addressing climate change through the london plan

Doug McNab reflects on how the policies and approach of the new London Plan could be upgraded to more fully address climate change mitigation and adaptation and wider sustainability issues

Photos: Doug McNab

Climate change is happening now. Globally, 14 of the 15 hottest years on record have occurred since 2000. The UK Climate Change Risk Assessment 2017[1] identifies the most urgent risks from climate change for the UK. These include flooding and coastal change risks; risks to health, wellbeing and productivity from high temperatures; the risk of shortages in the public water supply; and risks to natural capital.

The ratification of the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement in November 2016 was an important step towards reducing global greenhouse gas emissions and bringing climate change under control. It commits signatories to 'holding the increase in the global average temperature to well below 2ºC above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5ºC above pre-industrial levels'.[2] It also secured global agreement by governments to tackle climate change adaptation. But the United Nations Environment Programme (UNEP) 2016 *Emissions Gap Report*[3] highlights that countries' climate pledges amount to less than half of the cuts needed to reach the goals agreed, and that raising ambition before 2020 'is likely [to be] the last chance to keep [open] the option of limiting global warming to 1.5ºC in 2100'.

The latest report from C40 Cities[4] provides a similarly stark warning. It analyses the emissions trajectories that 84 member cities need to achieve to enable the Paris Agreement targets to be met, and concludes that:

> *'The overriding and deeply significant finding of the work is that the next* ***4 years will determine whether or not the world's megacities can deliver their part of the ambition of the Paris Agreement****. Without action by cities the Paris Agreement can not realistically be delivered. The business-as-usual path of C40 cities' emissions needs to 'bend' from an increase of 35% by 2020, to peak at only a further 5% higher than current emissions.'*

The message is clear: only urgent, stringent cuts to greenhouse gas emissions – particularly in wealthier, high-emitting cities – will be consistent

with maintaining a reasonable chance of avoiding dangerous climate change. Those countries with the highest total historical carbon emissions, such as the UK, could be argued to have a particular moral imperative to lead the way in tackling climate change.

Planning – important in addressing climate change, but currently failing

The built environment is responsible for around half of the UK's emissions of carbon dioxide (CO_2), an important greenhouse gas. Therefore planning has a key role to play in reducing CO_2 emissions further and faster and in helping society to adapt to our already-changing climate.

The National Planning Policy Framework (NPPF) has some positive things to say about planning and climate change. It recognises that planning:

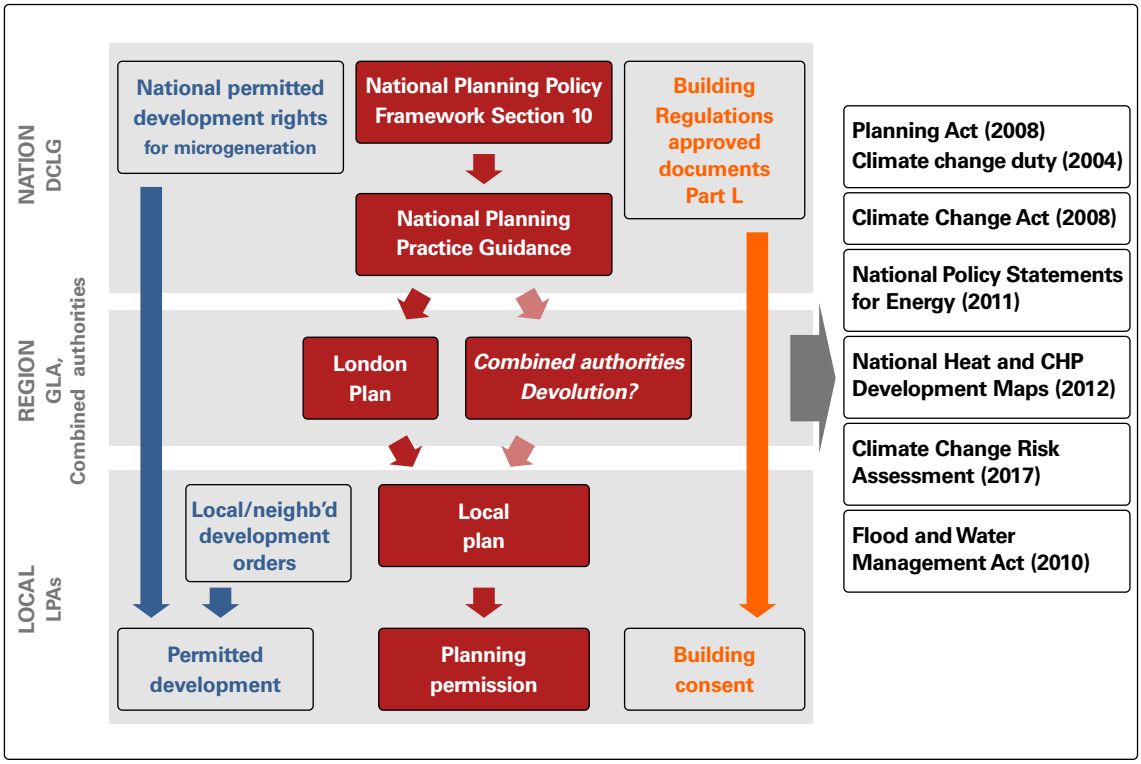
'plays a key role in helping shape places to secure radical reductions in greenhouse gas emissions, minimising vulnerability and providing resilience to the impacts of climate change, and supporting the delivery of renewable and low carbon energy and associated infrastructure. This is central to the economic, social and environmental dimensions of sustainable development.'

