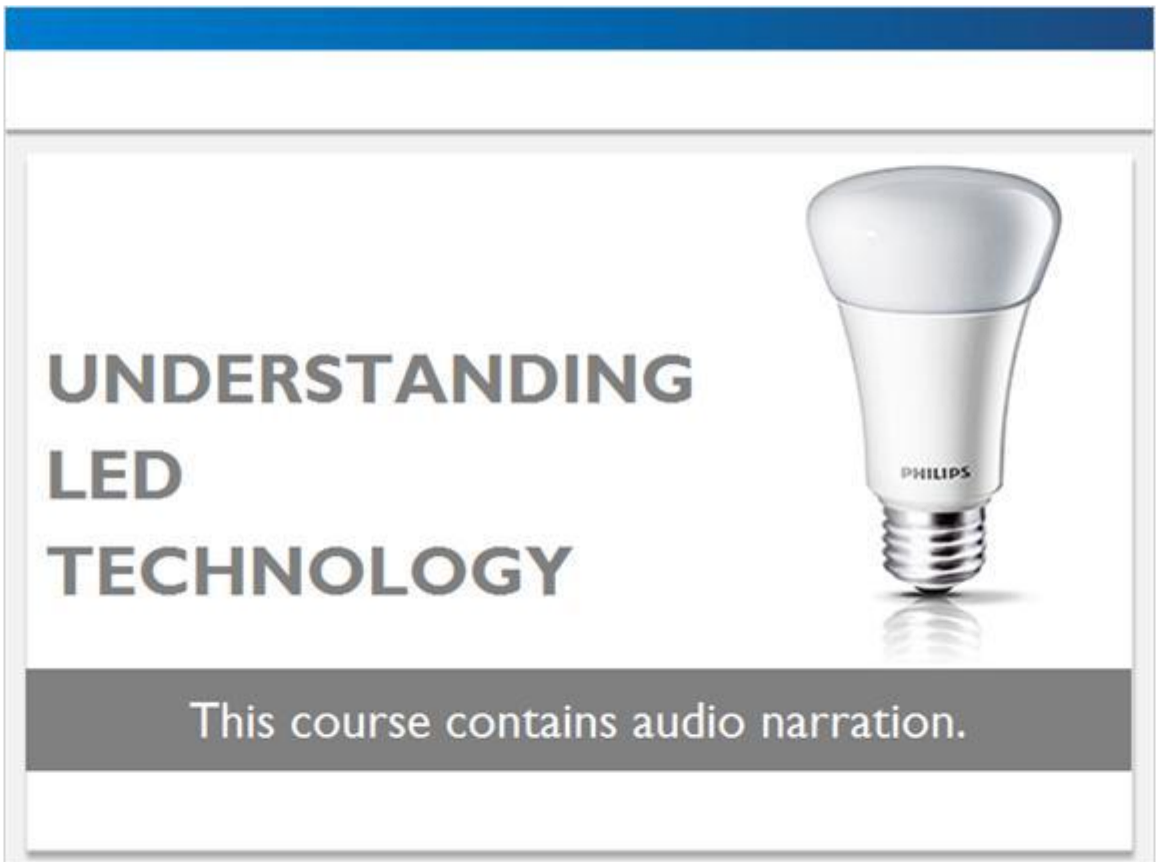
Understanding LED Technology

1. Understanding LED Technology

1.1 Welcome



Notes:

Welcome to the course on Understanding LED Technology.

1.2 Overview

Notes:

LED lighting represents the most sweeping change and the biggest opportunity in lighting since the invention of electric light sources.

After completing this course, you should be able to:

- Understand the LED market and the key LED opportunities
- Know the basics of LED technology
- Recognise the savings from controls
- Identify the trends in the market
- Know the rules for choosing good quality LEDs

1.3 The LED Market

1.4 LED Market

Notes:

The LED market is the fastest growing business in lighting today. It is projected that LED lighting will represent 75% of lighting business by 2020. This represents a remarkable and unique transformation in our lighted environment.

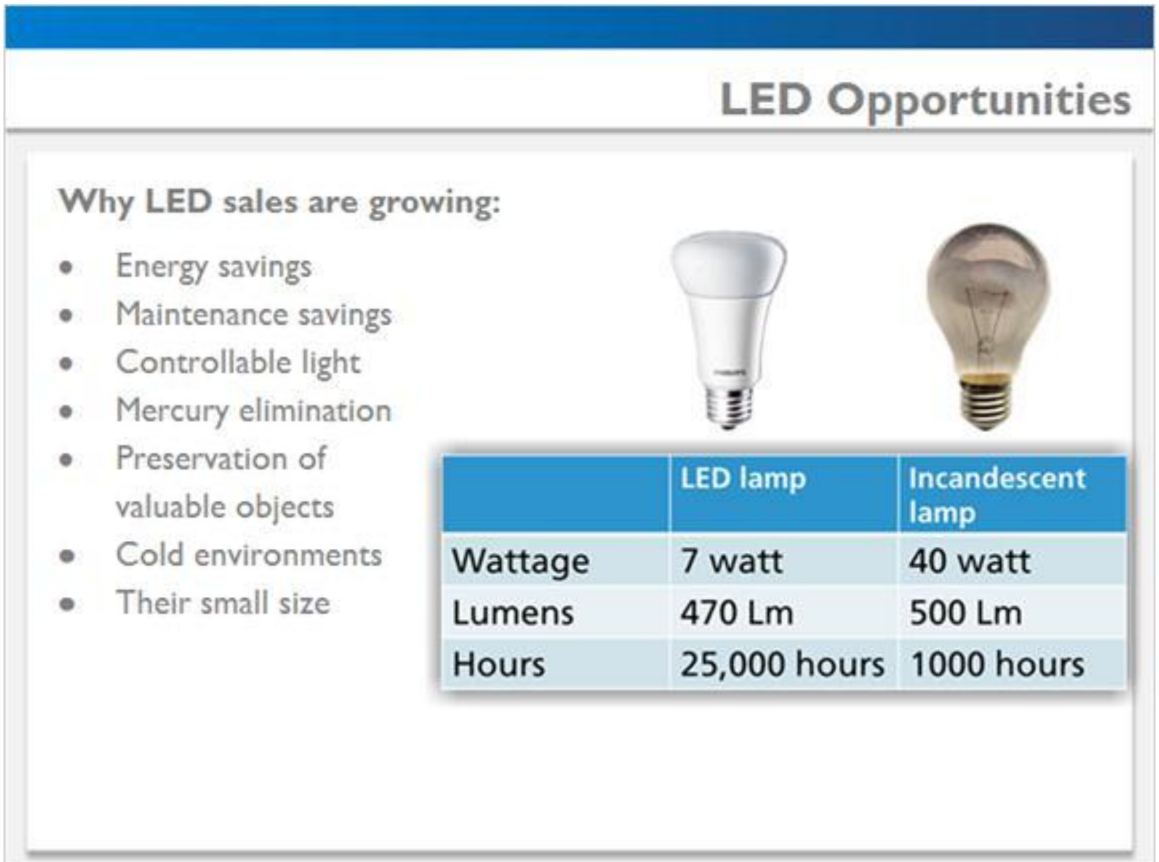
The LED market consists of many different lighting segments:

- LED chips and arrays, which produce the light
- LED modules that are ready for installation in luminaires
- Electronic drivers needed to properly energise the LEDs
- LED luminaires, and
- LED lamps designed to replace conventional incandescent and fluorescent lamps in existing fixtures

Market players include manufacturers, such as Philips; distributors and contractors; and a variety of organisations that influence technology, standards, and market adoption.

1.5 The LED Opportunities

1.6 LED Opportunities



	LED lamp	Incandescent lamp
Wattage	7 watt	40 watt
Lumens	470 Lm	500 Lm
Hours	25,000 hours	1000 hours

Notes:

Today, the rapid growth of LED lighting is driven primarily by the economic benefits that LED technology offers: most importantly, energy and maintenance savings.

The economic benefits are most significant when LEDs replace incandescent and halogen sources. Here's an example. A 7 watt LED lamp with 470 lumens consumes 77% less energy than a 40 watt incandescent with 500 lumens. Its rated life of 25,000 hours is twenty-five times as long. And, like many LED lighting products, it can be dimmed for additional energy savings. You should always check compatibility with the dimming system.

The many available energy rebate schemes increase the return on investment.

LED lighting offers other benefits as well. Unlike fluorescent and HID technology, LEDs contain no mercury. Further, LEDs emit virtually no infrared or ultraviolet radiation, which is important for material preservation in museums and retail stores.

LED lighting also operates effectively in cold environments (significantly better than fluorescent), which is important for cold storage and refrigerated displays.

The small size of LED emitters creates compact lamps and luminaires, as well as directional control of light into precise beams.

Note that LEDs are constantly improving their efficiency, light output, and life. The figures shown in this presentation are representative. Please check the actual data for the LED lamp that you are using.

1.7 Where is LED Lighting Used?

Notes:

For new installations, LED luminaires can be used for almost every application.

