended by PremiumLight**

<table>
<thead>
<tr>
<th>CRITERION</th>
<th>ENERGY SAVING LAMP</th>
<th>LED-BULB</th>
<th>LED-SPOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour temperature (K)</td>
<td>2700–3200</td>
<td>2700–3200</td>
<td>2700–3200</td>
</tr>
<tr>
<td>Colour rendering</td>
<td>&gt;80</td>
<td>&gt;90</td>
<td>&gt;80</td>
</tr>
<tr>
<td>Average lamp life-time (h)</td>
<td>&gt;10000</td>
<td>&gt;25000</td>
<td>&gt;25000</td>
</tr>
<tr>
<td>Switching cycles</td>
<td>&gt;10000 (&gt;500000*)</td>
<td>&gt;25000</td>
<td>&gt;25000</td>
</tr>
<tr>
<td>Efficiency Class: Basic efficiency criterion according to label</td>
<td>A</td>
<td>A+</td>
<td>A+</td>
</tr>
</tbody>
</table>

* for applications with frequent switching

Information on concrete lamp models meeting such requirements is provided in the product section of PremiumLight website and in other specific web-services offered in the different EU-countries (e.g. www.topprodukte.at). If you check these services you find a large number of recommended lamps. Further important information sources for your lamp selection to be considered are:

- Information on product packages (see example beside)
- Information from independent product testing (see also testing results on PremiumLight website)
- Visual testing of lighting quality at the point of sale
STEP III. COMPARE THE INFORMATION PROVIDED ON LAMP PACKAGES

The relevant information for your lamp selection is provided on the lamp packages or in the product information provided in webshops. Compare the information with criteria recommended in section II.

| Power demand in watt compared to power demand of incandescent lamp: | This shows the power demand of the lamp and of a comparable incandescent lamp of the same light-output. The information can be used to select the right lamp comparable to an incandescent lamp to be replaced. |
| Lumen: Luminous flux (respectively brightness of lamp) | The lumen indicates the light-output (or brightness) of a specific lamp |
| Watt (W): | Wattage of the lamp |
| Lumen per watt (lm/W): | Lumens of the lamp per its power, which tells about the lamp's efficacy. |
| Colour temperature in Kelvin (K): | warm white (2700-3200K), neutral white (3200-4000K) or cold white light (4000-6500K) |
| Colour rendering index (CRI): | The colour rendering index indicates how good a specific lamp shows the different colours of objects. The maximum colour rendering is Ra=100. Ra>80 is mandatory, Ra>90 is very good. |
| Average lifetime in hours/years: | (time after which at least 50% of the lamps are fully functional) |
| Mercury content: | Mercury content is only relevant for fluorescent lamps. For good lamps it should be less than 2,5mg. |
| Warm-up time until 60% of brightness is reached: | Fluorescent lamps need a warm-up time until full light output. If the lamp is used in a location where fast warm-up is needed, select model with short warm-up time. |
| Energy efficiency class according to label: | Fluorescent lamps should belong at least to class A, LEDs preferably should belong to class A+. To date no A++ are available. The best products are A+. |
| Switching capability: | Switching capability (switching cycles) indicates how often a lamp can be switched before failure. For locations with frequent switching models with much higher switching cycles can be selected. |
| Option of dimming: | In case you want to dim your lighting consider if the lamp is dimmable (shown by the specific symbol). |
Consider proper handling and disposal of your lamps!

How to properly dispose different lamp types?

Halogen lamps, fluorescent lamps and LEDs use different technology and therefore also different chemical compounds. Thus you have to take different considerations for proper disposal.

Halogen lamps and LEDs do not contain mercury. However due to some electronic components the lamps are to be disposed as electronic waste.

You can
✓ return the lamp to the retailer where it has been bought
✓ bring the lamp to electronic waste collection point.

Fluorescent lamps contain small amount of mercury and therefore have to be disposed as special waste.

What to do if a lamp breaks?

If a fluorescent breaks, small amounts of mercury vapor may be emitted. This is normally not a significant risk if the following measures are considered:
✓ Avoid any direct contact between lamp parts and your skin
✓ Do not inhale the vapour containing Hg
✓ Ventilate the room
✓ Collect the lamp parts with a cardboard or other device you also dispose with the lamp afterwards. Do not use any cleaning tools which will be used again
✓ Put the lamp parts in an airtight container and dispose them at a special waste service.

The WEEE-directive obliges all manufacturers of electric and electronic equipment (including CFLs and LEDs) to take back used products. Aluminium is one of the most cost-effective materials to recycle, suitable to be used again without loss of quality.

What you should know about potential health and environmental effects

Potential impacts of lamp technologies on health and environment have been discussed during the phase-out of the incandescent lamps. Studies have shown, potential impacts are low respectively negligible if lamps are operated and disposed properly.