It further states that local planning authorities (LPAs) 'should adopt proactive strategies to mitigate and adapt to climate change'.[5] The Climate Change Act 2008 also places a duty on local authorities to reduce CO_2 emissions.

In light of the above, the findings from a recent Town and Country Planning Association (TCPA) study[6] are dispiriting. It found that the majority of new Local Plans in England reviewed in the research lacked robust planning policies on climate change mitigation and adaptation, with no carbon reduction targets and limited regard to some types of climate change impact, such as increased surface water flood risk, heat stress and sea level rise.

The TCPA report and a recent Royal Institution of Chartered Surveyors (RICS) report[7] identify a number of recent changes to national policy that are contributing to both weaker climate change policy and, where policy does exist, less rigorous implementation, such as:

- the scrapping of the 2016 zero-carbon target;
- the winding down of the Code for Sustainable Homes, and changes to sustainable drainage requirements;
- the Housing Standards Review (and associated written ministerial statement indicating that local planning authorities should desist from setting their own sustainability standards relating to the construction, internal layout or performance of new dwellings – although there is uncertainty about the extent to which this is binding without legislative changes);



The relationship between planning and climate change considerations in the English planning system
Source: Planning for the Climate Challenge? Understanding the Performance of English Local Plans[6]

- an overriding pressure to maximise the delivery of housing numbers, combined with a strengthened focus on the viability of development, with environmental sustainability requirements sometimes viewed as an added cost/pressure on viability and a 'nice to have' complication that gets in the way of delivering more units; and
- local government cuts (which have hit planning services particularly hard, often leading to the loss of staff with energy and environmental sustainability expertise).

The TCPA study concludes that the planning system 'remains *critically unprepared* to deliver both carbon dioxide emissions reduction and the kind of resilience measures needed to deal with the scale of climate change impacts anticipated in the UK, as identified by the scientific evidence'.

Current projections by the Committee on Climate Change show that emissions from the built environment will exceed what is required in 2030 by 18%.[8] The Committee has recommended that a much stronger policy framework for building in de-carbonisation is required over the next three decades.[9]

London – a beacon for climate change planning, but policy enhancements are needed

While there are important examples of local authorities across England taking a lead on climate change through both planning and wider projects[10] (such as Norwich's 'fabric first' procurement framework), the Mayor of London and a number of London boroughs have arguably led the way on strong planning for climate change mitigation and adaptation. This has been enabled by high demand for development in London and, in the case of London Plan policies, the Greater London Authority Act's emphasis on 'promoting the improvement of the environment in Greater London' (section 30(2)(c)).

The Greater London Authority's (GLA's) recent clarification of the London Plan 'zero carbon homes' requirement, as set out in its Housing Supplementary Planning Guidance, applying from October 2016 (and contrasting starkly with the loss of the national policy on zero-carbon homes), has been a notable recent positive development for climate change mitigation in London. Nevertheless, progress in reducing CO_2 emissions is falling well short of target. Interim results show that in 2014 London's CO_2e (carbon dioxide equivalent) emissions were 37.8 million tonnes.[11] This is a 16% reduction on 1990 levels, despite an ever-increasing population (an increase of 26% since 1990). However, former Mayor Boris Johnson set a target of a 60% reduction on 1990 levels by 2025.

It is clearly important that the London Plan continues to set stretching environmental standards both to enable local authorities to deliver high-quality, low-carbon, healthy, resilient development across London; and, more broadly, to drive industry to innovate, upskill and deliver such development more cost effectively across the UK and into export markets.