The biggest market sectors are:

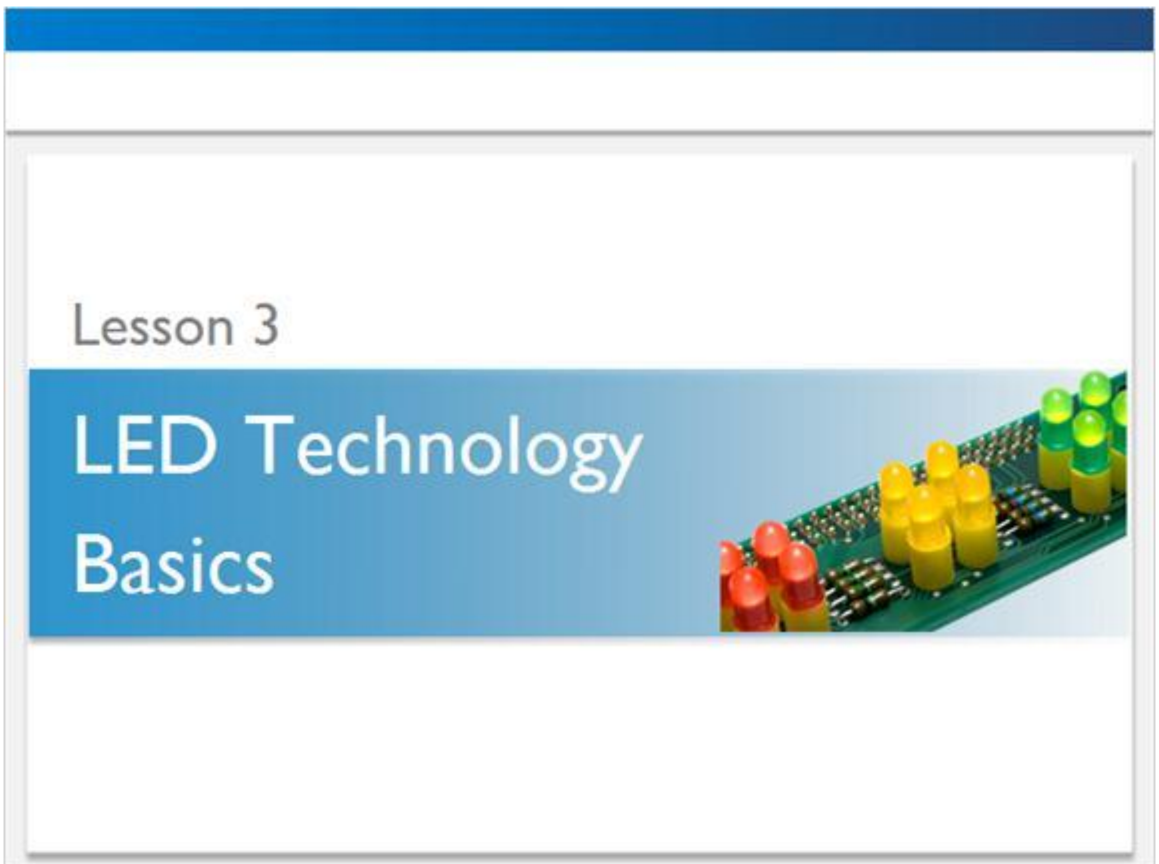
- Retail
- Hospitality
- Healthcare
- Offices
- Educational and

• Residential

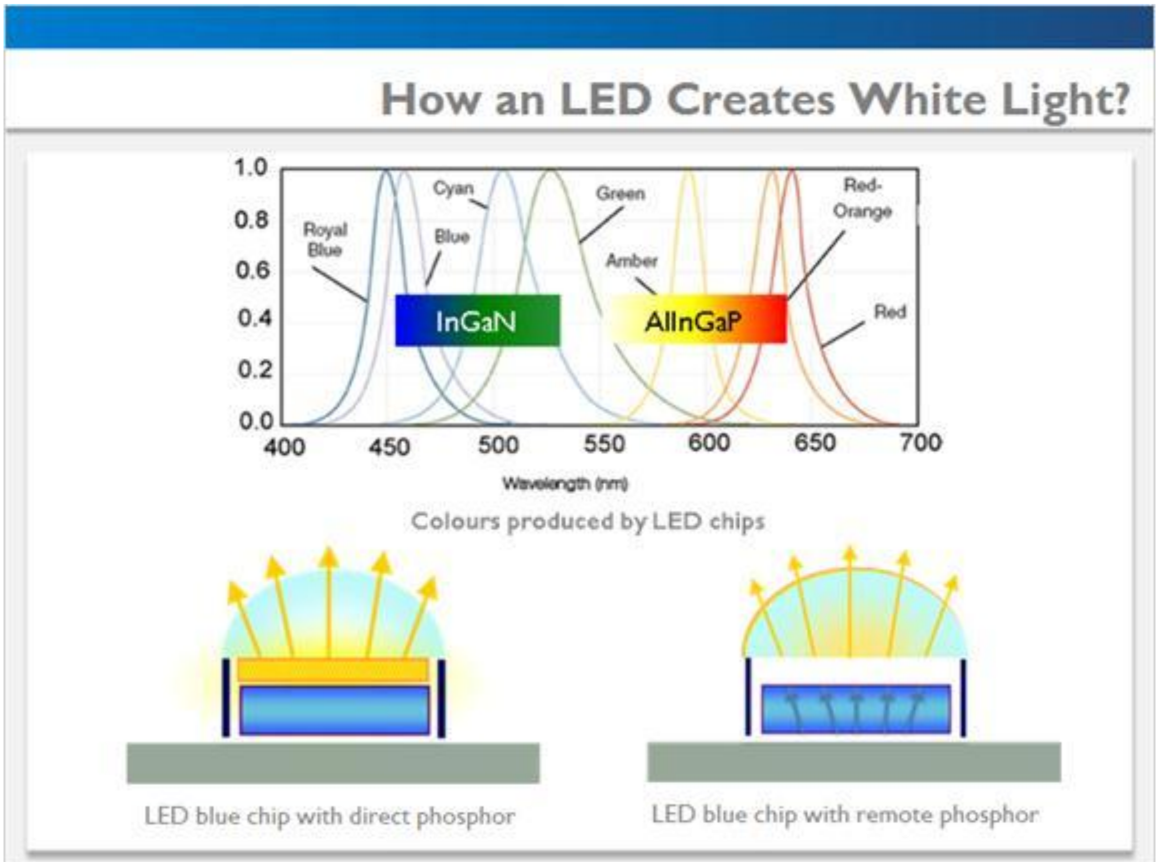
All these sectors are also suitable for retrofit installations.

Until now, many owners of these applications have resisted using compact fluorescent sources due to the lack of available retrofits, and inadequate lighting quality (in terms of colour, beam intensity, or dimming). LED lamps with high efficiency, high intensity, good colour, and many available types have become commercially viable in a wide range of applications. And more opportunities open up all the time.

1.8 LED Technology Basics



1.9 How an LED Creates White Light?



Notes:

Depending on their composition, LEDs can create light in different colours.

To create white light, a blue LED is covered by phosphor material. The phosphors convert some of the blue light to other colours. The combination of all these colours produces white light. The more phosphor on the LED, the less blue is in the white light mixture and the warmer the colour of the light. The less phosphor on the LEDs, the cooler the colour. Since phosphor conversion consumes some energy, warm-coloured LEDs (with more phosphor) produce fewer lumens than cool LEDs.

Most LED lamps and luminaires use blue LEDs with the phosphor applied directly to the chips. Other lighting products may use a remote phosphor technology, where the phosphor is applied to a diffusing material that covers an array of blue LEDs with a short distance between the phosphor and the LEDs themselves (hence the name “remote phosphor"). In both cases, the conversion process is the same.

1.10 An LED System

Notes:

Introduction:

An LED lamp or luminaire consists of four critical components:

- An LED array
- A driver
- Optics and
- Thermal management

In a well-designed LED lamp or luminaire, all of the components are engineered to work efficiently together.

Click on each icon to learn more.

LED Array:

An array is composed of several “chips” or emitters, mounted to a printed circuit board to emit light.

Optics:

The optics may be a lens, diffuser, reflector, or a combination. Without precision optics, LEDs emit light in a soft, nearly hemispherical distribution, which is rarely useful.

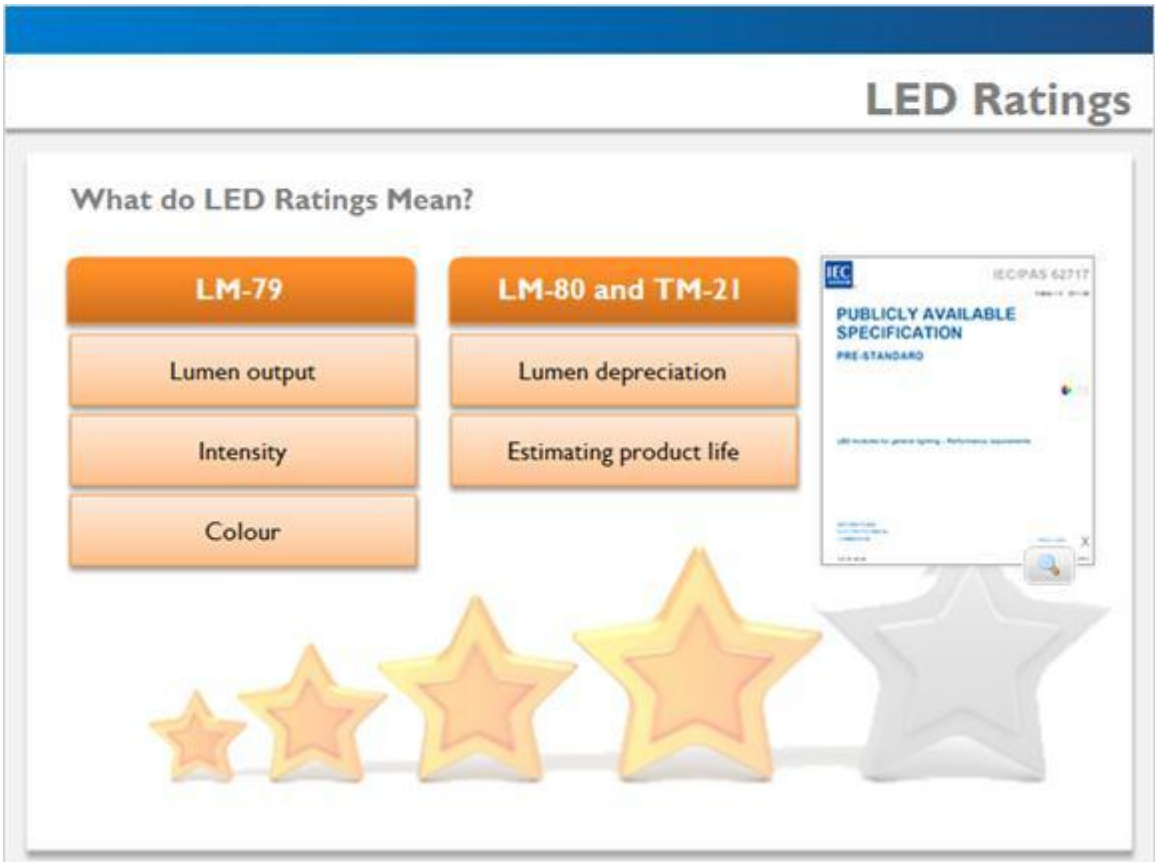
Driver:

The driver is an electronic device that provides the correct current and voltage to the LEDs for proper operation. In an LED luminaire, the driver is often a standard model, which is similar in concept to a ballast. In an LED lamp, the driver is built into the lamp itself and is customised to the LED array it powers.

