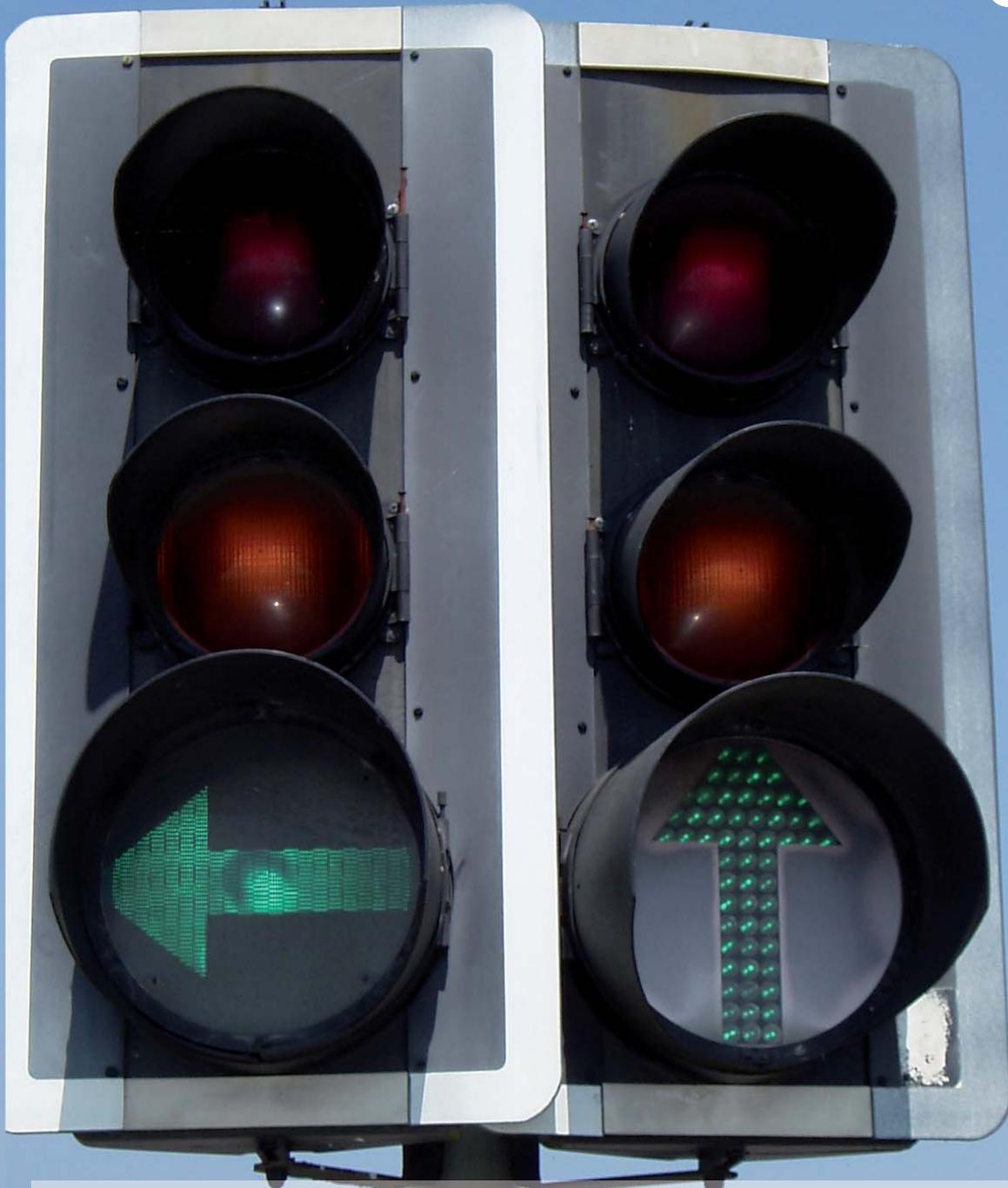


December 2006

QUICK HITS

3. Traffic signals



Converting all traffic signals to LED lights would save 57,000 tonnes of CO₂ per year by 2010

UKERC

What are Quick Hits?