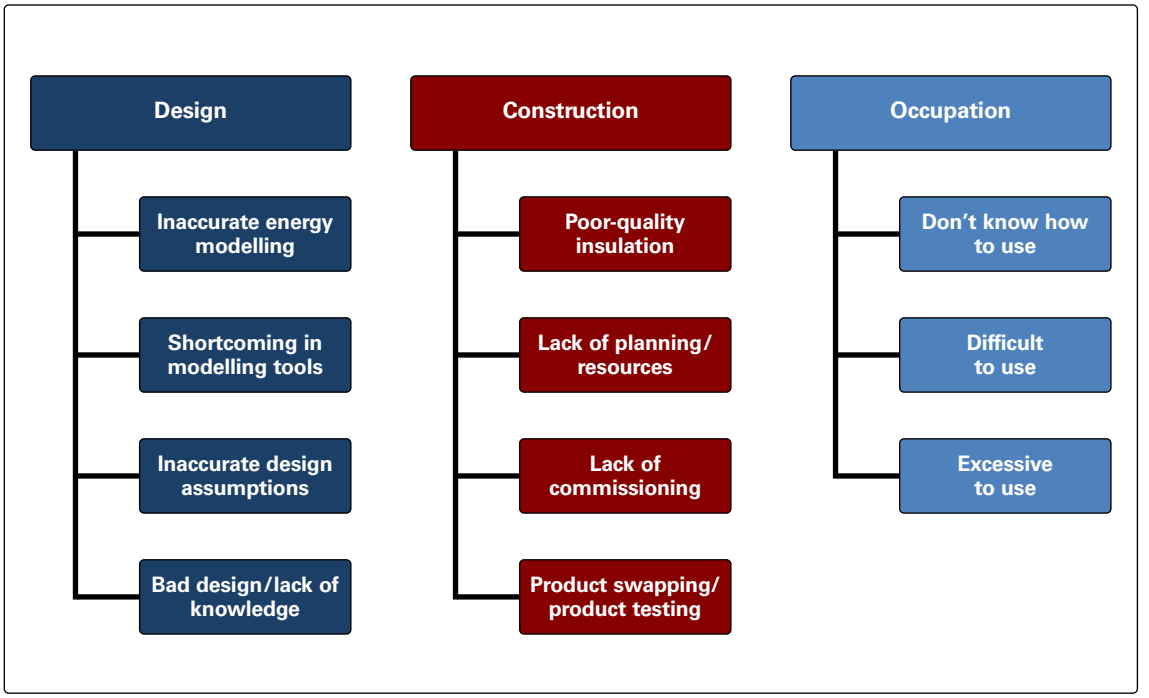
There is an important opportunity for the new London Plan, under development this year, to upgrade its policies and approach with regard to climate change mitigation and adaptation and wider sustainability issues. Some ideas for doing so are outlined below.

'It is clearly important that the London Plan continues to set stretching environmental standards to enable local authorities to deliver high-quality, low-carbon, healthy, resilient development across London'

The performance gap

There is now widespread evidence of a significant performance gap between modelled and actual in-use energy performance of buildings, due to multiple factors at design, construction and occupation stages.[12] This is a fundamental issue for planning because planning permission is generally granted on the basis of modelled energy performance (some London boroughs condition the submission of an 'as-built' Energy Performance Certificate for all major developments to try to secure confirmation of delivery of the 'as-modelled' performance; however, the robustness of this verification mechanism is widely questioned). As Clare Murray, Head of Sustainability at Levitt Bernstein has noted,[13] modelling inaccuracies and other determinants of the performance gap 'render the CO_2 reductions on paper meaningless and prevent the best outcome for residents and maintenance teams'.

To address this challenge the GLA could develop stronger policy on post-completion monitoring and evaluation of both 'regulated' and 'unregulated' emissions (for example by introducing a requirement for Display Energy Certificates for all major non-residential developments, as promoted by CarbonBuzz and others,[14] or by introducing a 'green performance plan' requirement similar to the policy approach developed by the author at Islington Council[15]). The GLA could also work with the Government in light of the Bonfield Review findings[16] to develop good practice standards for energy measures, including consistent and robust monitoring.[17]



The performance gap

Source: The Future of Policy and Standards for Low and Zero Carbon Homes[7]

The growing build-to-rent sector may provide an important opportunity for trialling a new approach to monitoring, as developers in this sector should have a long-term interest in refining the performance of their properties, which may extend to energy issues through, for example, lower energy bills for tenants. There will also be increasing opportunities for research collaborations with boroughs, utilities and academia to analyse in-use building performance data secured via smart metering and low-cost internet-connected thermal sensors. This would enable lesson-learning to inform future planning policy and guidance and improvements to energy and overheating modelling tools used to demonstrate compliance.[18]

These sorts of intervention would all contribute to meeting London's new zero-carbon target for 2050.