Thermal Management:

Thermal management conducts heat away from the LED using a heat sink and then moves it away from the lamp or luminaire using cooling vents, a small fan, or other mechanisms.

1.11 LED Ratings



Notes:

Like other lighting products, LED lamps and luminaires are photometered (that is, measured for light and life) according to industry standards.

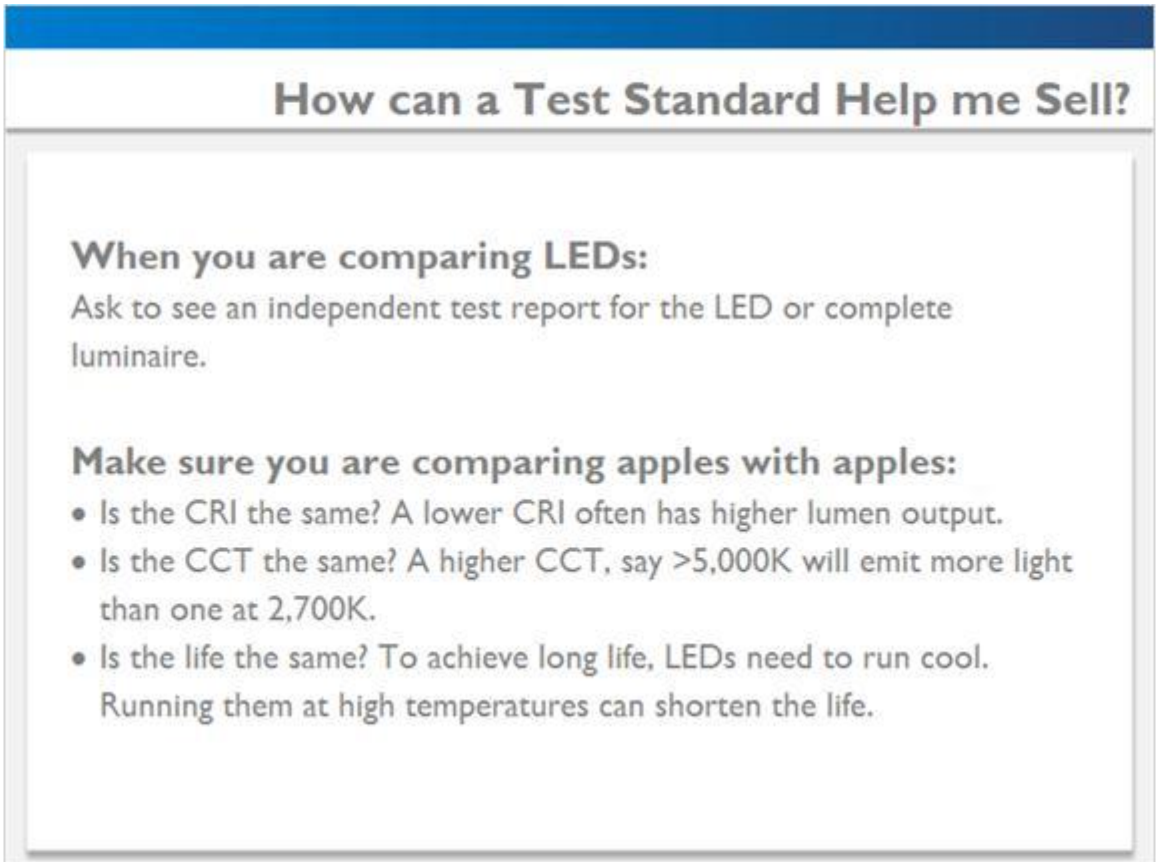
LM-79-08, developed by the Illuminating Engineering Society of North America (or IES) is the standard for measuring LED light output and colour. Its key requirement is that luminous flux (output in lumens), intensity (candela), and colour (colour temperature and CRI) be measured from the complete device, not based on the LED chips alone. The IEC has published PAS standards which are similar and will recommend that manufacturers work to a common test method.

Life ratings are more complicated because they use predictions based on a testing period that is typically shorter than the expected life of the LED product.

LM-80-08 sets the standard for measuring the light output of LED chips over time, that is, lumen depreciation. TM-21-11 recommends how LM-80 measurements should be extrapolated beyond the test period and applied to a specific product. Both LM-80 and TM-21 are from the IES of North America. European legislators are working towards common test standards known as PAS. Philips and other major manufacturers already test to these PAS recommendations.

Nevertheless, the procedures still permit considerable latitude in rating the product.

1.12 How can a Test Standard Help me Sell?



Notes:

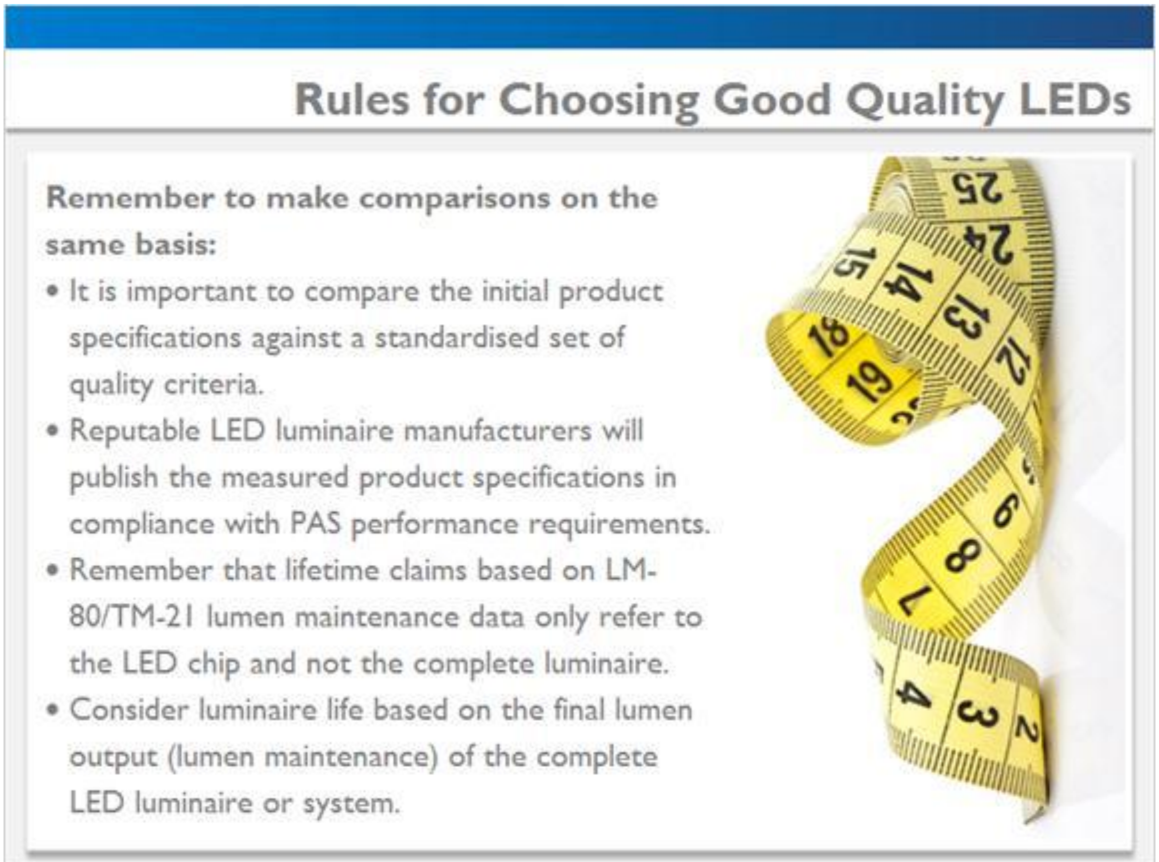
When you are comparing LEDs:

Ask to see an independent test report for the LED or complete luminaire.

Make sure you are comparing apples with apples:

- Is the CRI the same? A lower CRI often has higher lumen output.
- Is the CCT the same? A higher CCT, say >5,000K will emit more light than one at 2,700K.
- Is the life the same? To achieve long life, LEDs need to run cool. Running them at high temperatures can shorten the life.

1.13 Rules for Choosing Good Quality LEDs



Notes:

Here are the rules that will help you in choosing good quality LEDs.

You should remember to make comparisons on the same basis.

