15 WAYS TO SAVE ENERGY

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We talk often of saving energy, it's a term everyone uses, but we often don't know how to save, where to save unless it's easy to replace a product with another newer technology that we are told simply saves. I hate the idea in lighting that we can divorce energy from efficiency and this from performance and comfort. After all, if you save energy but can no longer see then have you really achieved anything more than you could have done by simply turning off the lights?

In order to make it simple to decide where to save and how, I propose we break energy saving in lighting into 15 simple areas. If you approach all of these, then it is possible to save significant amounts of energy. Once you have done so of course, remember that good design always includes the people you design for, so review from their point of view if your proposal will be beneficial overall.

Our first step is to look at **Luminaire Technology** which itself can be split into four steps. Each step includes a simple coloured icon to remind us where we are.

Lamp efficacy is the amount of light emitted from a lamp (in lumens) compared to the quantity of power used by the lamp to produce this light (in Watts). We all know about lamp efficacy, it is the biggest miss-selling of light sources to the wrong customers we have seen for many years. If we are to believe the marketing, LED will save the world, and it might, but for the most part the truth has not been told. In the race to sell LED we as an industry have let the marketing take over. The raw chip lumen output is still to this day sold as so much more efficient than any other source. The figures of course speak for themselves, numbers rarely lie. Unfortunately, the public at large do not understand the numbers and this is where lighting earns its reputation for technical complexity. You have to understand so many things about light and lighting to convert electricity to light and then get it to the task in a meaningful way and then into the eye.

It should not be so difficult to understand though. You don't buy petrol based on its kWh/L, you already know it is irrelevant until put in your car and driven with your style. Energy to light is no different. But actually lm/W is perhaps a good place to start. If you put two light sources of differing efficacy in the same luminaire, the most efficient in raw lm/W is most likely to be the lead to the most efficient luminaire.

Of course we are used to the graphs of ever increasing efficiency but it is interesting that we never talk about the plateau in performance that LED must eventually reach and that as with every light source so far, efficiency has always been balanced with colour quality.

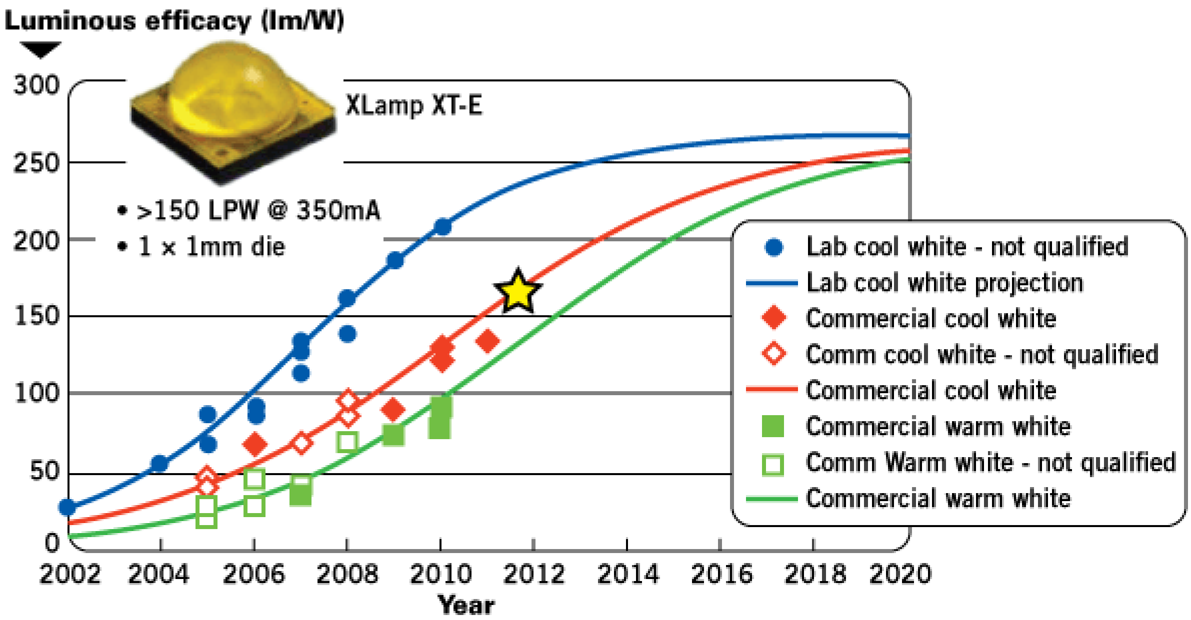

Figure 1 DOE LED Roadmap

By changing the light source a performance improvement, assuming you take nothing else into account, could be 1000%, though that is unfair as a practical comparison. For a start it sounds too much like the poor LED marketing I've already refered to and in fact that's exactly where it comes from.