Carbon targets

The GLA's recent clarification of the London Plan zero-carbon homes requirement was a positive step forward in terms of reducing CO_2 emissions from residential development, and there may be limited scope to improve on this policy, at least in the shorter term. The current London Plan indicates that non-residential development will need to be 'zero carbon' for the period 2019-2031, but what this means is yet to be defined. It is also unclear what changes will be made to energy requirements in the Building Regulations by 2019, especially as, following Brexit, there is uncertainty as to whether the EU Directive on 'nearly zero-energy buildings' by 2020 will apply.

The new London Plan should define what 'zero carbon' means for non-domestic developments, to give certainty to developers and industry. This could simply mirror the approach adopted for zero-carbon homes, with a 35% on-site target (relative to Part L of the Building Regulations, 2013) and offsetting of all residual emissions. However, the latest evidence on technical feasibility and financial viability should be reviewed to see if there is scope to increase the on-site target for some types of non-domestic development (for example, previous testing has indicated that large retail parks can achieve higher on-site targets[19]).

Embodied carbon and the circular economy

Embodied carbon in building materials is becoming an increasingly significant proportion of the whole-life CO_2 burden of buildings as the operational efficiency of buildings is improved;[20] yet requirements for the use of sustainable materials in residential developments were recently lost following the demise of the Code for Sustainable Homes (and this issue is not addressed in the Building Regulations). Moreover, requirements for minimisation of construction waste have been lost with the removal of the legal requirement for site waste management plans.

The London Plan could address this significant regulatory void by establishing policy and guidance

on minimising the embodied carbon and wider environmental impacts of building materials (for example by incentivising the use of lean design to minimise use of primary resources and to select sustainably-sourced, low-impact and recycled materials) and through policy and guidance on minimising construction waste (including by maximising the efficiency of materials use on site and re-using, re-manufacturing or recycling materials where possible). The scoring methods for materials and waste used in BREEAM would be a good place to start.

Ideally policy and/or guidance should also address the need to design buildings to be 'long life, loose fit' (i.e. built of durable, easy-to-maintain materials and designed for a long life while being adaptable to changing user needs) and 'designed for deconstruction' (so that materials can be easily separated and re-used or recycled after the building reaches the end of its useful life[21]) to further reduce lifecycle impacts and support the circular economy.

Tall-building impacts on CO_2 emissions

There is a need to more fully consider and address the impacts of developments (particularly tall buildings) on energy generation on nearby sites, particularly overshadowing of existing solar photovoltaic panels.[22] For example, there could be a requirement to calculate the lost CO_2 emissions savings (relative to an appropriate baseline) from an overshadowed solar photovoltaic array and include these in the CO_2 calculations presented in the energy assessment submitted with a planning application; i.e. the development would have to do more to offset these additional emissions.

The impacts of tall buildings (individually or cumulatively) on the dispersion of pollutants from energy centre flues or waste recycling centres also need to be addressed, as they can undermine the functioning of such low-carbon infrastructure.

More subtly, the increasing number of tall-building developments in London may make designing buildings based on low-energy passive ventilation strategies an increasingly risky proposition due to their impacts on wind flows.

Impacts of high-density development on the urban heat island

High-density development can exacerbate summer temperatures which are already rising as our climate warms. This can have direct negative impacts on comfort, health and wellbeing – the UK Climate Change Risk Assessment 2017 estimates that the number of heat-related deaths could more than double by the 2050s from a baseline of around 2,000 per year. High-density development can also have knock-on impacts on active cooling demand in buildings, further exacerbating the urban heat island (UHI) through increased heat rejection to the external environment from these systems.

The UK Climate Change Risk Assessment 2017 states that 'urgent action is needed in the next five years across a range of policy areas to address overheating in homes and public buildings and to reduce the impacts of the urban heat island effect through urban design and planning'.

A requirement could be introduced in the London Plan for high-density schemes in the Central Activities Zone (considered to be analogous to the area that experiences the most intense UHI in London) to model their impact on the UHI (taking into account building geometry, albedo, vegetation, shadowing, anthropogenic heat sources, etc.) and demonstrate how the impact would be mitigated on site. Where this is demonstrated not to be feasible, then an offset payment could be secured via a section 106 agreement to fund off-site mitigation measures within the immediate area – for example significant street tree planting or retrofitting of green roofs (in an approach that would broadly reflect that currently used for carbon offsetting).