Quick Hits are a series of proposed initiatives developed by the Demand Reduction theme of the UK Energy Research Centre (www.ukerc.ac.uk). They are intended to make a useful contribution towards reducing carbon emissions by 2010, and are designed to be relatively easy for the Government or local authorities to implement. Legislative changes or expenditure needed would be small in nature, hence the title 'Quick Hits'.

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What is the Quick Hit?

The replacement of incandescent lamps with LED (light emitting diode) lights in traffic signals in the UK could reduce the demand for electricity by up to 70%. Additionally, the move could also offer substantial savings to highway authorities through less frequent replacement of lamps and, consequently, staff maintenance time.

The UK has an estimated 420,000 traffic and pedestrian signal heads¹, installed and managed by individual highway authorities². Each head contains two, three, or four 50W lamps, although for the majority of the time only one of these is lit up. These traffic signals currently use an estimated 101.7m kWh of electricity per year and cause the release of nearly 14,000 tonnes of carbon (around 50,000 tonnes of CO₂). The number of traffic signals in the country continues to grow at around 3% a year - Transport for London estimated an increase of 17.5% in the capital alone between 2000 and 2005³.

LEDs: the background

Historically, traffic signals in the UK and elsewhere have used white light incandescent lamps behind a filter to colour them red, amber or green. These lamps, which currently use tungsten halogen incandescent bulbs, have their light output further reduced due to having to pass through this filter.

The technology has now developed making it easy to replace such lights with LEDs. About the size of a pencil end, LEDs are already used in applications such as mobile phone displays and flat-panel computer monitors. They can produce red, amber or green light directly without the need for a filter, and are placed in an array of up to 60 LEDs to create the necessary light strength.

Energy use for LEDs signals is significantly lower than for standard incandescent lights. The energy consumption of LED traffic lights varies between around 17W bright and 8W dim⁴ - dimming occurs when ambient light levels fall below 'dawn and dusk' levels, although in some urban areas lights tend not to

be dimmed due to the higher ambient light at night. Comparable figures for ordinary signals are 50W bright and 25W dim. Whilst the technology for incandescent lights is unlikely to improve much, industry figures believe that improvements in LED technology mean there could yet be a further halving of the power needed for LEDs⁵.

LEDs also last much longer - possibly as long as 30 years - compared to 12-18 months for incandescent lamps. This allows for savings in traffic signal maintenance and lamp replacement costs because highway crews need to replace burned-out traffic signals less frequently. When an incandescent traffic signal lamp fails, it burns out at once, hence the widespread practice of replacing them all every 6-12 months. The numerous points of light in an LED lamp start to dim when they are past their prime, thereby reducing the light from an LED traffic light gradually over time. As different colours degrade at different rates, their brightness can be measured and units replaced as needed, rather than all at once. As an additional safety feature, LED lights are also more visible in foggy conditions, as their light flux is spread over more of the area taken up by the light source.

How much energy could be saved

Traffic lights are not individually metered, and highway authorities usually agree a fixed rate with their electricity provider for the power needed. The pricing codes for demand from incandescent tungsten halogen lamps and LED lights are usually fixed based on their wattage, so LED lights are charged at one-third of the rate of incandescent lamps.

As traffic signals are installed and maintained mostly by highway authorities, there is no national database that provides a list of the total number in existence across the UK. However, the 2000 Traffic Signal Survey by the Traffic Control User Group (which represents traffic control engineers working for UK highway authorities) estimated that the number of pedestrian crossings in the country was 13,800, while the number of signalled junctions was 12,300. Assuming a 3% annual increase, these figures would now stand at around 16,500 and 14,700 respectively.