Our second focus then needs to be on the electronics that drives the light sourceThe **ballast classification** is a European system for measuring the efficiency of the lamp control gear, termed the EEI (Energy Efficiency Index).
Classes are A1 BAT to B2, where class A1 BAT is the best, and B2 the worst.
We've known for many years that there are benefits to driving light sources at high frequency. Smaller components, less energy lost, more comfort through less visible flicker, it all makes sense. This still applies today, yet across the world the majority of light sources are sold with poor quality, low frequency gear. Just take a walk down you local DIY store lighting aisle and look for the flicker in your peripheral vision, or use your camera to look for flicker in existing installations. Even with savings of 25% the world is reluctant to change, perhaps energy is just simply not valuable enough yet for you and me to care? Whichever, even with regulation outside of Europe many poorer markets stick to old technologies. We consider ourselves an educated market but there is still a huge leap to be taken. In the last 40 years we have gone from three TV channels to thousands of them, from B/W to colour, to variable colour temperature, Dolby surround, digital broadcast and internet enabled screens. In the same time we have not established dimming as the de facto control option for any light source. Even the game changing LED is offered at base level without dimming. To me this is like offering a TV without volume control, or channel selection perhaps. Can this really be right? In the Business to Business world the contractual route devalues energy saving, and we as an industry let it happen.
Again it's a little unfair as a comparison but it is possible to save up to 30% when choosing the right ballast technologies.

Third in our energy saving steps is to consider where the light goes from our light source, how we shape the distribution.

The direction light is emitted from a luminaire dictates how efficient it is in lighting the relevant surfaces such as desk, walls and ceiling, or the road surface and pedestrian paths. When light is emitted in directions that do not light the required surfaces this is waste light and a large proportion of it looses its purpose. It may also result in visual distraction or glare. A more efficient luminaire is one in which a higher proportion of light reaches the required surfaces.

Luminaire distribution is a double edged sword. As a designer I want to play light across surfaces, balance the brightness, and play with contrast and luminance... in short lighting for people. But the most efficient distribution, based on the majority of legislation, is to punch light down from above and light the desk. We know as designers this is wrong, but no matter how we write the guidance, sooner or later, the good old down light or louvred modular will return leaving high brightness and harsh directional light. Of course I'm predicting doom, but again with our business model and fascination with LED the risks are already there. It is possible to save here really and only if the task has changed or the distribution was previously wrong.

It is simply impossible to separate the light source, gear and optical design from the luminaire and our fourth saving brings these together.

The luminaire body itself will not be 100% efficient, causing additional light loss. The measure of this light loss is termed the light output ratio, or LOR, for the luminaire. How you design, fabricate and maintain your luminaire, or at least design it for maintenance make a huge difference to performance. Two down lights of the same LED can have wildly differing performances, both in light out for energy in, and in terms of life and colour. Good luminaire design in fact is more important than it ever was. The sort of technical design we used to see only in high performance spotlights and floodlights, now needs to be incorporated into simple luminaires as the need to control, heat, power and glare become important once more.

This is the first point I think where it is really safe to claim a saving. Indeed that's why I group the first four ways to save energy into a group called Technology. Here all factors of lamp, gear and distribution are combined and other factors linked to this combination (optics, colour, heat, electrical safety and so on) become truly relevant. In a typical down light overall improvements of 80% from the above considerations are possible, though true installed savings of nearer 30% are more realistic before any controls.

Of course we all know lighting efficiency is not all about luminaires and light sources, though actually outside the lighting industry it is still a popular misconception. Whilst it is possible to save considerable energy by removing outdated luminaires and replacing them with new versions, there are other ways, eleven I have yet to introduce that can save as much, if not more.

First we need to consider how and when we use light, and how we stop using it when it's not needed.