This could be a powerful mechanism for delivering more ambitious green infrastructure measures across London, potentially linked to strategic targets for increases in street tree cover or urban greening measures. A methodology could be developed with leading experts in UHI modelling such as Professor Sue Grimmond from the University of Reading,[23] and drawing on existing modelling tools such as the Urban Multi-scale Environment Predictor (UMEP).[24] This could be set out in the GLA's energy assessment guidance, alongside existing guidance on internal overheating modelling. There could also be a requirement for the strategic planning of Opportunity Areas to be informed by such modelling at a wider spatial scale – something being explored for the Old Kent Road Opportunity Area in Southwark.

Internal overheating of buildings

The internal overheating of buildings can lead to adverse impacts on comfort, health and health inequalities[25] and productivity. Overheating is an increasing concern as peak summer temperatures rise with climate change, particularly in dense urban areas where external temperatures can be higher as a result of the UHI. The London Plan already sets out a cooling hierarchy, and the GLA provides some useful guidance on how to undertake robust modelling of internal overheating. However, this approach needs to be strengthened by including a clear requirement for such modelling and a clear presumption that 'comfort cooling' will not be incorporated in developments where it has been demonstrated that passive measures can address the risk of overheating.

The modelling methodology should ideally be able to reflect the anticipated density of occupation and type of use, as these factors can have a significant

A sustainable urban drainage system at work – 'there is potential benefit in exploring the introduction of a sustainable drainage offset policy'

impact on internal temperatures (although, as noted above under the 'performance gap' heading, further empirical research is needed to improve overheating models). If such modelling is not secured and robustly analysed at planning stage, more developments could become increasingly reliant on active cooling systems, leading to increased energy consumption and CO_2 emissions, a worsening UHI effect (as a result of heat rejection from these systems), and potentially significant health and productivity impacts if power outages occur.

Surface water flood risks

Many developments fail to achieve a greenfield run-off rate on site, for justifiable reasons. There is potential benefit in exploring the introduction of a sustainable drainage offset policy, particularly in 'constrained areas', such as where there is very limited capacity in the combined sewer network and therefore new development across the sewer catchment needs to achieve very low run-off rates to avoid expensive and highly disruptive infrastructure upgrades. This is an approach that is being scoped out for the Old Kent Road Opportunity Area Planning Framework/Area Action Plan in Southwark.

Helping nature adapt to climate change

The London Plan and associated strategies (for example the All London Green Grid) are already quite strong on green infrastructure planning. However, one possible improvement would be to include a requirement for all major developments to deliver a net gain in biodiversity, assessed before and after development using a Defra (Department for Environment, Food and Rural Affairs) endorsed biodiversity impact calculator.[26] This could be informed by principles and guidance on biodiversity net gain recently produced by IEMA (the Institute of Environmental Management and Assessment) and others.[27] By introducing a clear requirement to deliver net gains it may be possible to increase the ecosystem services provided by nature, and at the same time, by improving local habitat provision and connectivity, help species to move and adapt in the face of ongoing climate change.

Energy networks

Further development of decentralised energy networks in denser parts of London will be an important means of delivering CO_2 savings. Existing London Plan policy and guidance should be retained and further strengthened where possible, including through exploration of the feasibility/viability and CO_2-saving potential of a more direct approach to 'thermal planning' of heating and cooling loads and underground inter-seasonal thermal storage.[28] Conversely, it may be useful to explicitly highlight flexibility with regard to decentralised energy requirements in some circumstances, for example where innovative super-insulated schemes are proposed which have very low heat demand. Continued funding of technical support to boroughs will also be important.

With regard to communal heat networks within development sites, there is emerging evidence that

installing such systems in smaller schemes to comply with existing policy can lead to significantly higher revenue costs for building occupiers relative to individual boiler solutions; this is likely to be a particular issue where a scheme involves affordable housing and fuel poverty is a consideration. It may be useful for the GLA to establish a threshold size of development below which communal heat networks are not considered appropriate, just as it has already done for combined heat and power.

Smart grids

Smart grids will be an important means of helping to supply electricity more efficiently and sustainably in future by allowing real-time, two-way communication between electricity suppliers and consumers and the implementation of demand-side management strategies. They can help to balance supply (increasingly variable as renewables increase) and demand and thereby reduce the need for peaking generators.

'The development of smart grids and wider smart technologies and their implications for planning processes, policy and guidance should be kept under review'

The development of smart grids and wider smart technologies (such as internet-connected sensors and control systems for smoothing traffic flows and the use of building information management models for three-dimensional visualisation of buildings and wider infrastructure[29]) and their implications for planning processes, policy and guidance should be kept under review.