- It is important to compare the initial product specifications against a standardised set of quality criteria. Many manufacturers choose their own criteria and methods for testing and producing data. You can only make a true comparison against an agreed and standardised test -- for example, test temperature, switching, power, lumen output, etc.
- Reputable LED luminaire manufacturers will publish the measured product specifications in compliance with PAS performance requirements. Since LEDs are a global product, we also refer to the American photometric standards such as LM and IES.
- Remember that lifetime claims based on LM-80/TM-21 lumen maintenance data only refer to the LED chip and not the complete luminaire. You also need to consider the quality of the driver and the thermal management of the luminaire.
- Consider luminaire life based on the final lumen output (lumen maintenance) of the complete LED luminaire or system.

1.14 Product Labels

Notes:

There will soon be compulsory requirements for the information displayed on the lamp packaging.

The most important of these is the Eco label with ratings from A++ to G. This will be introduced on 1st September 2013. Over a period of years, the less efficient lamps will be discontinued from sale in the EU. The Eco labelling is just one part of the general movement towards more efficient electrical products including lamps and luminaires. These all fall under the Energy Related Products Directive, known as ERP. Apart from labelling, the ERP also covers functionality (life and lumen depreciation) and energy efficiency (lumens per watt). The details of the scheme are rather complex and you should ask a Philips specialist if you want to know the details.

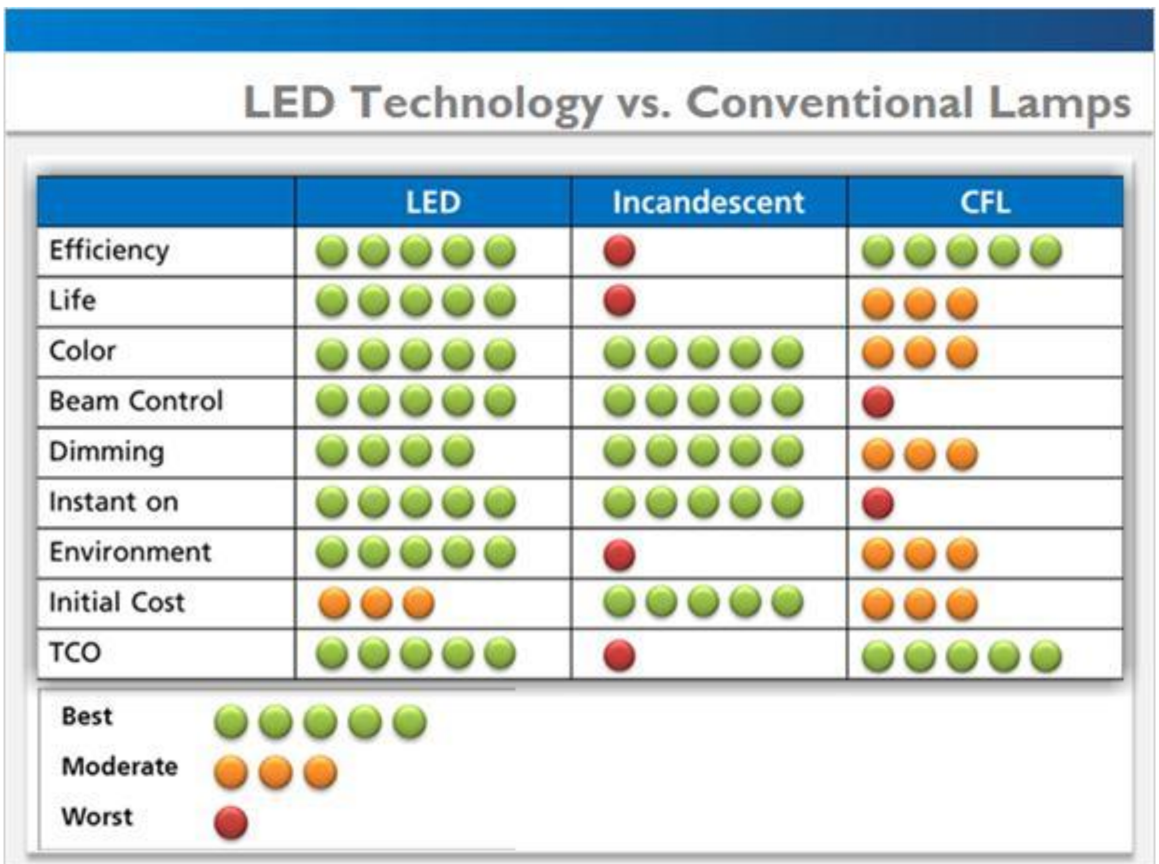
Product information such as life, lumen output, intensity, and so on must be tested to IEC or PAS standards. This ensures that LED lamps from different manufacturers are all tested against the same set of criteria. If you look at the Philips MasterLED package, you can see the following information and more:

- **Wattage**: Typically, a 6 or 7W LED will replace a 35W or 50W halogen.
- **Life**: This is tested to a PAS standard.
- **Colour temperature**: This describes how warm or cool the lamp appears. 2700K or 3000K is ideal for

replacing incandescent lamps. 4000K is used where you want a cooler appearance.

- **Dimmable**: The labelling must say if the lamp is dimmable or not.
- **Lamp cap**: Such as GU10 or GU5.3. You obviously need this information so that the lamp will fit the luminaire.
- **Lumens**: Again, this is tested to a PAS standard.
- **Intensity**: This is measured in Candelas and is used for spotlights rather than all round or omni-directional lamps.
- **Order Code or Part Number**: When you want to order more!

1.15 LED Technology vs. Conventional Lamps



Notes:

This table compares high quality LED lamps to incandescent and compact fluorescent lamps. Please note that these are general evaluations and not specific lamp comparisons.

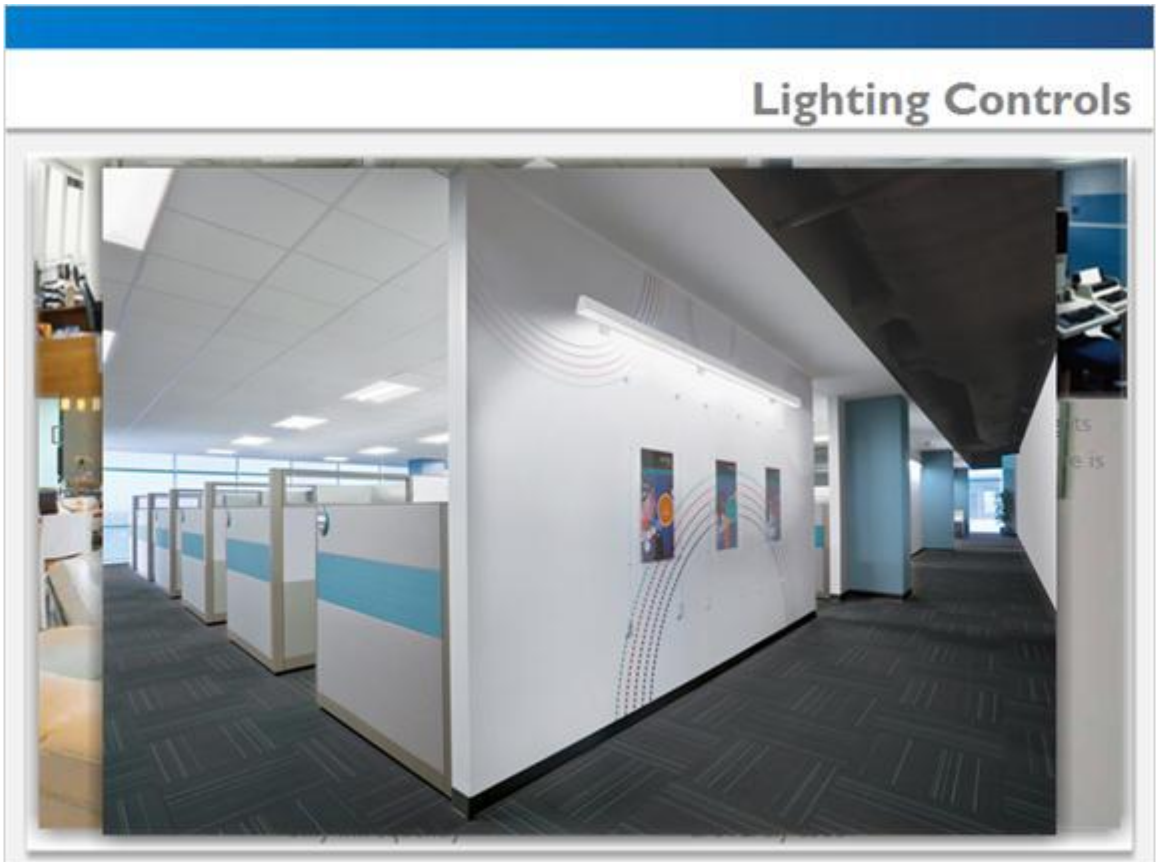
As you can see, LED lamps enjoy powerful advantages over incandescent technology in terms of energy efficiency, life and environmental impact. Incandescent technology still has a slight edge in terms of colour rendering, beam control and dimming. Compared to the compact fluorescent lamps, LEDs have an important edge in life and beam control. LEDs, which have no mercury, are also more environmentally friendly. And many users do not like the colour or warm up period with CFL lamps.

In terms of cost, incandescent lamps typically have the lowest initial cost, but the highest total cost of ownership. LEDs are the best here. Although linear fluorescent lamps emit more lumens per watt than linear LED replacements, when installed in most luminaires, the resulting efficiency is about equal.

Operation in cold weather and the absence of mercury are two key advantages for LEDs. Finally, the life of LED lamps is not affected by frequent switching, whereas the life of fluorescent lamps is.