We will group the next five ways to save energy into the title of **Controls.**

When a space is unoccupied the lighting is frequently left turned on, wasting energy. Automatic controls can detect if anyone is in a space and turn the lights on, turning them off when the space is no longer occupied. Two main types of controls exist: Presence – here lights are automatically turned on when a person enters the space and automatically turned off when the space is unoccupied and Absence – here lights are automatically turned off when the space is unoccupied, but need to be turned on manually when entering the space. Absence controls are more effective at saving energy than presence controls, we know as a human species when we need more light and turn it on, but since we are wasteful as a species with energy, we rarely turn off the lights. Of course education plays a big part here, as does self discipline, but in case we don't remember Absence controls simply make sense.

So our fifth way to save is **Absence Control**, savings on average reach 24%, but can be higher or lower based on the application. In a similar way, we also need to consider other light sources into our space, the major one of course being daylight.

When lighting an area it does not matter whether the light is from natural or artificial light sources, as long as enough light is present for our task and our comfort. Of course in spaces which receive daylight significant savings can be made by dimming the lighting during the day in response to an increasing quantity of daylight being received in the space. Similarly as the amount of available daylight decreases, for example in the evening, the artificial light level is increased. This ensures the correct lighting conditions are maintained whilst using less energy.

Our sixth and perhaps most beneficial saving is from Dalight, savings on average reach 31%, but can be higher or lower based on the architecture and location.

When designing the lighting for an area it is necessary to include additional lighting to ensure that the required lighting levels are achieved as the installation ages. This is to compensate for aging of lamps and the accumulation of dirt on the luminaire and surfaces within the area. By dimming the luminaires at the start of life, or after maintenance on the space has been carried out, energy consumption can be reduced whilst maintaining the correct lighting levels. As the installation ages the output is increased to compensate for decreasing lighting levels. This is done until the next scheduled maintenance when the lighting will automatically dim again. It is often argued that we provide too much light; this is one obvious way to reduce those claims from day one.

Savings from **Maintenance,** our seventh saving method, on average reach 28%, but can be higher or lower based on the application.

Our eighth method is about giving people control, **Task lighting** just what they need at a particular time. What if we put lighting on control circuits so people can turn on energy efficient lighting in just the form they need? This is a very good and an easy way to control a space, to make the room and lighting suit the needs of the moment and indeed it can save energy, provided we plan, commission and use it correctly. When people work late, at different times or work in a different way – they can use lighting in their immediate work or area without having the light turned on in the whole area. For specific work areas you can use dimmable task lighting to adapt to your requirements, or you can use dimming to change the task focus in a conference room for instance. The same theory can be applied to outdoors, in a way to control exterior systems in zones according to the needs. The target is to have light on at the right time and the right place.

Savings on average can reach 36%, but can be higher or lower based on the application.

Set working hours exist in many applications. Therefore fixed times during the 24 hour cycle when lighting will not be required exist. To save energy **Timed Control** or an automatic cut-off can be installed on the lighting circuits within the building to turn all lights off during unoccupied hours. This requires consideration of emergency lighting within the building. Removing the mains supply could activate the emergency lighting so careful planning is needed. Also as with any control system you need to make it easy to change. For example owning a building that turns off the lighting at seven in the evening when you want to work late is not a pleasant experience if you do not know how to over-ride the system. Having said that this is one of the most widely used exterior lighting controls systems, after all daylight is pretty dependable, predictably arriving and leaving each day, each year.
Savings using our ninth method, and last in our group of Controls, in theory can reach 100%, but using this method with simple computer controls (the scheme here uses no dimming) it is possible to save up to 72% at a particular point in time, I suppose 100% is difficult, but a total saving overnight on this particular night of 64% is quite practical.

