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# Sustainable cities – modelling urban energy supply and demand

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**Abstract**

A model of urban energy consumption has been developed using energy supply data and post-code information. The model simulates spatial and diurnal variations in energy demand, and also models the effect of energy-management measures and associated reductions in $CO_2$ emissions. A linear programming optimisation module is used to identify the most cost-effective measures to achieve specified $CO_2$ or energy reduction-targets. When combined with data from an associated attitudinal survey, the model can be used to assess the potential for $CO_2$ reduction in the urban environment.
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## 1. Introduction

The potential threats posed by global-climate change and the need to achieve substantial cuts in $CO_2$ emissions were recognised in the UK government's Energy White Paper [1], which declares an aspiration to achieve a cut of 60% of current levels by 2050. The White Paper also identified a clear role for local government to contribute towards reducing greenhouse-gas emissions. Guidance on the role of local authorities to reduce energy consumption has been in place for many years [2]; similarly, the OECD has also reported on local action [3] in reducing consumption and improving quality-of-life. The local government association produced an energy-policy statement in 1998 and updated guidance in 2004 [4,5]. International comparisons of the different approaches of different towns and cities have also been made [6]. However, although the technology exists to improve dramatically energy efficiency [2], these technical improvements are not being made on a large scale. The non-technical barriers, including attitude and behaviour, are key reasons for this lack of progress. The successful authorities and regional bodies are ones in which there are well-functioning networks of local authorities, utilities and the public, private and voluntary sectors to deliver energy efficiency improvements and promote the use of renewable energy [7]. However, there has until recently been little concerted effort to link the technological and social-economic issues involved in managing the energy requirements of a sustainable city, and, where data have been made available, it is still difficult fully to evaluate the impact of carbon-reduction measures [8].

A recent survey identified that most local authorities are not yet fully addressing climate change issues [9], although a small number have made good progress [10]. A far greater number of local and regional bodies must implement measures to reduce greenhouse-gas emissions. However, despite the need for evidence that the measures implemented are, or have been, effective, there are no clear mechanisms for predicting and monitoring these emission reductions at a local to regional level; the Sustainable Development Commission through its ***d***CARB-UK project [11] identified the need for a series of different models to identify cost-effective approaches and assess progress in reducing $CO_2$ emissions.

The work described here stems from a project which aimed at analysing both technological and socio-economic aspects of domestic and commercial energy-consumption and use the results to produce a model for urban energy-management, which could account for both factors. Some of the detailed findings of the project have been published elsewhere (see [12–15]); the purpose of this paper is rather to describe the methodology and capabilities of the model.

Patterns of energy consumption in the urban environment are highly diverse, being influenced by a range of environmental, technical, social and economic factors. The aim of this work was to produce a Geographical Information System (hereafter GIS) software-tool to allow an assessment of the impact of urban growth and aid the management of energy consumption by the optimisation of demand-side management, energy-saving measures, embedded generation and use of renewable resources. Creation of a user-friendly software-package, encompassing the full range of energy management issues suitable for the general user, was beyond the scope of the project;

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