There may be ways that developments can be future-proofed to facilitate such innovation (beyond the provision of high-speed internet connectivity) – for example, the draft Old Oak and Park Royal Local Plan requires proposals to provide open and usable data to inform the Old Oak and Park Royal Development Corporation's activities and processes (the scope of this is not fully defined, but it would include appropriate digital building information management models and potentially could extend to data on energy, water, waste and pollution). The idea is that this will help the Corporation to more effectively plan, deliver and manage development, as well as creating business opportunities in app development. However, there are significant concerns about privacy and data security that will need to be addressed.[30]

Freight consolidation

The existing London Plan already includes strong transport policies that help to reduce CO_2 emissions (for example maximum car parking standards, cycle parking standards, and support for public transport), but one area that may merit further exploration is freight consolidation (i.e. reducing the number of vehicles carrying freight by making sure that their carrying-capacity and routing are optimised). A North London freight consolidation centre claims a 41% reduction in CO_2 emissions, as well as benefits for air quality, congestion and road safety.[31]

New policy could encourage Opportunity Areas to plan proactively for the provision of urban consolidation centres in suitable locations; and/or strategic developments meeting certain criteria (for example proximity to key transport routes and the level of freight trip generation) could be required to assess the feasibility of incorporating micro-consolidation centres, supporting last-mile low-carbon distribution (for example via bikes and electric vehicles). Micro-consolidation centres are located much closer to the delivery point than urban consolidation centres and tend to serve smaller areas, handling smaller and lighter goods.

Moving climate change considerations upstream in the design process

All of the above ideas relate to outcomes-based policies. However, guidance could also usefully be provided regarding process[32] – specifically by clarifying expectations on environmental design thinking at pre-application stage and in design review.

The Design Council's guidance on design review notes that a core principle of this approach is to offer advice from a diverse range of experts with a broad spectrum of skills and experience, including, among others, people from the sustainability and environmental services field. However, in the author's experience design review panels rarely include experts with significant technical knowledge of sustainability issues such as energy, overheating and surface water flood risk – despite the fact that early decisions about layout, massing and facade design can have fundamental impacts on the ability to satisfactorily address these important climate change mitigation and adaptation issues.

Some brief suggestions regarding wider environmental sustainability issues are set out below:

- There is a need for stronger policy and guidance on how to ***model and assess wind impacts***, specifically in relation to tall buildings. This should move beyond the Lawson comfort criteria to include consideration of the comfort requirements of outdoor seating areas (taking into account wind

chill), as well as impacts on the safety of cyclists on surrounding roads (not just pedestrians) and air quality at street level. It may also be relevant to consider impacts on the natural ventilation of nearby buildings. The use of wind assessment to inform the strategic planning of larger areas, including for reduced air pollution, would also be worth exploring and encouraging.

- Given the high levels of air pollution in London, the performance requirements of the existing ***air quality neutral standards*** should be questioned. It is suggested that a trajectory for the ratcheting up of these standards over time should be set out in policy (informed by projections of technological advances and cost reductions in this area), similar to the carbon trajectory created previously for the Building Regulations. More emphasis could also be given to considering how urban design, including building massing and layout, can facilitate air circulation and dilution of air pollution, as mentioned above (see, for example, Frankfurt's approach). Limits to the effectiveness of green infrastructure in improving air quality could also be recognised.[33]
- The introduction of ***performance standards for sunlight and daylight*** in policy may be useful,[34] as the widely used BRE guidance on site layout planning is guidance only, and recent research has emphasised the importance of sunlight and daylight access for health and wellbeing.[35] Such standards could include consideration of setting differential standards for certain types of area or development – for example, in high-density urban areas higher sunlight and daylight standards may be justified for public spaces that will be important amenity spaces for large numbers of people all year round.
- Although the written ministerial statement relating to the Housing Standards Review indicates that local standards, including on water, should not be established, given that there are concerns about the very significant impacts of drought on the London economy and the increasing water deficit in London it may be worth considering introducing stronger ***requirements for rainwater and greywater recycling***. They would need to be informed by a review of the latest technologies and their associated costs (capital and revenue) and carbon impacts.
- The London Plan and associated guidance could do more to encourage use of ***innovative waste technologies*** in new development – for example anaerobic digestion combined heat and power and vacuum waste systems, which can be effective means of increasing recycling rates and reducing waste truck movements (and associated impacts on air pollution, congestion and public realm design).