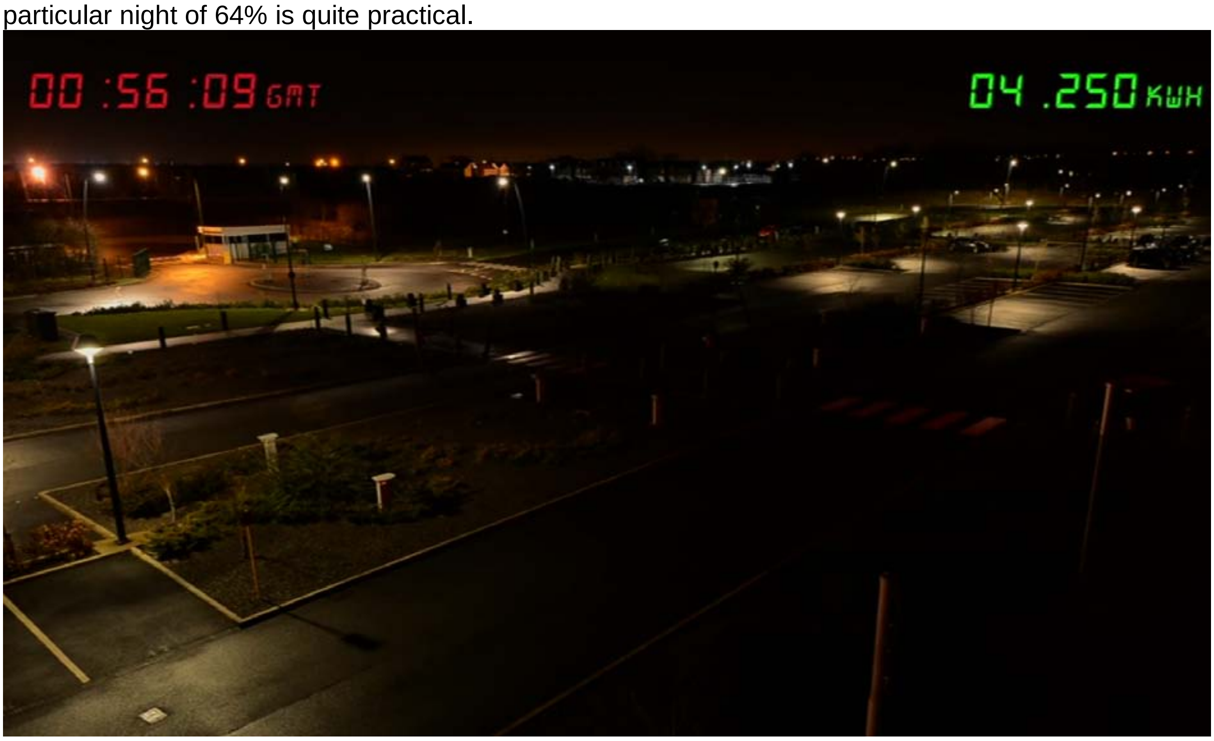

Figure 2 Timed control saves 72% of the car park energy at 1am

Time to move on to our next group of savings. Methods 10 to 13 are related to **the Application.**

This is simply lighting the task with the correct amount of light. Controversial perhaps would be to ask just how much light and when and where is right. We are used to non-lighters siezing the numbers and blandly using 500 lux. But we know its much more about balance, task, surround, and variability as the needs change. Our problem here is that no two people are alike, so their needs differ. Even the same task can differ; driving on a road at rush hour is completely different from 2 am in the morning and at 2 am in rain or fog changes this again. Saving by lighting the task is one thing; lighting for a specific set of conditions and a moment in time is where we will see further significant savings, so we can see each of these methods becoming more and more interlinked. But whether it's about the face, the paper, the keyboard, the road or some other task, lighting should be important for people, not just the numbers.

Method ten for saving energy is to understand and light the **Task** in your application, not to light to an unrelated number across an imaginary working plane. Work done by Barry Wilde some time back looked at a number of real applications: the approach of lighting wall to wall with 500 lux versus lighting the task. The predicted savings were in the region of 64%. In each case he found the actual space needing a higher level of illuminance was around 36% of the floor space, not surprising that the numbers match up.

When lighting is installed the wiring of the luminaires frequently inhibits efficient use. Lights that are switched with no consideration of the location of workers or available daylight can result in significantly increased energy consumption. We know this from experience, and in some places we have rules to strictly limit this approach. It is important that people can use the switch sensibly, but we often fail to tell them in a meaningful way which switch is theirs, or we put it so far away it makes no sense to bother using it. Now with modern technology sensors only activate energy efficient lighting in zones where personal activity is detected. But zoning still plays an important part. The luminaires nearest a window will benefit more from dimming than those distant to it. Switching or dimming these together has to take advantage of this. An example might be the inability to switch off or dim lighting near windows due to luminaires more remote from the window being on the same wiring circuit. Careful consideration of the location of desks, windows, etc. when wiring the luminaires can make greater energy savings possible.

With our eleventh saing, Zoning, it is very difficult to predict what savings are possible here. How do you zone lighting, is it in response to working groups or daylight, how is it controlled and so on are aspects that should be considered.