Table 1. Current consumption of UK traffic signals

	Sites	Traffic signals per site (heads)	Pedestrian heads per site	Total no. of heads	Total Consumption	
					Before dimming	After dimming
Pedestrian crossing	16,500	6 (50%) 4 (50%)	2	115500	5.78MW	5.02MW
Small junction	7,350	12	8 (60%)	123480	6.17MW	5.29MW
Large junction	7,350	20	8 (60%)	182280	9.15MW	7.93MW
TOTAL	31,200			421260	21.1MW	18.24MW

Table 1 shows the power consumption of traffic signals in the UK if all are lit using tungsten halogen lamps. In trying to calculate the total amount of electricity savings available, a number of assumptions need to be made. These include:

- a pedestrian (Pelican) crossing typically has either four or six vehicle heads and two pedestrian signals;
- a typical small signalled junction has four arms with three vehicle signal heads per approach - 60% have pedestrian signals (two per approach);
- a more complex junction will have five arms with four vehicle heads per approach; again, 60% have pedestrian facilities.

Furthermore, most signals are dimmed by 33% during the hours of darkness⁶. In this scenario, we assume that this accounts for 80% of all UK signals being dimmed during the hours of darkness (50% of the year)⁷. The scenario doesn't take account of the extra power required for the brief amount of time that red and amber signals are jointly displayed, nor does it include those signals which have additional 'arrow' lights.

The energy consumption of LED lights in traffic signals in the UK is generally accepted to be about 33% of normal incandescent lights. Their requirement would therefore be 6.08MW (one-third of the current total consumption of 18.24MW). Taking into account the existing level of LED usage in traffic signals (estimated at around 3%), the amount saved by converting all the traffic signals currently in the UK to LED lights would total 11.61MW, equivalent to 101,700 MWh of electricity. This would save some 13,830 tonnes of carbon (50,700 tonnes of CO₂) a year at current (2006) levels⁸; assuming that growth in traffic signals continues at 3% a year, the potential that could be saved by 2010 is 15,565 tonnes of carbon (57,100 tonnes of CO₂).

What prevents wider use of LEDs?

While their use is now extensive in countries such as the USA and Germany due to the power savings that they offer, LED use in Britain has yet to become widespread. Many highway authorities have trialled

limited use of LED lights, particularly on mast arms across carriageway lanes where the increased costs of bulb maintenance makes the cost equation more favourable, but concerns over technological reliability and cost have caused take-up to be slow. Improvements in LED technology, and a greater appreciation of the cost and CO₂ savings LED lights offer, mean that the highway authorities are now much more willing to consider their introduction. However, it would appear that many highway authorities in the UK are operating a "wait and see" policy, given the lack of real world UK data on which to assess the potential of LEDs.

The principal concern is that of cost. A standard signal head, consisting of one red, amber and green light costs around £150, while the price for an LED head is currently around £600-£700. The high cost is in part due to the Department for Transport choosing a brightness standard for LED signals of 400 candela, twice the level adopted in most other European countries. As well as needing more precise drive circuits, individual LEDs also currently cost more than tungsten halogen lamps, not least because manufacturers have yet to recoup the investment made in research and development and in the capital equipment needed for production. However, prices would fall as the investment is paid off and as production yields, product reliability and efficiency all improve.

There have also been concerns over the reliability of some of the lights⁹, and the difficulty of meeting the requirement to monitor for red lamp failure. UK traffic signals have a built-in safety capability to monitor and report bulb failures. With incandescent lights these are relatively easy to monitor, but LED signals contain many light sources and are considerably more difficult to monitor. If lamp monitoring is needed, it pushes energy consumption for LED lights up to about 20-25W.

However, technological improvements are likely to reduce the impact of this problem: Transport for London (TfL) has been working with manufacturers to adjust signal power characteristics such that LEDs can be successfully monitored without having to change the controllers which drive them, and a project to trial these is currently running. Further-

more, TfL is also trying out new LED designs that work with most common traffic controllers and reduce replacement costs to only £200-£300 per head.

The exact cost of changing over to LED signals is hard to ascertain due to the difficulty in accurately forecasting installation costs and future cleaning requirements. The benefits in terms of reduced electricity charges and maintenance costs are easier to quantify, however. TfL reports that it currently envisages an overall payback period of around five years.