● ***Dr Doug McNab*** *has over 10 years' experience of working in London as a planner, focusing principally on environmental sustainability issues. He is a Team Leader in Planning Policy at Southwark Council. The views expressed are personal. Feedback directed to douglas_mcnab@hotmail.com would be very welcome.*

Notes

1 *UK Climate Change Risk Assessment 2017: Evidence Report*. Committee on Climate Change, Jul. 2016. www.theccc.org.uk/tackling-climate-change/preparing-for-climate-change/climate-change-risk-assessment-2017

2 Paris Agreement. United Nations Framework Convention on Climate Change. https://unfccc.int/files/meetings/paris_nov_2015/application/pdf/paris_agreement_english_.pdf

3 *The Emissions Gap Report 2016. A UNEP Synthesis Report*. United Nations Environment Programme (UNEP), Nov. 2016. http://web.unep.org/emissionsgap/resources

4 *Deadline 2020: How Cities Will Get the Job Done*. C40 Cities/Arup report. C40 Cities, Dec. 2016. www.c40.org/researches/deadline-2020

5 *National Planning Policy Framework*. Department for Communities and Local Government, Mar. 2012, paras 93 and 94. www.gov.uk/government/uploads/system/uploads/attachment_data/file/6077/2116950.pdf

6 *Planning for the Climate Challenge? Understanding the Performance of English Local Plans*. TCPA, Nov. 2016. www.tcpa.org.uk/planning-for-the-climate-challenge

7 *The Future of Policy and Standards for Low and Zero Carbon Homes*. Royal Institution of Chartered Surveyors, Feb. 2016. www.rics.org/Global/Low_Zero_Carbon_150216_dwl_aa.pdf

8 *Buildings and the 5th Carbon Budget*. Association for the Conservation of Energy. Oct 2016. www.ukace.org/wp-content/uploads/2016/09/ACE-RAP-report-2016-09-Buildings-and-the-5th-Carbon-Budget.pdf

9 *Next Steps for UK Heat Policy*. Committee on Climate Change, Oct. 2016. www.theccc.org.uk/publication/next-steps-for-uk-heat-policy/

10 *The Role of Local Leadership in Creating Sustainable Homes*. Green Paper. UK Green Building Council, Jan. 2017. www.ukgbc.org/resources/publication/role-leadership-creating-sustainable-homes

11 See the London Datastore 'Interim London Energy and Greenhouse Gas Inventory (LEGGI) 2014' webpage, at https://data.london.gov.uk/dataset/interim-london-energy-and-greenhouse-gas-inventory—leggi—2014

12 See, for example, work on the performance gap by the Zero Carbon Hub, at www.zerocarbonhub.org/current-projects/performance-gap, and by Carbon Buzz, at www.carbonbuzz.org/

13 C. Murray: 'Chasing zero carbon targets in dense residential developments is like chasing rainbows'. *The Architects' Journal*, 6 Sept. 2016. www.architectsjournal.co.uk/opinion/chasing-zero-carbon-targets-in-dense-resi-developments-is-like-chasing-rainbows/10010488.article

14 Although engaging with management of 'unregulated' energy loads such as appliances and IT servers is likely to be considered beyond the remit of planning, particularly for non-domestic buildings, as those responsible for the design of the building often have little or no influence on how a building will be fitted out or used

15 Recognised as best practice in the Greater London Authority's Sustainable Design and Construction Supplementary Planning Guidance – see www.islington.gov.uk/planning/planningpol/pol_supplement/ environmental-design

16 P. Bonfield: *Each Home Counts. An Independent Review of Consumer Advice, Protection, Standards and Enforcement for Energy Efficiency and Renewable Energy*. Bonfield Review Report. Department for Business, Energy and Industrial Strategy/Department for Communities and Local Government, Dec. 2016. www.gov.uk/government/uploads/system/uploads/attachment_data/file/578749/Each_Home_Counts__December_2016_.pdf

17 A number of studies have raised concerns about compliance checks for Building Regulations Part L – see, for example, Zero Carbon Hub research on the performance gap (see note 10). The North West Bicester eco-town scheme is being subject to rigorous monitoring and evaluation, providing a valuable evidence base for future developments. The GLA could develop a similar approach for schemes on public sector land in London, perhaps extending to a requirement for the use of Government Soft Landings

