Good neighbours

The energy impact of tall buildings on neighbourhoods should be taken into account when evaluating their carbon emissions, say **Julie Futcher**, **Gerald Mills** and **Ivan Korolija**

Parts of London have been transformed in recent years as buildings of more than 20 storeys are inserted into an urban landscape mainly comprised of buildings of less than five storeys, as standalone buildings or as clusters such as those in the City of London.

However, it is expected that tall residential buildings will become a more common presence throughout the metropolitan area, where 263 towers are planned.

The arguments in favour of high-rise are familiar and include their efficient use of valuable space and lower energy demands for homes/businesses and transport. Moreover, these new buildings will be subject to legislation requiring energy accounting to ensure that operational energy loads generate no carbon emissions.

The government's Zero Carbon Buildings (ZCB) policy stipulates a 'fabric-first' approach that reduces the energy demand by managing energy exchanges across the building envelope.

The second phase is to reduce energy use on-site through more efficient technology or renewable energy generation. If these actions are insufficient, allowable solutions (AS) (*http://bit.ly/1FfMrTO*) will be permitted offsite. As yet there is no guidance on what constitutes allowable solutions, but it could include upgrading other buildings or generating renewable energy elsewhere.

There are also counter arguments against tall buildings. For example, the environmental benefits are contingent on coherent land use planning, especially the transport network. Moreover, the costs are borne by the surrounding neighbourhood in terms of environmental impacts – sunshine, daylight, wind and visual obstruction.

These impacts generally increase with the absolute and relative height of a building vis-à-vis its neighbourhood, and are invariably asymmetric; taller buildings have a greater impact on the lower lying buildings than vice versa.

When these impacts are evaluated, it is in a piecemeal fashion (for example, daylight and wind analyses) that does not address their synergistic effect. We have examined the energy impacts of the proposed Bishopsgate Goodsyard (BGY) scheme, consisting of a cluster of tall buildings, on the adjacent Boundary Estate (BE).

We propose that these impacts should be taken into account when evaluating the energy performance of tall buildings under the ZCB policy and that AS could provide a means to do so.

Representing contrasting approaches to city planning, BGY illustrates London at the beginning of the 21st century with an emphasis on creating a compact, densely occupied city that is energy efficient and limits carbon emissions. Meanwhile, the BE represents London at the start of the 20th century when the concerns were about slum clearance, healthy housing and sanitary conditions.

Bishopsgate

The current planning proposal for BGY (September 2014) is a mixed-use development of eight towers ranging from 180.4m to 23.6m in height providing 1,464 residential units. The area is deemed suitable for tall buildings owing to its location on the edge of City financial district and as a transport hub.

Its energy management strategy is to achieve CO_2 savings of 35% over Part L 2010 using a combination of passive design and energy efficiency (17%), combined heat and power (21%) and photovoltaics (1%).

Boundary Estate

BE was the first large scheme undertaken using the Housing of the Working Classes Act 1890 to tackle the problem of unsanitary housing conditions in London. The scheme rehoused 5,524 people in 1,069 tenements based on a calculation of two persons per room and every habitable room was designed to have at least a 45° angle of light horizontally and vertically.

Little has changed since construction. For example, the external walls are 28cm thick without cavity or insulation and windows are single glazed. The buildings are Grade II listed, the majority allocated to social housing by owner Tower Hamlets. The layout maximises access to sun and daylight with 15m wide streets, which are

The Boundary Estate layout maximised access to daylight

Image © Alamy

Table 1

Building element	Current construction	**U values:** as built	**U values:** proposed (2014)
External walls	15" brick wall without cavity or insulation	1.583	0.28
Roof	Wooden rafters Welsh slate and/or terracotta tiles No or limited roof insulation	2.823	0.182
Windows	Single transparent 4mm glass – casement, sash and pivot	5.871 Solar heat gain coefficient: 0.847 Visible transmittance: 0.892	1.946 12mm air cavity, 4mm Low-E clear inner pane Solar heat gain coefficient: 0.628 Visible transmittance: 0.761
Ground floor	Foundation of vaulted arches infilled with rubble Damp proof course around base of ground-floor flats	1.378	0.273
Internal floors	Concrete One block still has wooden floors	**Temperature set points °C**	
		Occupied time:	During unoccupied time:
Dividing walls	Modified original layout Brick or blockwork	Bedrooms 19	12
		Living rooms 21	
Heating	Original coal fires replaced with gas heating system	**Light/equipment gains:**	
	Occupancy parameters	Bedrooms: $9W/m^2$ Living rooms: $11.5W/m^2$	
Occupied time	Bedrooms: 10pm - 8am Living rooms working family: Weekends: 8am - 10pm Weekdays: 5pm - 10pm Living rooms constantly occupied: 8am - 10pm	**Infiltration (constant)**	
		Existing fabric: 0.5 air change per hour	Upgraded fabric: 0.25 air change per hour
		Occupancy density	
		Bedrooms: $8m^2$/person	Living rooms: $10m^2$/person

oriented to align the longest facade to the solar path. The scheme was completed in March 1900 and is still regarded as a model of good design and planning.

The energy impact

The designs of both BE and BGY emphasise passive design strategies to achieve their objectives. However, the location and scale of BGY allows it to access daylight, sunshine and wind at the expense of BE. Figure 1 shows the period when this impact is greatest, during the winter months when BE is in shadow for much of the day.