When designing the lighting for an area it is necessary to include additional light to ensure that the required lighting levels are achieved as the installation ages. This is to compensate for aging of lamps and the accumulation of dirt on the luminaire and surfaces within the space. By selecting light sources which minimise loss of light output through time, and luminaires with characteristics suitable for the environment (e.g. IP rating), the light loss through time can be minimised. By optimising the **Maintenance** of the installation, our twelth saving, the correct balance of resource required to maintain the lighting against additional installed lighting can be achieved. Of course this assumes maintenance is carried out on a regular basis because we all know of many installations that have failed lamps, dirty diffusers and so on.

It is very difficult to predict what savings are possible here. How do you maintain the lighting, what light source, luminaire, gear, environment and so on? On its own it is not really clear that maintenance makes a saving, but if you do it more often, then in theory you need to install less luminaires in the first place.

Our final aaplication based saving is to do with light that does not hit the intended target, **Waste Light**, consuming energy whilst lighting the wrong place. This may result in areas within a space being unnecessarily lit or over lit, more seriously it may result in stray light trespassing onto neighbouring properties or spilling into the atmosphere, adding to the sky glow we can see around most urban areas.

Figure 3 Sky glow evident in Shanghai

Careful control of light may allow the installation of fewer light fittings or the use of lower power lamps, and thus saving energy. We often think of waste light being just part of the external environment and outdoor lighting, but in reality waste light comes from internal lighting too. It could be stray light from corridor to office, light from atrium through a glass facade, retail lighting that streams to the pavement, or light to an artefact that spills beyond into the eyes of the viewer.

It is very difficult to predict what savings are possible here. How do you position lighting, what optical control you use, and what application it is all play a role. In exterior lanterns using a zero cut-off compared to a bowl type optic can save light pollution but increase spacing of columns. Use of a shallow bowl is often better, use of LED offers similar benefits to those shown in the downlight example earlier, reducing the required power of light by aiming it without the need for a large reflector system.

And so to my final group of energy saving methods, those related to the **Environment.**

Light, especially in interior spaces, is reflected from the surfaces within the space. Each time light bounces off a surface it decreases in quantity, a proportion of the light being lost related to the inefficiency of our fourteenth saving, that of **Surface Reflectance**. These losses quickly add up (after two reflections from surfaces with reflectances of 50% only 25% of the initial light remains), on a road as low as 10% reflectance might be considered good. The use of light highly reflective surface finishes can reduce the amount of installed lighting required to achieve a target light level and therefore can improve the efficiency of the scheme. The simple example of a black or white desk lit to 300 lux demonstrates reflectance; it’s clear a lighter colour needs less light to appear bright. Of course it is not always possible, or practical to paint everything white. Spacial perception we know is a problem when you do, but there are opportunities, such as using high reflectivity paints to increase what returns to the eye.

Typical white paint for a wall absorbs about 20% of the light that falls on it. High reflectance paint, it looks the same, but absorbs only 10%. Less light absorbed means less light needed in the first place and as such saves energy.

That leaves us with one method to save energy, the fifteenth, and the final for our environment. I say ‘our’ as in fact it relates to how we respond to our lit environment.

Traditional electricity meters are generally hidden away and display energy usage in numbers remote from peoples common experience such as hours of use or money spent. Moving the meter to a more visible place and displaying information useful to the consumer frequently results in a more energy conscious attitude as the results of actions can quickly be seen in increased or decreased energy use.

Visible smart metering relies on clear graphics and an emotional response from the user of the space. As with others it's difficult to predict savings. At a trial installation at a school in London, we refurbished three classes. Paint, windows, blinds were all brought up to a modern standard. But the lighting approach in each was different. In the room where we only installed a smart meter and gave access to the data to the school children, they saved more than in the automatically controlled classes. Now of course competition played an important part of that result, but it shows that you can often save more by education, by giving people a reason to save rather than just investing in all the modern technologies. No matter which of the 15 Ways to Save Energy you employ, until people understand the impact of each they will continue to focus on the easiest and best marketed. I'd for one would hate that to just be light source efficacy when we have so many more ways to save that can impact less on our enjoyment of our world.

Of the fifteen ways that lighting can contribute to energy saving, it's the last one provides most food for thought: perhaps it will only become possible to truly save when it actually hurts us physically or emotionally if we do not save energy.