Electromagnetic fields (EMF)

In our daily life, electromagnetic fields appear from electrical appliances as mobile phones, TV receivers, PC, TV, kitchen equipment and lighting sources. In case of too close or prolonged exposure to an electromagnetic field negative impacts affecting nerves and muscles may occur.

The institute ITIS has measured the magnetic and electric fields of CFLs and simulated the induced current in the human body. ITIS found that the electric fields were 50 times lower than levels necessary to affect nerves and muscles. Thus there is no risk if a certain minimum distance to lamps is considered. The specific study, as well as other studies recommend to keep a distance of minimum 20-30 cm to CFLs if exposed for longer periods. LED components are not likely to emit a significant EMF. The levels of EMF should be comparable with those emitted by an electronic transformer. CFL and LFL produce larger electric fields because their electrodes are connected to high voltage sources.

UV-radiation

UV-radiation has sometimes been discussed as a potential negative effect of fluorescent lamp technology. However studies have shown that typical UV-levels are negligible if a minimum distance of 20cm from the lamps is kept for situations with long-term exposure. Such long-term exposure may occur for example at work places or in bedrooms. There are about 250000 people living in the EU which are suffering from diseases which make them more sensitive to light. This specific group should take more care when selecting specific light sources.

Photobiological safety

Photobiological hazards are related to the effects of optical radiation on the skin and the eye. High levels of light on the retina in theory could cause thermal damage and photochemical damage in the eye. Due to the high brightness, bare LEDs and LEDs operated with lenses may have high radiance levels. This is not an issue for classic double capped retrofit LED bulbs. Current LED technologies for LED retrofit lamps do not reach critical levels.

However a negative impact due to high intensity blue light emissions may be an issue especially for some LED products with bare LEDs emitting large amounts of blue light, in case the viewer is exposed at short distances.
**Light flickering**

Light flickering might appear from most types of lighting sources. Flickering shall be limited as it might cause negative effects like headache, blurred vision, eyestrain, reduced visual task performance etc.. Light flicker is related to the power supply quality. Today many CFLs provide reduction of flicker to 18% even with inexpensive driver technologies. This minimum acceptable quality level is comparable to flickering of very low-power incandescent lamps (e.g. 25 W).

CFL and LED lamps flickering might be especially a problem in dimming conditions. Dimmer compatibility therefore shall be stated by the manufacturers.

**Mercury content**

The Mercury content of todays CFLs is relatively low and may not exceed 2,5 mg. Despite these very low levels it has to be considered, that in case of lamp damage one must take previously mentioned measures.

More than from lamps, mercury emissions are generated in electricity production. If we can save energy by using CFLs and LEDs, this will also decrease the amount of mercury released into the environment from energy production. As CFLs are recycled, the mercury they contain is recovered and prevented from harming the environment. LED lamps do not contain mercury.
Glossary

**Candela:** Indicates how much light a directional bulb emits in one direction.

**Colour Rendering Index (CRI):**
See "Rendering”.

**Energy efficiency:** How much light a light source provides in relation to energy consumption (light output). Measured in lumens per watt (lm / W).

**Colour rendering:** Light source’s ability to reproduce colours faithfully. Can both be expressed in CRI or Colour Rendering Index (CRI) which are two names for the same number.

**Colour Temperature:** The colour temperature describes light’s own colour and indicates whether the light is warm or cold. Shown in Kelvin (K), where the scale is from 0 to 10,000 K. The lower the temperature, the warmer light.

**Ballast:** Fluorescent tubes and energy saving bulbs can not be connected directly to the mains. It is necessary to include a ballast, which transforms the current and voltage to the supply the bulb requires. In retrofit CFL bulbs are ballast built into the lamp socket.

**Built-in driver:** LEDs need a driver to provide the proper power. In 230 V LED supply voltage driver built in the bulb socket. In 12 V LED is a simple electronic circuit, which controls the flow from the transformer to the LEDs.

**Built-in transformer:** The most effective 230 V halogen bulbs (energy class B) has the transformer built into the lamp socket.

**Kelvin:** The different shades of white light (light colour temperature) measured with Kelvin scale (K).

**Brightness:** How much light a light source sends in a particular direction. Shown in candelas.

**CRI:** See "Rendering”. Reflector means a lamp having a mirror coating, which limits the light in the certain directions and instead sends more light in other directions.

**Directional light:** Some bulbs emit the light in a more or less narrow cone in one direction - for example spot light bulbs.

**Base:** The base of the bulb. May be formed with thread or pins.

**Watt / wattage:** Lamp power consumption and therefore determines the final light sources energy consumption.

**Lifespan:** Measured in hours (h). If lamp life is 1,000 hours, and the bulb used in almost 3 hours each day, equivalent to the bulb holder in one year. There is considerable difference in the life of the light source. Halogen and incandescent bulbs have the shortest lifespan.

**Luminous flux:** The visible light from a light source in all directions together. Shown in lumen (lm). Lamp packaging indicates lumen. Two lamps with the same lumen value, gives equal amount of light.