1.16 Basics of Controls

1.17 Lighting Controls



Notes:

Many people think controls are used for changing colours and for scene setting, that is, to produce a specific lighting effect. However, the use of controls is much wider. Their biggest application is in energy saving.

The proportion of energy used for lighting buildings is different for each type of building, but a figure of 30-35% is often used. This gives all of us a huge opportunity to save energy. In this respect, lighting controls are even more important than LEDs in terms of saving energy. The most efficient LED or luminaire is still wasting energy if it is ON when it could be OFF or dimmed.

Think of the office and factory buildings you see at night where the lights are ON but the offices are empty. Some light is needed for security and cleaning and maintenance, but most is wasted energy. Unnecessary light also adds to light pollution and sky glow.

The simplest controls are movement sensors such as PIR. These can easily be added to an installation. More advanced systems dim the lights to lower levels, but for this, you need suitable drivers and a way of transmitting the signal. This can be down a wire or remotely using a hand held device or wall switch.

1.18 Save Energy Using Controls

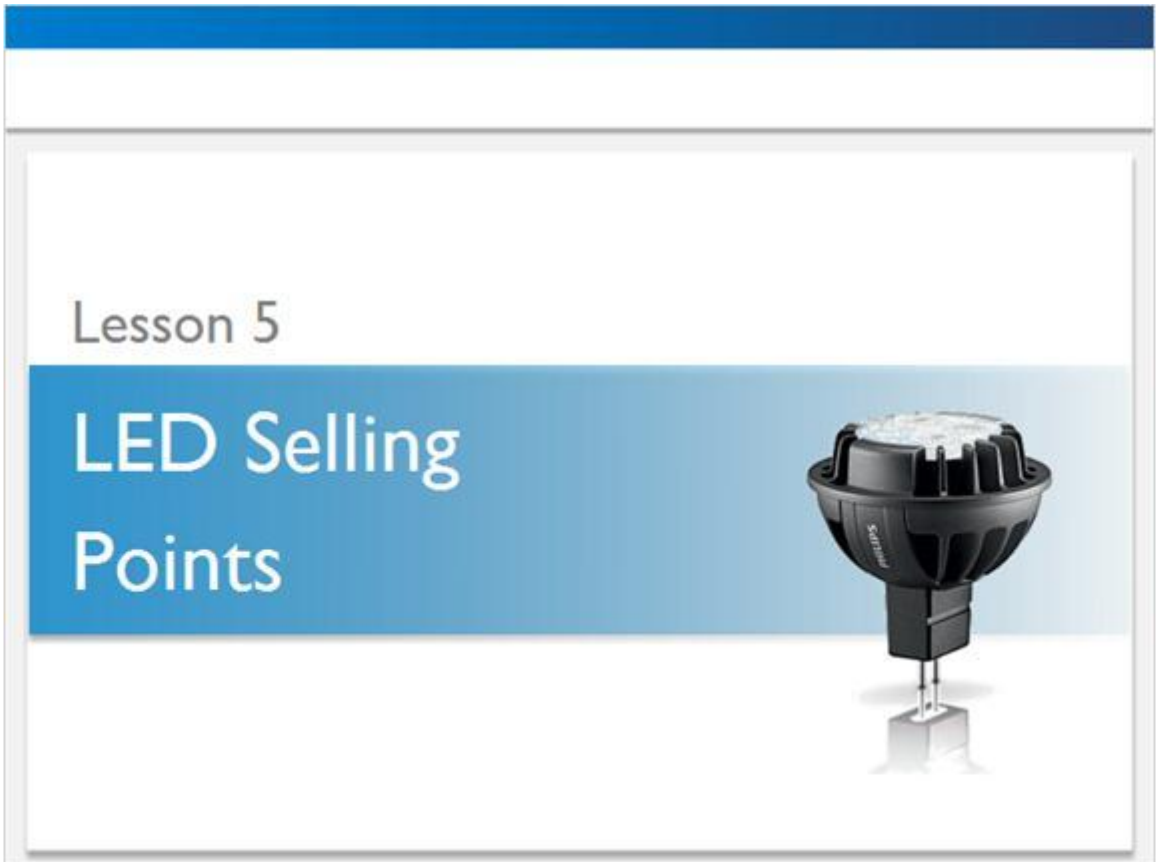
Notes:

There are many ways to save energy. Here are some of them.

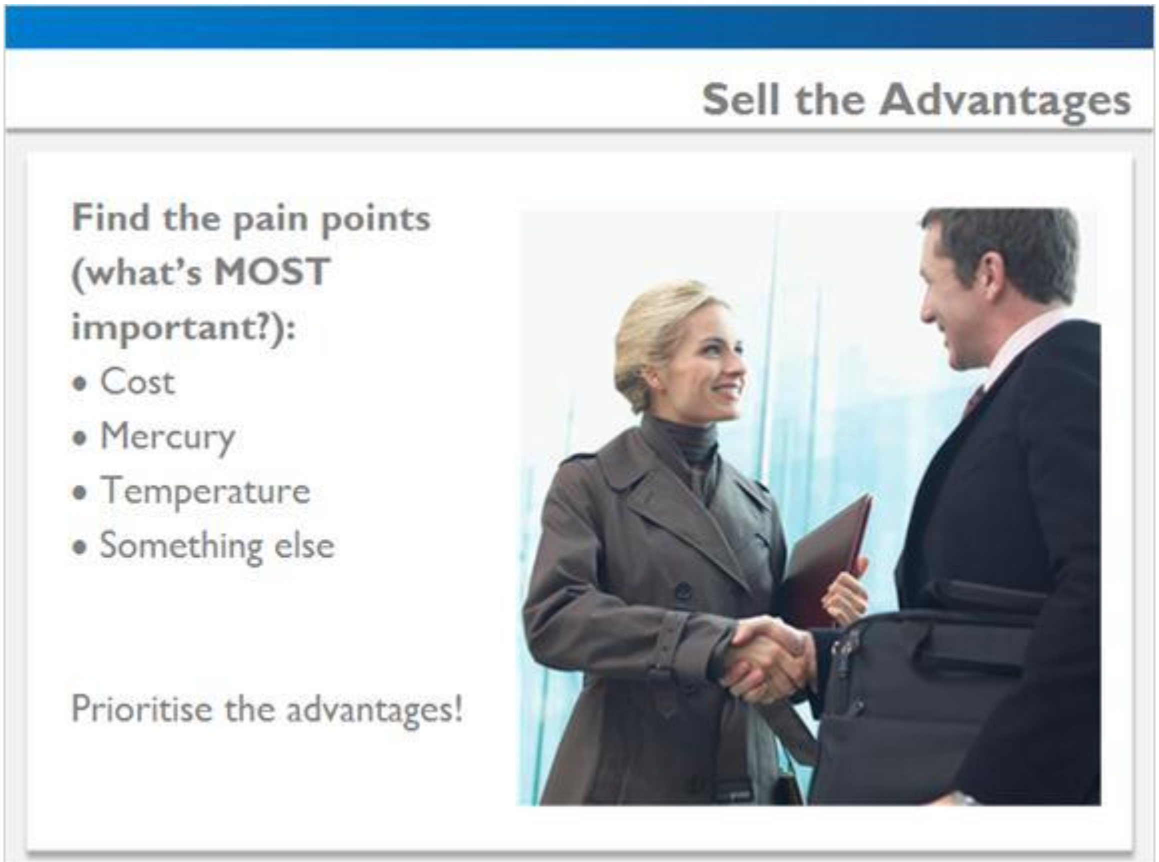
Click on each icon to learn more.

- **Smart Scheduling**: The Smart Scheduling feature switches light on at floors or rooms only when expected to be used. It saves up to 15%.
- **Occupancy Control**. The Occupancy Control uses occupancy sensors and switches on lights only when somebody is present. It saves up to 30%.
- **Daylight Harvesting**: Daylight Harvesting maintains a constant light level and uses the available daylight. It saves up to 70% on individual luminaires and 35% for a building.
- **Task Tuning**: Task Tuning adjusts light output to the level that is required for the tasks at hand and saves up to 20%.
- **Personal Control**: Personal Control allows local control for individual users and gives higher levels of comfort. It saves up to 15%.

1.19 LED Selling Points



1.20 Sell the Advantages



Notes:

Successful selling begins by identifying the "pain points". What is your customer most dissatisfied with in their present solution? Is it cost, mercury, temperature, or something else?

Once you have determined what’s important, you can concentrate on how an LED solution meets that need. This one important benefit is more important than a list of possible advantages. Once you have identified the key benefit, you can add the others to support our basic proposition.

1.21 Find the Opportunities

Notes:

Most potential buyers of LED lamps look for economic benefits in terms of energy savings (including HVAC) and maintenance savings. These two opportunities are most significant when LED lamps replace incandescent or halogen sources and where lamps operate for long periods.