18 For a number of years industry experts have expressed concerns about the accuracy of the Standard Assessment Procedure (SAP) methodology used for modelling the energy/carbon performance of homes against Building Regulation Part L – for example querying the robustness of built-in assumptions about the performance of technologies such as combined heat and power and active cooling systems. These modelling inaccuracies are one of the key determinants of the performance gap identified by the Zero Carbon Hub (see note 10). See also K.J. Lomas and S.M. Porritt: 'Overheating in buildings: lessons from research'. *Building Research & Information*, 2017, Vol. 45 (1-2). www.tandfonline.com/doi/full/10.1080/09613218.2017.1256136

19 *Non-domestic Carbon Dioxide Emissions Target: Feasibility and Viability Study*. Hoare Lea, with David Lock Associates and Gardiner & Theobald, for Greater London Authority, May 2015. www.london.gov.uk/file/22710/download?token=CB2B4zLh

20 S. Sturgis and G. Roberts: *Redefining Zero: Carbon Profiling as a Solution to Whole Life Carbon Emission Measurement in Buildings*. RICS Research Report. Royal Institution of Chartered Surveyors, May 2010. Available at http://sturgiscarbonprofiling.com/redefining-zero/

21 See Islington's Environmental Design Supplementary Planning Document, available at www.islington.gov.uk/planning/planningpol/pol_supplement/environmental-design; and C. Morgan and F. Stevenson: *Design for Deconstruction*. SEDA Design Guides for Scotland: No. 1. Scottish Ecological Design Association (SEDA), 2005. www.seda.uk.net/assets/files/guides/dfd.pdf

22 The author made an early attempt to address this issue in Islington's Environmental Design Supplementary Planning Document – see www.islington.gov.uk/planning/planningpol/pol_supplement/environmental-design

23 See, for example, Professor Grimmond's slides from an ARCC/CIBSE event on the Adaptation and Resilience in the Context of Change (ARCC) network's 'Urban microclimate: overcoming obstacles to high density resilient cities' webpage, at www.arcc-network.org.uk/people-making-changes/urban-micro-climate/

24 See the Urban Multi-scale Environmental Predictor (UMEP) website, at www.urban-climate.net/umep/UMEP

25 The Climate Just web tool – available at www.climatejust.org.uk/ – provides a useful spatial picture of social vulnerability to climate change at a neighbourhood scale across England. It identifies local climate disadvantage as an outcome of exposure to climate hazards combined with social vulnerability

26 Such as Warwickshire County Council's Biodiversity Impact Assessment Calculator – see http://heritage.warwickshire.gov.uk/files/2013/06/Guidance-for-Biodiversity-Impact-Assessment-calculator-v18.pdf

27 *Biodiversity Net Gain: Good Practice Principles for Development*. CIRIA/Institute of Ecology and Environmental Management, 2016. www.iema.net/policy/natural-environment/principles-and-guidance

28 *The Future Role of Thermal Energy Storage in the UK Energy System: An Assessment of the Technical Feasibility and Factors Influencing Adoption*. Research Report. UK Energy Research Centre, Nov. 2014. www.ukerc.ac.uk/publications/the-future-role-of-thermal-energy-storage-in-the-uk-energy-system.html

29 *Smart City Opportunities for London*. Arup, Mar. 2016. www.london.gov.uk/sites/default/files/arup-gla_smart_city_opportunities_for_london.pdf

30 L. van Zoonen: 'Privacy concerns in smart cities'. *Government Information Quarterly*, 2016, Vol. 33 (3), 472-80. www.sciencedirect.com/science/article/pii/S0740624X16300818

31 *The London Boroughs Consolidation Centre – A Freight Consolidation Success Story*. Case Study. Transport for London. http://content.tfl.gov.uk/lbcc-case-study.pdf

32 RIBA's *Green Overlay to the RIBA Outline Plan of Work* (Nov. 2011) is a useful reference point – see www.architecture.com/files/ribaprofessionalservices/ practice/general/greenoverlaytotheribaoutlineplanofwork2007.pdf

33 T. Pugh, A. MacKenzie, J. Whyatt and C. Hewitt: 'Effectiveness of green infrastructure for improvement of air quality in urban street canyons'. *Environmental Science & Technology*, 2012, Vol. 46, 7692-9. www.greenroofs.org/resources/GreenInfrastructurePaper.pdf

34 See, for example, Policy 25: 'Reducing carbon emissions and adapting to climate change', in *The Plymouth Plan 2011-2031. Part One*. Plymouth City Council, Sept. 2015. http://web.plymouth.gov.uk/plymouth_plan_part_one.pdf

35 See the Adaptation and Resilience in the Context of Change (ARCC) network's 'Urban microclimate: overcoming obstacles to high density resilient cities' webpage, at www.arcc-network.org.uk/people-making-changes/urban-micro-climate/