time and between places. It may be partly for these reasons that urban morphologists have so far seldom explicitly considered vegetation as a component of urban form.

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Urban form and energy

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In a recent 'viewpoint' in this journal it was argued that three fundamental issues should be on the urban morphological research agenda for the present decade (Oliveira, 2011). One of these was the development of key cross-disciplinary links between urban morphology and the various fields of knowledge studying the city in order to promote effective integrated research on urban areas.

Energy plays a fundamental role in today's world. The way urban areas are built has a great influence on the present and future demand for energy. The influence on transport demand is mainly expressed in trip generation and on built structures in terms of end uses such as heating, cooling and lighting. Despite the undeniable linkage, scientific research on urban morphology has remained poorly linked with that on energy. On the one hand, urban morphology focuses on the physical stocks of cities and on the processes and actors shaping them, somehow ignoring the issue of urban flows. On the other hand, research on energy has been adopting sectoral visions of the problem and has not been able to deal effectively with the spatial dimension of cities embracing all the different scales. The absence of a comprehensive view has been disabling further advances in shared knowledge and action on energy efficiency and urban sustainability.

Most literature on energy has been addressing one of two scales of analysis. At the city scale, scientific research has been exploring the dichotomy between compact and diffuse patterns of urban development, the variations of density (of built forms and of inhabitants), and the land-use patterns, connecting these aspects with transport (including systems management and the construction of infrastructures). At the building scale, recent research tends to cluster around three main lines of investigation: the establishment of different frameworks for classifying built forms (from an urban energy perspective); the design of innovative methods for estimating the energy consumption of buildings; and finally, the analysis of the potential of buildings for improvement. Despite the remarkable advances achieved at both scales of analysis, the two communities of researchers seem to exist in largely separate worlds. As Batty reminded us, although it might seem strange, there is hardly any work on connecting what we know about the size and shape of buildings to what we know about their location (Batty, 2008).

However, in the last few years, a number of studies have started to address intermediate scales of analysis – between the city, taken as a whole, and the building, seen as a self-defined entity – that have been previously ignored, possibly due to the complexity of environmental processes and the lack of data. Osmond (2010), Bonhomme *et al*. (2011) and Sarralde *et al*. (2011) propose a set of tools that, despite some limitations, do enable researchers and practitioners to start dealing with the issue of energy consumption at intermediate scales. The first of these papers proposes the urban structural unit, a descriptive and explanatory framework that considers both the stocks and flows – of energy, information and materials – of the city. The second paper offers MUSE as a model to measure the patterns of energy consumption driven not only by the characteristics of transport and buildings but also by a number of features of specific urban microclimates. The third paper proposes a model to measure energy consumption considering not only the characteristics of urban form but also the renewable energy potential of cities. An additional step is taken by Ratti *et al*. (2005) and Salat (2009). Drawing on a quantitative morphological approach promoted by Lionel March back in the 1960s, Ratti *et al*. (2005) use digital elevation models and the lighting and thermal simulation tool to analyse the effects of urban texture on building energy consumption. Ratti and his colleagues consider the following parameters in their analysis: built volume and built surface, passive and non-passive zones, orientation of façade, urban horizon angle, and obstruction of sky view. Following a similar line of research, Salat (2009) uses a number of environmental metrics – such as building shape and passive volume – to explore energy consumption in different parts of the city. Both papers present applications of their methodological proposals in large European cities.

The development of new approaches, theories, concepts and methods should offer greater understanding of the interrelationships between urban form and the level of energy being used to maintain contemporary urban systems (considering both the quantity and the quality of the energy sources). It should also inform the debate on current urban development strategies, promoting the sustainable use of resources, land and energy as key ingredients for long-term prosperity. Finally, it should enable communication between hitherto rarely linked research communities, and generate insights into how to promote new research outputs for planning practice.

Among the different issues under discussion in contemporary debate on cities, energy is certainly one of the most important. Rising energy prices, the urgent need to reduce emissions and mitigate climatic change, and the large investments that will be needed to make installations and infrastructures fit for the future, make urban energy a key challenge for the present decade. The inclusion of a morphological dimension in this debate is essential.

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Morphological complexity: a response

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Ley (2012, p.79) categorizes fractal morphology as one of ‘the more exact methods of the natural sciences’ and, while criticizing geometrical methods, calls for the use of ‘methods from both the humanities and life sciences’. He stresses the limitations of the sciences that study urban form, arguing that there is a need to consider the people and processes shaping urban form to provide ‘full