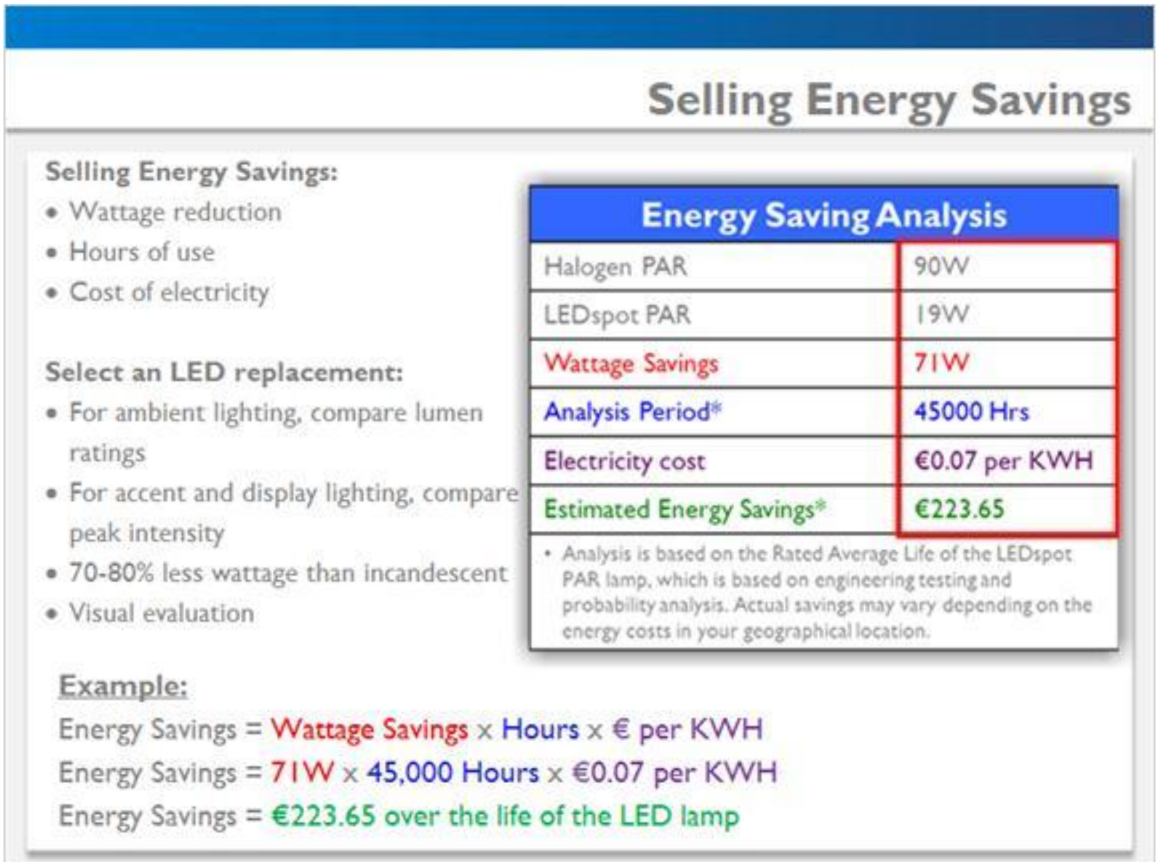
In addition to simple money, some potential buyers are motivated by environmental concerns such as energy usage and hazardous chemicals. For these buyers, the absence of mercury in LED lamps is a key attraction. Reducing mercury in the environment is a key issue for many customers.

For other users, cold temperature operation presents challenges for their current fluorescent lighting. LED lamps offer an energy-efficient alternative that performs significantly better.

Users also look to the quality of light from LED lamps for improvements in the appearance of a space and the materials in it. Increased brightness, clean and uniform beams of light, and good colour rendition, all help transform dull environments into more exciting and productive ones.

We will go through each of these opportunities in more detail.

1.22 Selling Energy Savings



Notes:

Saving energy with LED lamps depends on three factors:

- The wattage reduction
- The hours of use, and
- The cost of electricity

The first step is selecting an LED lamp that effectively replaces the lighting provided by the conventional lamp currently in use.

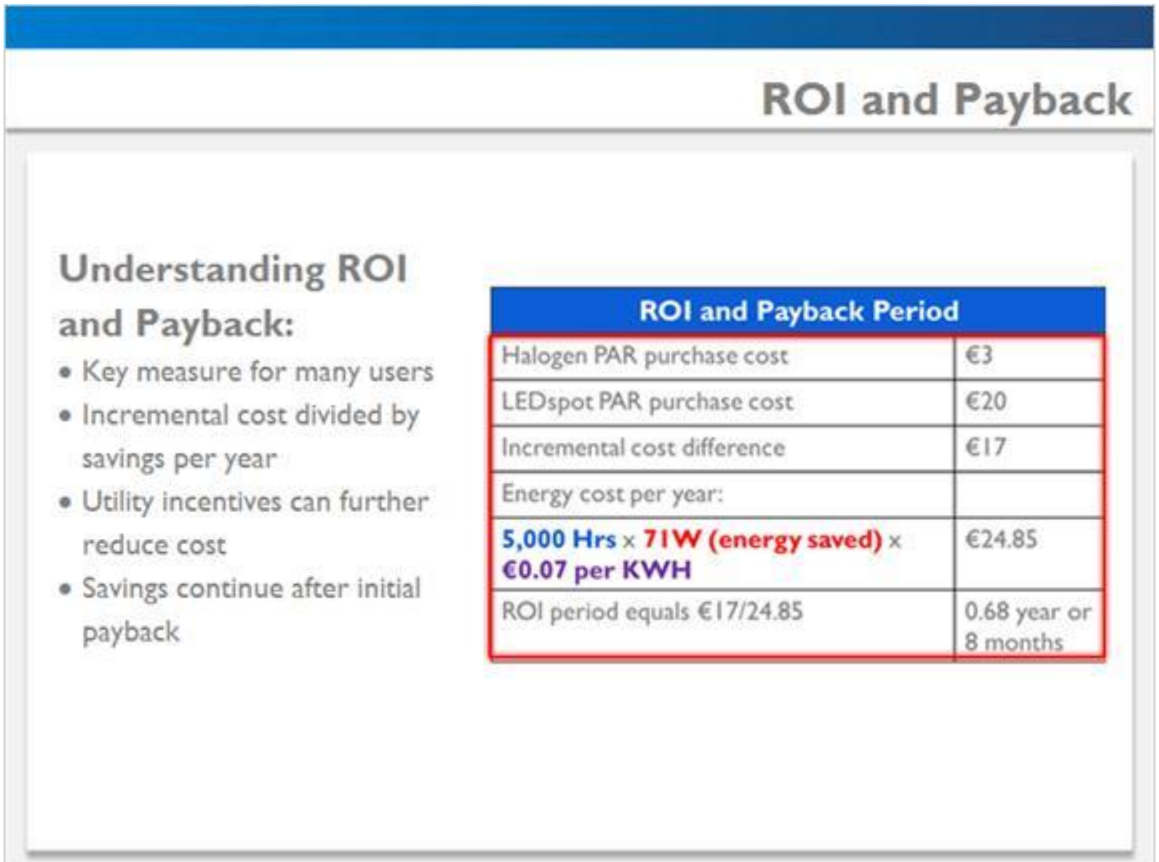
For ambient lighting, compare lumen ratings. For accent and display lighting, compare the maximum intensity (or Imax).

Based on the efficacy of Philips LED lamps, consider a lamp that replaces 70-80% of the standard incandescent or halogen wattage. Since lighting needs vary in different applications, demonstrate the suggested LED lamp for a visual evaluation. Side by side comparisons are always useful in showing the advantages of LEDs.

To determine the total energy savings provided by the LED lamp, multiply the wattage savings by the life of the LED lamp (in hours) and the estimated cost of electricity (per kilowatt-hour).

In our example, replacing a 90 watt halogen (1350 lumens) with a 19 watt Philips LED lamp (1100 lumens) can save €223.65 over the 45,000 hour rated life of the LED lamp (at 7 euro cents per kilowatt-hour). And, this is just the energy savings!

1.23 ROI and Payback



Notes:

Many users think of payback -- how fast the savings pay back the incremental cost -- as the measure of cost effectiveness. Once you have calculated the total energy saving, shown in the previous slide, you can calculate the payback.

Incremental cost is the difference in purchase cost between the Halogen PAR and the LEDspot PAR. Now divide the incremental cost of the LED lamp by the annual savings. In this case, €24.85. This is the payback period in years. In our example, assume that lighting operates 5,000 hours per year and the incremental cost of the LEDspot PAR lamp is €17. Then the payback is about eight months.

Some energy company rebates and utility schemes can reduce the incremental cost and accelerate LED payback.

Payback analysis is useful, but remember that the savings continue as long as the LED lamp continues to operate.

1.24 Selling Reduced Heat Gain

Notes:

When you reduce the wattage in the lighting system, you also reduce the heat contributed to the space and the cost of HVAC, which can be significant to some users. Lighting energy savings translate into further savings through the reduction in cooling costs.