A simple analysis was undertaken to assess the impact of this shading on BE heating loads during the winter period. A 3D model (using SketchUp) was created from the planning application for BGY and from Google Earth. Glazing ratios, construction details and occupation patterns for BE were obtained from site visits and residents (Table 1). These data were imported into Energy Plus, a dynamic

Figure 1: BGY shading impact

November mid-morning, noon and mid-afternoon with (top) and without (bottom) proposed towers

December mid-morning, noon and mid-afternoon with (top) and without (bottom) proposed towers simulation model that is used widely to assess building energy performance.

Results

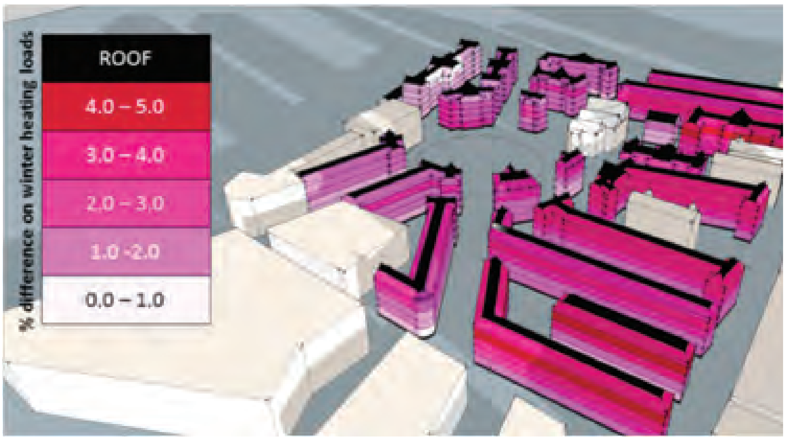
To evaluate the current heating demand in BE during the six-month period from September to March, a cursory assessment was undertaken. In our simulations we neglected the energy demand for purposes other than raising the indoor temperature and assumed a boiler efficiency of 86%; under these circumstances, the average heating demand was 90kWh/m²/yr or about 105kWh/m²/yr of boiler gas consumption.

The effects of overshadowing are evaluated in percentage terms against this crude benchmark. In addition, we considered the impact if BE's current building fabric were to be upgraded to those required by the current Part L (2014).

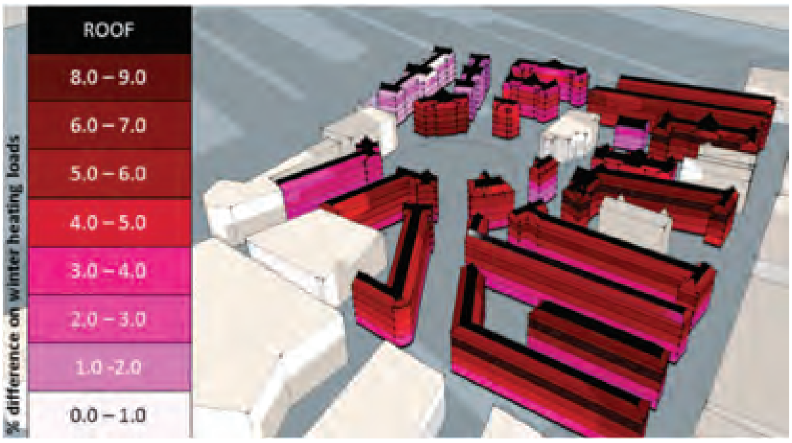
In its current state, BE has a very high winter heating demand, which would increase with shading by between 1% and 5% (see Figure 2). The largest increases occur in the upper floors, which are more exposed to solar gain, and those in the south-west quarter, which are closest to BGY and in shade the longest. The buildings to the south east were affected less, owing to overshadowing by the Avant-garde tower that is already in place. Also buildings in the north east, furthest from BGY, were little affected by the proposed development.

By comparison, if BE were upgraded to Part L (2014) standards, its energy performance would be improved dramatically (up to 70% based on our simulations). Interestingly, the overshadowing would still have an impact on this lower winter heating demand of up to 9%. The pattern of impacts is the same as that before upgrading but the greater importance of solar gain in the refurbished estate means that the relative impact of overshadowing is increased.

Figure 2: Heating loads



Percentage difference in heating loads per floor between September and March for buildings in their current thermal condition



Percentage difference in heating loads per floor between September and March for upgraded Boundary Estate buildings

ZCB policy

As it stands, the ZCB policy will change cities one building at a time. Given that the rate of new build is relatively small in relation to the existing stock (perhaps 1%-2% on an annual basis), reducing urban energy use and carbon emissions will take some time.

Allowable solutions could accelerate this transformation by linking the energy performance of projects such as BGY to the neighbourhoods that are directly impacted by its design. This would have the effect of extending the envelope of energy accountability beyond the building site.

Does BGY have a responsibility to its neighbouring buildings, especially those that bear the energy costs of the development? If so, the refurbishment of BE offers a good solution. This not only satisfies AS criteria (including the desire to tackle fuel poverty) but it also provides a mechanism to improve the current building stock in cities as the UK moves towards the 2050 energy targets.

This work represents a different perspective on energy management tools at an urban scale where the interactions between buildings provide an opportunity to mitigate carbon emissions. Allowable solutions may provide a framework for the development of tools suited to this complex and urgent task.

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