# THE BIG PICTURE

When photovoltaics were installed on this south London building it was an exemplar. Then the neighbours built higher, overshadowing part of the roof. If any part of a PV string is in shadow the output from the entire string is affected, so the decline in generation from this installation has been dramatic

MASTERCLASS
Professor Doug King

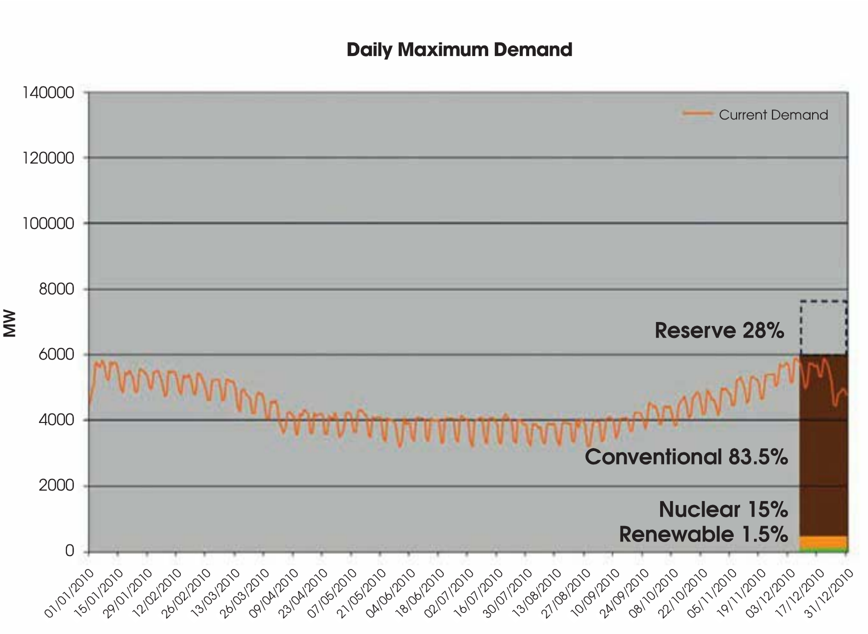
This month's article looks beyond low carbon design to consider the broader potential implications of the apparently straightforward decisions made by engineering designers

Previous Masterclasses have focused on aspects of design that will allow us to manage energy use in buildings and so deliver low carbon operation. However, if we want to become the engineers of a low carbon society, we must turn our minds to much wider issues than simply addressing energy use in the individual buildings we design.

In the same way that architects must consider their designs in the context of much broader urban design issues, so we must now begin to consider the impact of our low carbon approach on our neighbours, on the energy supply infrastructure, and on the economy as a whole. We cannot deliver the new low carbon paradigm for society if we continue to just consider individual buildings in isolation.

Recently, policies for onsite renewable energy have created a reliance on small-scale generation in urban locations, which may not be the sustainable solution in the long term. In a previous Masterclass (June 2010) I outlined the physics behind wind energy, which demonstrates that it is virtually worthless in an urban environment.

The other popular alternative for urban renewable generation, photovoltaics, requires good solar access to the building




**Between 17:30 and 18:00 on 7 December 2010, UK electricity demand peaked at just over 59 GW. At that point in time less than 17% of the demand was met from low carbon generation sources, 15% from nuclear power and 1.5% from genuine renewable sources**

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on which they are installed. In an urban environment buildings change, and rooftops that might presently be an ideal location for photovoltaics can become shaded by adjacent new developments, negating their potential and wasting the investment. The fact is that, on the whole, it is better to develop renewable energy resources out of urban centres.

We are also beginning to see the use of biofuels in city centre locations in order to achieve high environmental ratings for what are essentially conventional, energy-guzzling air-conditioned buildings. However, there is no distribution infrastructure for biofuels, in the way that there is for gas or electricity.

Thus, adopting biofuel as a low carbon solution for buildings brings with it an increase in transport fuel consumption, city centre pollution and traffic congestion in order to deliver the fuel by road (see box, left). Furthermore, not every renewable fuel is unlimited in supply: we need to exercise judgement about the best use for biofuels.

To use biodiesel for combined heat and power to offset unnecessary consumption in buildings denies the use of that fuel for road transport, which is a much more valuable use for society overall. So, whilst the carbon performance of an individual building is improved, the social costs may negate any benefit gained.

The present single-minded pursuit of zero carbon homes may also have unintended consequences. Due to the subsidies available under feed-in tariffs and the Renewable Heat Incentive, zero carbon in housing is likely to be achieved by installing an air-source heat pump supplied with renewable energy from photovoltaics on the roof. This approach to zero carbon does not actually lead to energy self-sufficiency, but relies fundamentally on a form of carbon offsetting.

Photovoltaics do not generate on a winter's night when the heat pump demand is highest. Without any means to store electricity, it is necessary to generate sufficient surplus during the summer to offset consumption by the heat pump during the winter. This works provided that zero carbon homes are in the minority, leaving sufficient consumers to absorb the surplus generation, displacing fossil fuel and allowing the zero carbon adherents to claim the carbon offset. Since new zero carbon homes represent such a small proportion of the total, then this strategy will work fine in the short term.