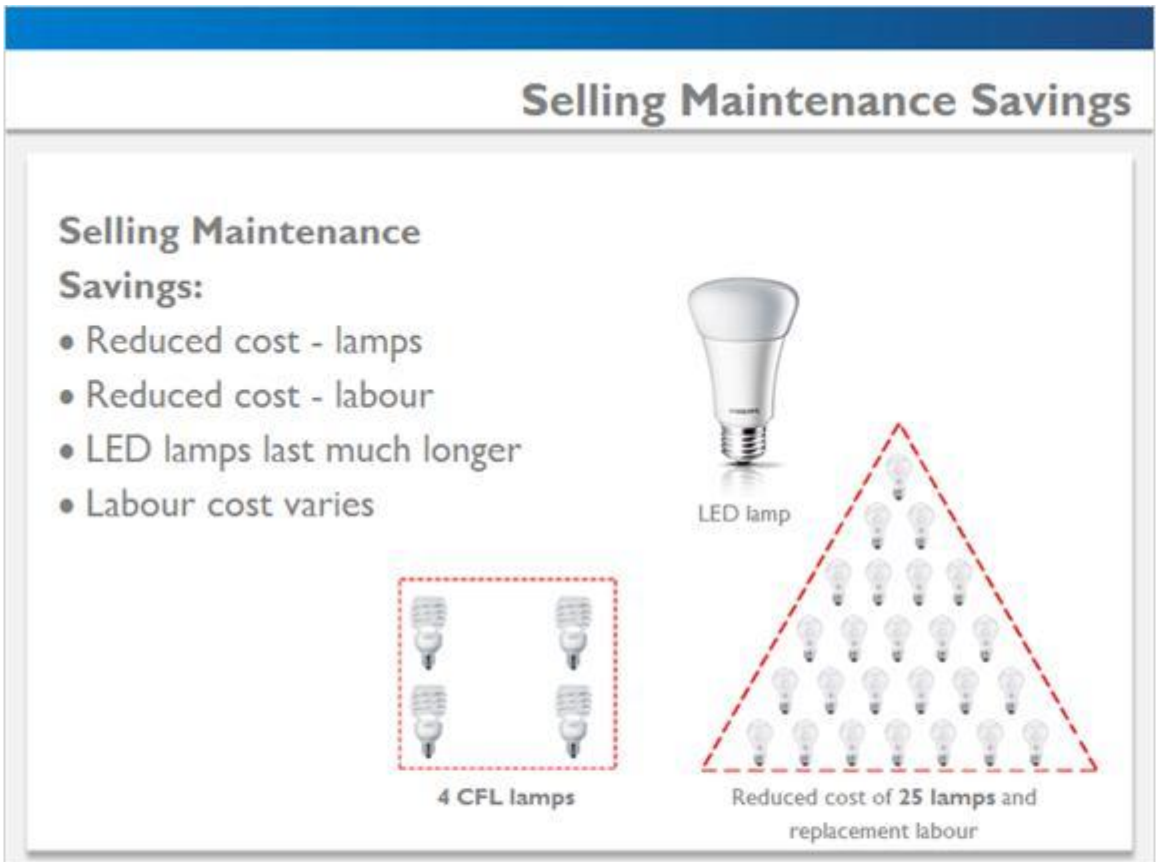
Calculating the savings is difficult, however, because it depends on the geographical location, the balance between heating and cooling cycles, and the design of the HVAC system and the building itself.

Some applications, such as retail display with incandescent lighting, generally struggle with cooling and may be very interested, even without specific numbers.

Think of food stores, where cooling is important or specialty stores, where the display lighting contributes a lot of heat into a small space.

The key is identifying heat gain as a user “pain point” . . . so be sure to probe effectively.

1.25 Selling Maintenance Savings



Notes:

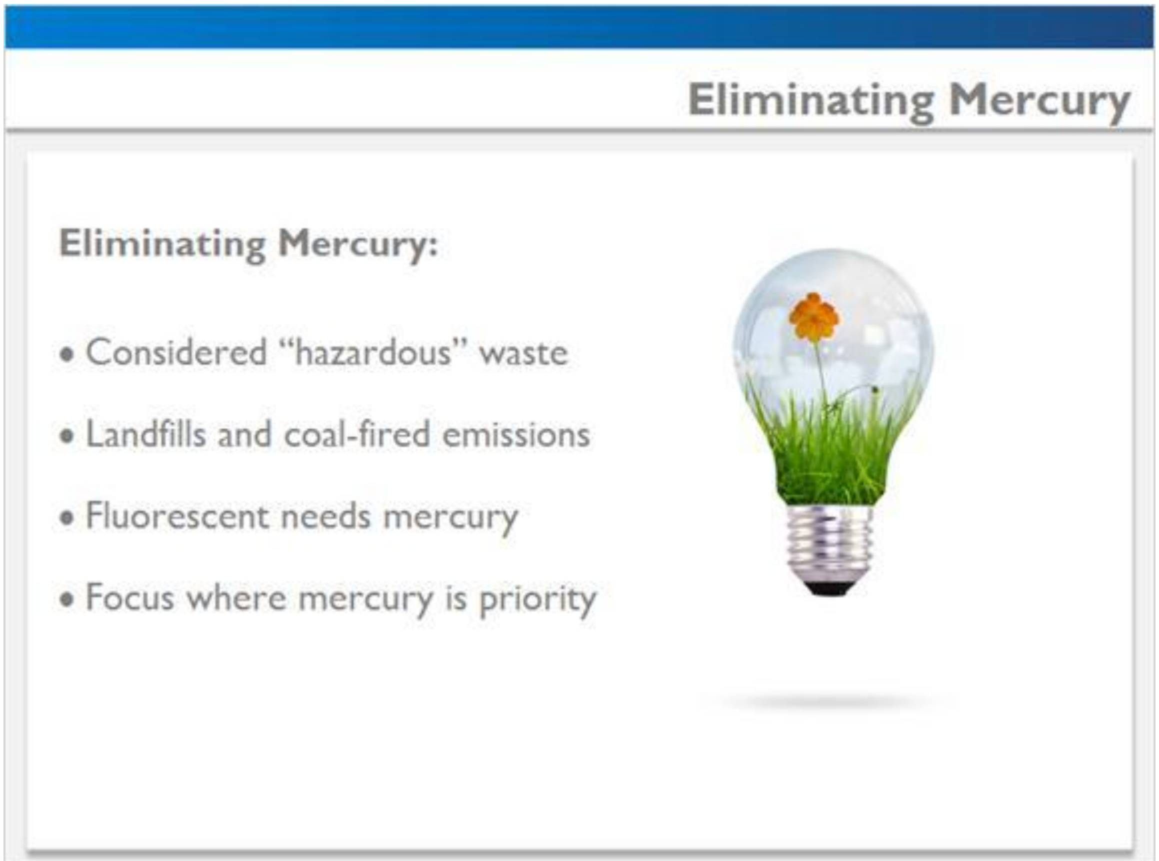
Maintenance savings include the "reduced cost” of lamps you do not have to purchase and the labour to install them.

In this example, you would need to install and replace more than twenty-five standard incandescent lamps (with a rated average life of 1,000 hours) over the typical 25,000 - 50,000 hour rated average life of the LED lamps. You would most probably use at least four CFL lamps with an average rated life of 8000 hours in the same time period.

Labour cost varies. Replacing each lamp after it fails may take thirty minutes (or more): think of bringing a ladder back and forth and recycling the CFL.

Group relamping typically costs less but needs to be done while most of the lamps are still working!

1.26 Eliminating Mercury



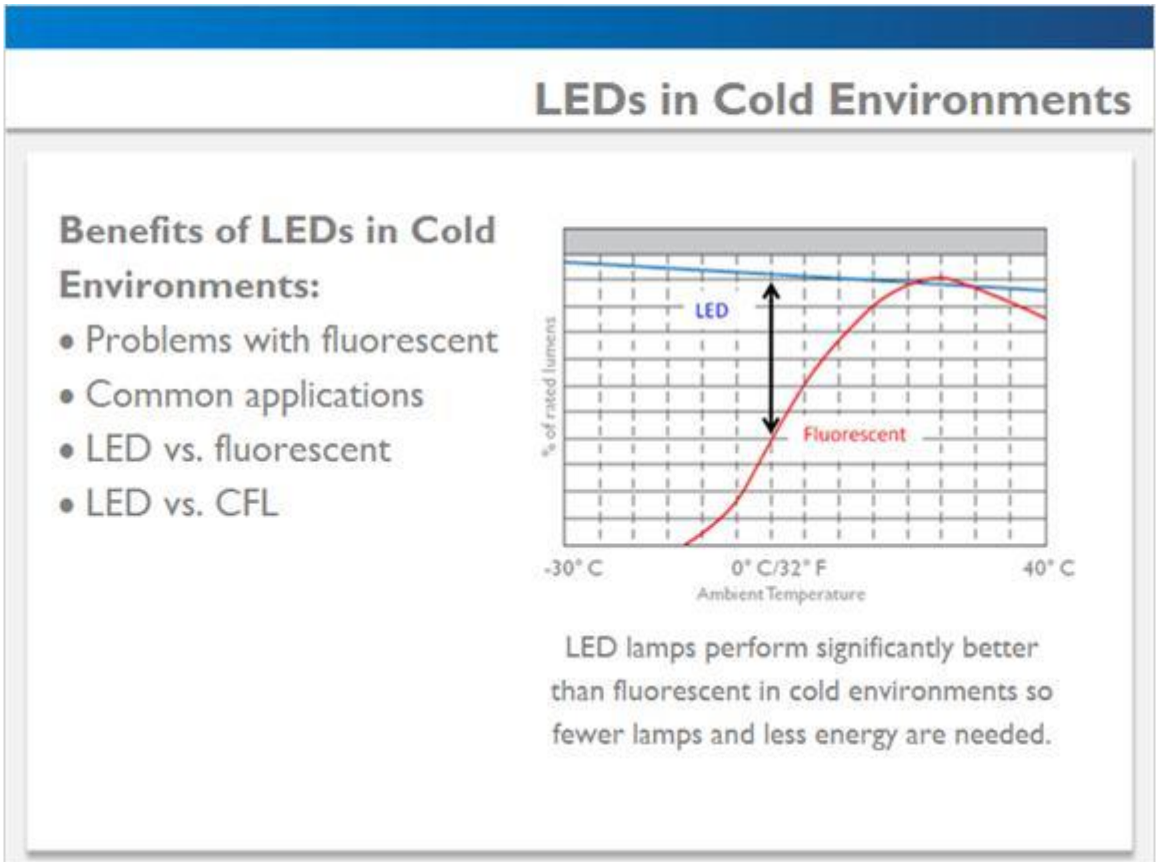
Notes:

In Europe, mercury is considered "hazardous waste" and lamps have to be recycled in the proper manner. The waste can be an especially serious concern should mercury enter the food chain through a landfill or disperse in the atmosphere through coal-fired power plant emissions. Over the last several years, many healthcare institutions (and other users) have committed to reducing or removing mercury in their facilities.

