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Evidence continues to mount concerning the contribution that carbon emissions from human activity are making to global warming and climate change [1], the costs that this will impose on future generations if unabated [2] and the challenging GHG mitigation targets and strategies required to minimise temperature increase [3]. There are multiple pathways available for the decarbonisation of modern societies and they tend to fall under three principal categories: technological change, sustainable urban design and behaviour change [4]. All are necessary and require transformational change from current practice.

Technological change offers the clearest and most certain path to a low carbon future, with renewable energy at its core, linked to solar-electric and solar hydrogen systems for buildings and transport [5]. However, the speed with which this transition is currently occurring is not commensurate with the window of opportunity for the scale of carbon mitigation required, given the current path dependency of most developed and developing societies on fossil fuels and the regimes and infrastructures built around them.

Voluntary behaviour change represents the holy grail for a sustainability transformation, given its potential for occurring rapidly and at relatively low public cost. However, research to date points to a significant and persistent ‘attitudes-action’ gap among populations generally in relation to actual behaviours linked to GHG emissions and resource use [6]. In the current absence of any exogenous pressure that will force a tipping point in mass behaviour, and lack of evidence that grass roots ‘spontaneous interventions’ [7] have a capacity to snowball, attain critical mass and scale-up, uncertainty will continue to surround this vehicle for change until it is possibly too late. Indeed, there are those that argue that “…today’s focus on ‘behaviour change’ …is a distraction because it diverts attention and resources from the problem of building wider and more durable public demand for ambitious interventions.” [8].

The third pathway to more sustainable low carbon cities is via urban design. It is now estimated that urban environments account for 80% of all global carbon emissions [9].

Urban Design for Low Carbon Living

Urban design for low carbon living operates at several scales, ranging from manufactured products (domestic appliances, automobiles, building materials etc) to individual buildings, neighbourhoods
Precincts and entire metro regions. Innovation is occurring in all of these arenas from the perspective of decarbonisation, but it is critical for government, industry and community to have access to scientifically validated instruments capable of providing an evidence base to any claims related to carbon performance. This is particularly critical in relation to assessment of the carbon signatures of built environment objects, given the emergence of an increasing array of public instruments – carbon credits, carbon trading, carbon taxes, financial incentives for direct action etc – that depend for their legitimacy on an agreed evidence base.

Precinct scale design assessment is least developed among the spectrum of built environment tools targeting energy efficiency and carbon performance, that also include product declarations, whole building modelling and city modelling. Yet precincts constitute the critical operational scale at which a city is developed (greenfields), is re-built (brownfields, greyfields) and is operated. They are the ‘building blocks’ of our cities [10] and represent the scale at which urban design makes its contribution to city performance. Precincts constitute the origins and destinations for homes, schools, workplaces and recreation and the trip generators associated with connecting each. In aggregate, they are a microcosm of urban life. It has been argued, however [11], that the unsustainable nature of today’s cities is due in part to poor planning at the neighbourhood level. For example, the high levels of car usage and traffic congestion are a reflection of an absence of: mixed use development, variety in housing types (especially medium density) and lack of walkability and public transit access having been designed into urban neighbourhoods in recent decades. Purely in CO2 terms, variability in the housing and transport attributes of different suburbs means that neighbourhood-scale carbon emissions can vary by as much as 50% across Australian cities [12,13]. Precincts constitute a critical focus for the achievement of any carbon neutrality target for cities since this is the scale at which an optimal combination of urban design innovation, urban technology innovation and behaviour change can jointly occur.

A principal weakness with the carbon strategies of many governments is their lack of challenge and incentive to sectors such as the built environment to develop and implement a low carbon roadmap to guide future planning and investment. McKinsey and Company [14] developed cost curves for greenhouse gas abatement that identified aspects of the built environment as among the most prospective for intervention by government and industry. Their focus, however, was primarily at the scale of individual buildings and specific technologies. The incentive for government and industry to engage in more innovative precinct interventions and investments requires an evidence base that can quantify the benefits of implementing more resilient, sustainable low carbon urban design at this scale.

Needed: Urban Precinct Design Assessment Tools

Precinct design assessment is in its infancy. Precinct (neighbourhood) rating systems have emerged in a number of jurisdictions (eg, LEED ND in North America; BREEAM Communities in UK and Europe; GreenStar Communities in Australia). To date, all are voluntary; and all rely heavily on the veracity of outputs from tools that assess the performance of different aspects of precinct design, grouped broadly under carbon, triple bottom line sustainability and resilience criteria. Lack of scientific validation of current assessment tools generates uncertainty in respect of precinct rating and is inhibiting endorsement by government and wider take up by industry. Scientifically validated models for carbon assessment are a prerequisite for any prospect that carbon ‘credits’ might be assigned
under any future government or industry scheme that recognises the amount of carbon mitigation delivered by a particular urban development project. At present in Australia, built environment/property development has been excluded from such schemes. By comparison, the Australian federal government permits rural landowners to create carbon credits by taking action to cut emissions via a range of land-based projects under its Carbon Farming Initiative (www.climatechange.gov.au). Yet this area is projected to deliver less than 4 million tonnes a year of emission reductions by 2020 [15], a fraction of the mitigation potential offered by the built environment [14].