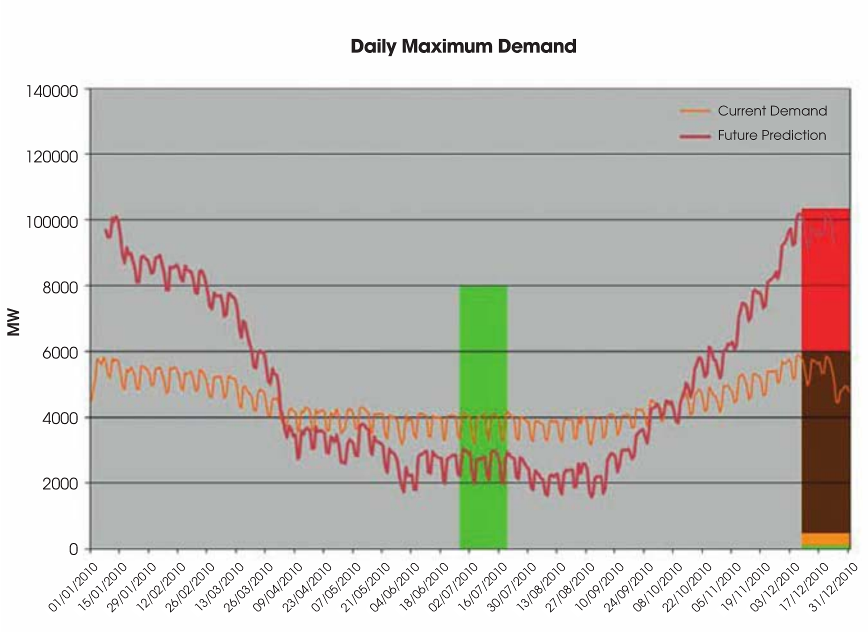
However, across the UK economy we need to achieve an 80% reduction in carbon emissions by 2050. New-build housing will only account for a small fraction of the stock in 2050, so if we are to achieve this target we will also have to make all existing housing near-zero carbon. With the subsidies available for the photovoltaic/heat pump approach, it is reasonable to expect that existing housing would follow suit.

Now, if every household in the UK were to install sufficient photovoltaics to offset their winter heating requirement, then, on a sunny July day, the generation from households alone would far exceed the current UK consumption – notwithstanding that this consumption will be reduced in the future through

## CITY EMISSIONS

In terms of transporting biomass into cities, there are concerns about the air pollution this may cause. For example, in the City of London, air pollution is such a significant issue that there is a dedicated campaign to raise awareness among business in the city. With transport accounting for 75% of city emissions, trucking biofuels into London will not help to reduce city pollution. See **www.cityoflondon.gov.uk/cityair** for more information.

By my estimate of future supply and demand, 22,000,000 homes with an average of 4 kWp PV would generate more electricity than the UK can possibly consume, negating any carbon offset potential, whilst the increase in winter demand for electric heat pumps in just two-thirds of these homes would result in a 50% increase in peak demand




energy efficiency. Unlike major generators, the grid operators cannot ask millions of householders to temporarily disconnect their photovoltaics in order to balance the demand.

This would create a massive, unmanageable surplus of electricity; we cannot store electricity on that scale, so, to achieve the fossil fuel offset needed to justify zero carbon, we would have to export to countries without renewable generation. This would require 15 to 20 times the undersea cable capacity that we presently have connecting us to the European mainland. Even then, if the whole of Europe is working to similar carbon reduction goals, there may be no demand for our surplus and therefore no offset available.

In winter, of course, it will still be necessary to power the heat pumps. It is almost inevitable that, in the short term at least, this huge demand will be met almost entirely from gas-fired power stations. All renewable generation suffers problems of intermittency and requires the quick backup provided by gas, whilst it is projected to take until around 2040 simply to replace our present, obsolete nuclear capacity. Clean coal technologies are as yet unproven and almost as expensive as nuclear power.

Then we need to consider the actual performance of heat pumps in practice. Typically the quoted coefficient of performance of 3 to 5 will be measured at an outside air temperature of 5C to 7C. With well-designed new and refurbished housing there should be little demand for any space heating at these temperatures. The heat pumps will be required to work most at outdoor temperatures below OC, when the performance rapidly approaches that of a direct electric heater. In fact, in many instances you may be better off, in carbon terms, with a good-old condensing gas boiler.

It is conceivable, therefore, that the current policies on zero carbon homes could actually lead to higher carbon emissions overall. This is, of course, an extreme example, but it does serve to highlight that the approaches we take in order to meet policy goals in the short term may not in fact be the most sustainable approach in the long term. We need to be aware that the directions we are taking now, through expedience, may not lead us directly to our destination, and that we may have to change direction before we can reach our ultimate goal.

If we want to deliver a sustainable, low carbon society, we simply cannot continue to act individually. We must consider all the implications to society of the decisions we make about individual buildings. We need to radically reappraise the approach that we take to design, and learn to think across a much wider range of disciplines than we are used to. Only then will we stop being mere building services engineers and become sustainable low carbon engineers. **CJ**

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## MEMBER BOOK OFFER

CIBSE is pleased to be able to offer its members a discount during October on publications relevant to this Masterclass.

***TM25 - Understanding Building Integrated Photovoltaics*** and ***KS15 - Capturing Solar Energy***, can be purchased as a pair for £24, a discount of £16.

***KS10 - Biomass Heating*** is £10, a saving of £12.

The price for non-members remains unchanged. See **www.cibse.org/bookshop** for further details.