Since fluorescent lamps require small amounts of mercury for their energy-efficient operation, eliminating mercury altogether has not been a viable option.

Where eliminating mercury is an organisational priority (as in many healthcare facilities, for example) the incremental cost of using LED technology may not be an issue.

1.27 LEDs in Cold Environments



Notes:

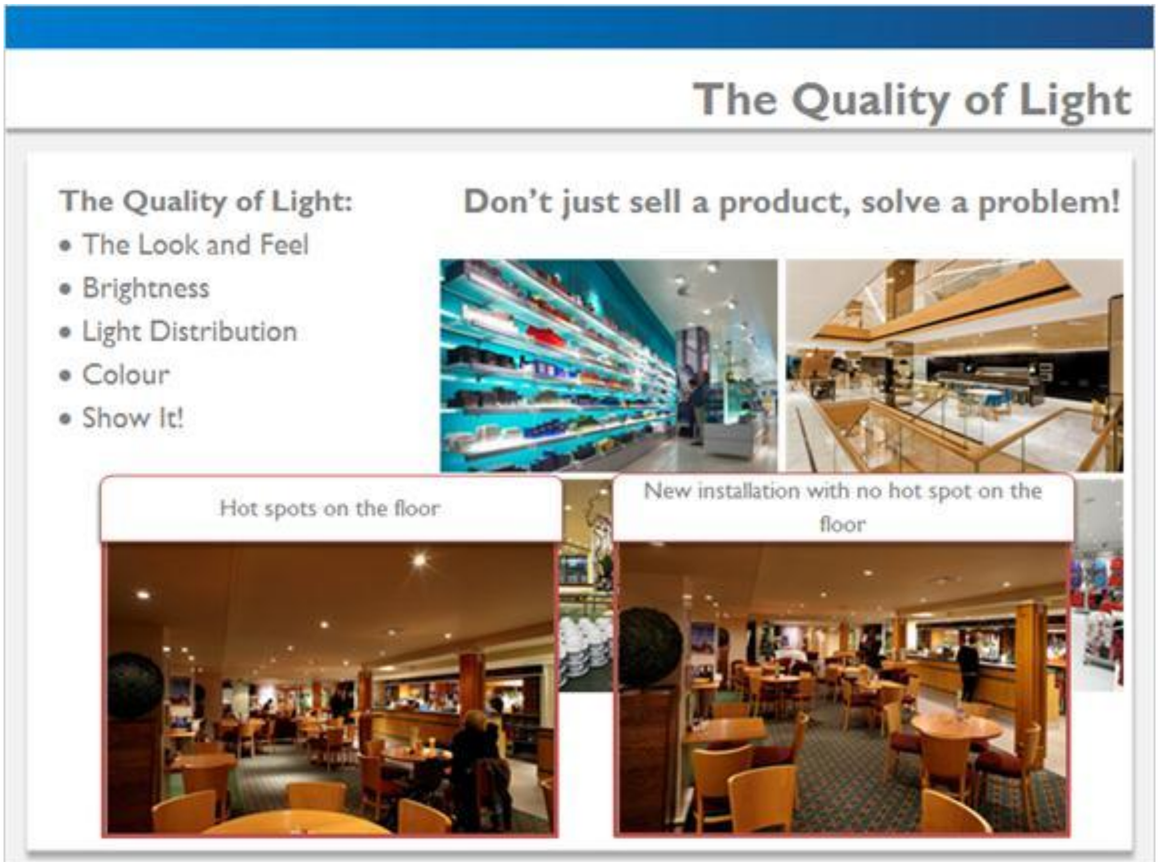
Unlike fluorescent lamps, which lose light output and efficacy as temperature falls below 25 degrees Celsius, LED lamps perform well in cold environments. Where usage is intermittent, the problem is worse because fluorescent lamps may not have time to warm up at all.

Common applications where users are interested in LED replacement lamps include sheltered outdoor spaces and cold storage.

At 0 degree Celsius, a T8 fluorescent lamp loses 60% of its 2600 rated lumens, while the LED lamp delivers its full 1650 rated lumens. In practice, fewer LED lamps will be required for the same level of illumination.

In such cold environments, CFLs -- even outdoor or amalgam CFLs -- will lose output, while LED lamps maintain full rated output.

1.28 The Quality of Light



Notes:

Retail and hospitality users, in particular, recognise that the appearance of a space and the materials in it, contribute significantly to their business success.

Take the time to uncover "pain points" with respect to the look and feel of existing lighting; instead of selling a product, you will be solving a problem.

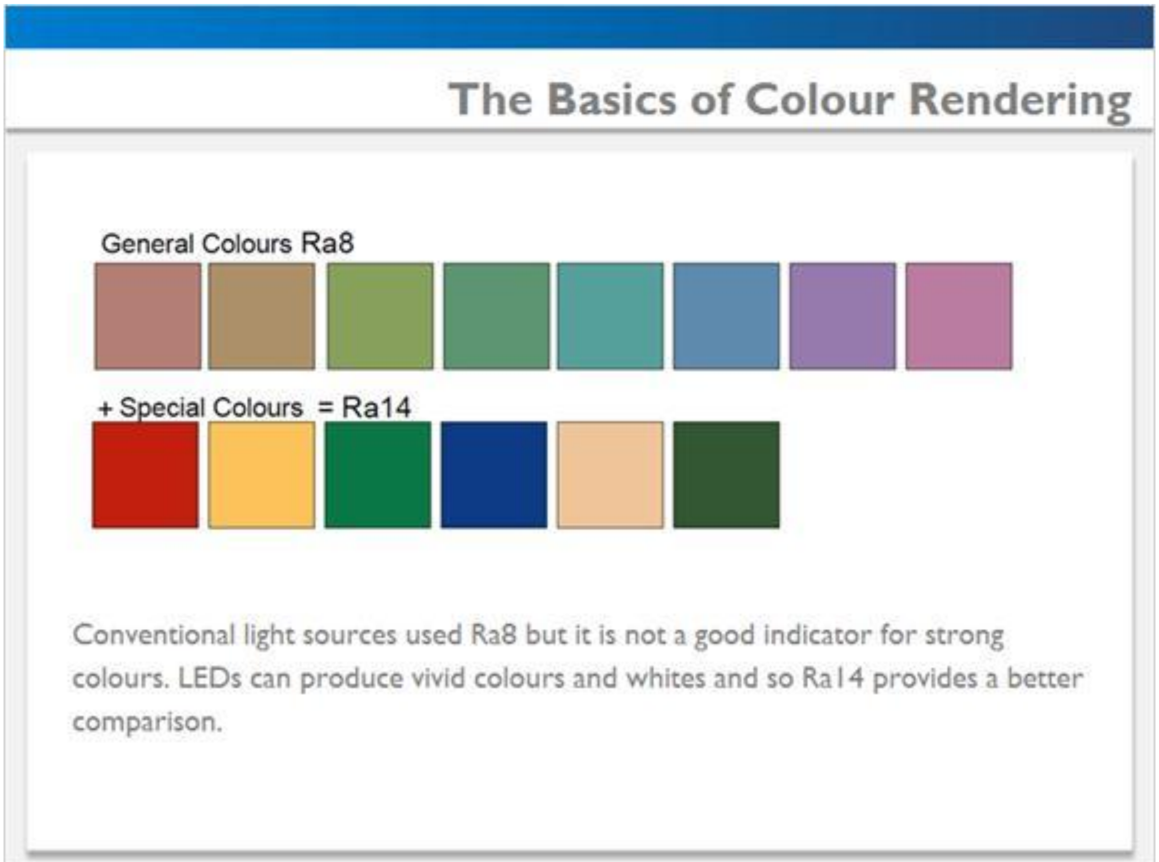
LED lighting can brighten a space with crisp white light. And, some of the energy saved by replacing halogen lamps can be applied to increasing the illumination level with higher output or additional LED lamps.

Beam quality -- a uniform field of brightness without hot spots or striations -- also makes a difference, especially in downlighting or wall washing. Aim LED and halogen PAR lamps at a wall, and you will see how smoothly the LED lamp distributes the light.

For typical retail and hospitality applications, the Philips 2700 or 3000 Kelvin lamps provide a combination of warm colour and crisp brightness many users favour. Recognise that colour rendering with LED lamps will differ from halogen lighting.

As with brightness and beam quality, providing a visual demonstration is the best way to show users the quality of light with LED lighting.

1.29 The Basics of Colour Rendering



Notes:

Historically, we used Ra8 but nowadays Ra14 is used when comparing LEDs.

Cheap LEDs are often poor at rendering reds. This is often referred to as the R9 value. A high value means good rendering of reds and similar colours such as orange and brown. This is especially important in the Retail and Hospitality sectors.

1.30 Good Colour Rendering Helps Sell Products

Notes:

Which would you buy? Poor quality LEDs often have weak reds.

1.31 Why Pay More for Good Quality LEDs?

Notes:

Find out about competitor pricing - they may be more expensive than you think. You should remember to make comparisons on the same basis.

Good quality LEDs look better. Cheaper LEDs also tend to be cooler in appearance and many have a green tinge.

Don't be afraid to compare the Philips product with a competitor.

Cheaper LEDs tend to run hot and have shorter lives.

Many super-efficient cheap LEDs have poor colour rendering. For retail applications, you need a CRI of at least 80. And, compare guarantees.

1.32 Summary

Notes:

You have reached the end of this Lighting University program.

You should now be able to understand the LED market and the key LED opportunities, know the basics of LED technology, recognise the savings from controls, identify the trends in the market, and finally, you should know the rules for choosing good quality LEDs.

1.33 Thank You

Notes:

Thank you for taking this course.