Have LEDs been implemented elsewhere?

LED technology has now made significant penetration into the traffic light market across the USA¹⁰. While the shift has been encouraged by the greater potential energy savings than in the UK - traffic signals in the USA use tungsten halogen lamps up to 100W, compared to the usual maximum of 50W in the UK - it has demonstrated how quickly conversion can take place with the right support and incentives in place. LED lights have been installed in many large cities, including New York City, which completed a £28.2m replacement project in 2004.

Take-up has been strong in California, where conversion has formed part of the Peak Load Reduction Program, introduced following the state's energy crisis in 2000-01. By early 2004, the state estimated that about half the lamps in California had been replaced with the LED type¹¹. As well as reducing costs, they have been popular for opening the opportunity to install battery backup systems to keep traffic flowing during power outages. There was a big push to convert to LEDs in the early 2000's, with many utilities and the Energy Commission providing rebates/incentives to help defray the cost of the LEDs. The reason for the big push was because of the substantial energy savings and the traffic regulatory agencies developing standards for LEDs. The state adopted efficiency standards for traffic signals in February 2002. In California, the law requires that vehicular traffic signal lamps made after March 1, 2003, meet a certain maximum energy use, and only LEDs can meet this requirement.

The California Energy Commission estimates that with the cost of LED traffic lights coming down, and energy costs rising, a city that converts all its traffic lights at an intersection to LEDs will reduce the energy use by an estimated 70%, resulting in a simple payback of 3-5 years. The Commission has offered a low interest rate loan programme to finance the cost of converting from incandescent to LEDs, with the savings from the project used to pay the debt service on the loan. State grants and loans for the replacement programme totalled nearly \$22m, and approximately 87 cities, counties, and public agencies in California have secured state or federal grants or loans to pay for installing LED traffic signals.

In 2001 the city of Portland, Oregon replaced nearly all its red and green incandescent traffic lights with LEDs. This led to annual energy and maintenance savings totalling \$400,000 and net payback in less than 3 years. The savings generated in this case broke down as energy (70%), relamping (18%), other maintenance (8%) and liability payments (4%). A similar program was also run in Denver, Colorado with similar positive results.

How could a changeover be funded in the UK?

There are currently a variety of funding sources for traffic signals. Many highway authorities fund maintenance work on them through their highways maintenance budgets. Funds for their installation can also be provided where agreed in the five-yearly Local Transport Plans, as part of government funding for major (£5m+) road schemes, or through 'planning gain' agreements with private developers.

However, other than the maintenance and electricity cost savings to be gained in the medium to long term for highways authorities, there are currently no known financial incentives to switch to LEDs. Traffic signals are an area that has been largely ignored by funds that have been established to encourage greater energy efficiency. Given both the electricity savings and the cost benefits to highway authorities, there are good grounds for recommending the establishment of a fund by the Government or the utility companies offering grants or loans to encourage a complete switchover to LED lights by 2010.

¹ Each traffic head consists of a single red, amber and green light, with an arrow (filter) light if applicable. A pedestrian head will consist of just the two lights (red and green)

² The highway authority is usually the county or unitary council for the local area

³ *Local Transport Today*, 17 May 2006

⁴ Exact figures vary according to different manufacturers and users

⁵ Keith Manston of Siemens Traffic Controls, personal communication

⁶ Voltage is usually reduced from 240V to 160V.

⁷ Policy on dimming is decided by each authority - the majority of highway authorities dim all their signals although some, including the Highways Agency and Transport for London do not dim in areas well-lit at night

⁸ This assumes an average carbon intensity of 0.136kg carbon for each kWh of energy

⁹ Oxfordshire County Council introduced 24 LED signal heads from 2003 where mast-arm or extra height poles are used, and had five failures in the first 18 months

¹⁰ LED lights had captured 30% of the market by November 2003. *California Says "Go" to Energy-Saving Traffic*, US Department of Energy 2004

¹¹ *ibid.*