Audits of new construction attempt compliance between ‘as designed’ and ‘as built’ elements of a building or precinct plan, but it is contentious whether ‘as operated’ should be part of precinct design assessment. Garde [16] argues that the focus should be on high performing precinct design elements that ‘contribute to the sustainability of projects by themselves, without requiring occupants to change their behaviour’. This is in line with arguments advanced earlier in this article: that built environments must be designed in a way that make it possible for residents to live more sustainable, low carbon lifestyles. There are many parts of cities where urban design and urban technology currently makes this difficult if not impossible for certain populations [17, 18].

A recent report for the Co-Operative Research Centre for Low Carbon Living was undertaken to identify the functionality, data and information platform required to deliver a 21st century design assessment tool for precincts that is scientifically sound for evaluating the carbon intensity, sustainability and resilience of current and future built environments [19]. Key requirements include:

1. Developing a new way of modelling precincts, referred to as Precinct Information Modelling (PIM) that meshes Building Information Modelling (BIM) with Geographic Information Systems (GIS), providing for transparent sharing and linking of precinct object information across the development life cycle; ensuring consistent, accurate and reliable access to reference data, including that associated with the wider urban context of the precinct – a digital platform on which ISO standards for urban precincts or communities can be best developed [20].
2. Defining and calculating ‘core’ indicators of performance assessment capable of replication across all classes of urban development where assessment against criteria of sustainability, resilience and low carbon built environment design outcomes is required. Currently there are a wide spectrum of indicators in play, but little or no consensus on their relative importance – especially with the more recent emergence of carbon and resilience as new arenas for demonstrating urban performance. Nor is there transparency in the methods by which many indicators are derived: a basic requirement for scientific validation.
3. Improving data availability for a range of precinct assessment tasks, including baseline information for precinct indicators, modelling and inputs to BAU benchmark calculations. Embodied energy data was identified as the most critical data deficiency of direct relevance to life cycle carbon assessment of the built environment.
4. Establishing benchmarks -- central for guiding decision-making in project design and project rating. There was no commonality across assessment tools for this process. There are benefits to be derived from a standard methodology and nomenclature, given the desirability of communicating performance to the marketplace and the prospect of meshing with precinct rating tools to achieve this. Establishing carbon benchmarks for built
environment precinct objects (embodied carbon) and precinct-based activities (operating carbon) are critical performance metrics related to designing a low carbon built environment.

5. Improved forecasting of future demand emanating from a precinct (e.g. energy, water, waste and transport -- all have carbon signatures). Other scenarios of interest include: future demographics on a small area basis, climate change vulnerability, energy costs, economic development etc.

6. More effective tools for evaluating distributed systems and the innovation potential of precinct supply side solutions. Demand profiles for precincts, whether energy, water, transport, building, waste or leisure-related, need to be able to be ‘matched’ with the most appropriate supply side options that are low carbon and eco-efficient in operation as well as meeting any other project-specific objectives/targets (e.g. carbon neutral, zero waste to landfill, recycled water for all non-potable use, price points for a percentage of housing that meets affordability criteria etc.). There is significant variability across existing assessment tools in relation to how supply options are identified and evaluated. At present, a range of distributed generation systems capable of operating at building and/or precinct scale are available and need to be able to be assessed on eco-efficiency criteria for their suitability to a particular project. Distributed systems permit the development of more autonomous, resilient, sustainable low carbon precincts and communities.

7. Ability to cost alternative design options to reflect, at minimum, capital vs. life cycle cost; allocation of costs and benefits between the principal stakeholders of precinct development; examining critical trade-offs (e.g. capital vs. lifecycle costs vs. carbon emissions from alternative energy technologies).

8. Developing reference sites -- managed by independent national and/or international organisations -- where new assessment tools (related to buildings, precincts and infrastructure) can be applied to established ‘test’ datasets of representative precinct designs and compared with established ‘best of breed’ assessment model outputs with a view to a comparison and spatial-temporal validation.

Given the criticality of the built environment to a climate and resource constrained 21st century that is also rapidly urbanising in order to accommodate a projected nine billion global population by 2050, developing best practice tools for measuring sustainable, low carbon urban development must gain a higher priority than is presently the case.
References
