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Energy analysis of the non-domestic building stock of Greater London

Ruchi Choudhary

Energy Efficient Cities Initiative, Department of Engineering, University of Cambridge, UK

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ABSTRACT

This paper presents a Bayesian approach for developing city-scale energy models of the built environment and demonstrates its application to non-domestic buildings in Greater London. The work draws upon available information of the building stock, such as: mapping databases, floorspace statistics, energy benchmarks, and measured energy consumption reported in display energy certificates of public buildings. The resulting model is able to describe the spread due to variation of energy consumption across buildings within a similar category. These spreads (or distributions) can be used for estimating the probability distribution of the gross energy consumption per local authority in Greater London. The work is driven by the need to quantify future energy demand of buildings in their urban context as a function of projected growth of buildings and populations, refurbishments, policies incentivizing energy efficiency measures, and changes in building operation. The focus on the non-domestic sector enables a framework that accommodates diverse set of activities and uses of buildings within an urban region.

1. Background

The UK Department of Communities and Local Government estimates that non-domestic buildings are responsible for almost 20% of the UK's energy consumption and carbon emissions. The percentage share of energy consumption by non-domestic building is more dominant in cities. According to 2008 figures reported by the Department of Energy and Climate Change (DECC), non-domestic buildings account for 46% of total energy consumption in Greater London, and more than 60% in local authorities of Westminster, City of London, Tower hamlets, Camden, and Kensington & Chelsea (see Fig. 1). While the gross total energy consumption of non-domestic buildings in Greater London has decreased by 4% since 2005, electricity consumption has increased by 3% overall. DECC [1] attributes the total decrease (albeit small) in energy consumption to be due to 'more efficient heating systems, insulation, greater efficiency of lighting and electrical equipment and improved energy management leading to appliances being switched off when not in use'. The overall increase in electricity consumption can be potentially attributed to growth in floor area or employee numbers. As shown in Fig. 2, the percentage changes since 2005 per local authority are more varied and larger. It should also be noted that increase in non-domestic electricity consumption since 2005 is not necessarily in those local authorities that have a higher percentage share of non-domestic energy consumption. The UK government's aim to reduce its carbon emissions by at least 80% by 2050 will require more effort than maintaining stable overall levels of consumption over the years in the non-domestic sector. The Carbon Trust asserts this view in CTC766 [2], requiring all commercial buildings to achieve at least an F-rated energy performance certificate by 2020. However, it is difficult to enforce aggressive upgrades unless they are cost-effective for the investors. Recent policies such as the Carbon Reduction Commitment (CRC) scheme, energy certificates, climate change levy & agreements (CCL), and renewable heat incentive (RHI) are likewise designed to reduce emissions from the commercial sector, but the extent to which they can be effective is not known. It is becoming increasingly necessary to be able to instrument and quantify which measures will be most effective and where (in terms of spatial geographies and building sub-sectors) they will yield most benefits.

2. Analysis of the non-domestic stock

Techniques for extending building level models to quantify energy consumption of a neighbourhood, district, or city region have come into closer scrutiny as policy-implementers are under pressure to take large-scale actions for reducing energy consumed by regions, districts, or building sub-sectors as a whole. A larger quantity of published literature on this topic deals with the domestic building stock, primarily because it is the dominant overall consumer of energy within the building stock nationally, and will hence play a critical role in meeting overall carbon-reduction targets

E-mail address: r.choudhary@eng.cam.ac.uk.

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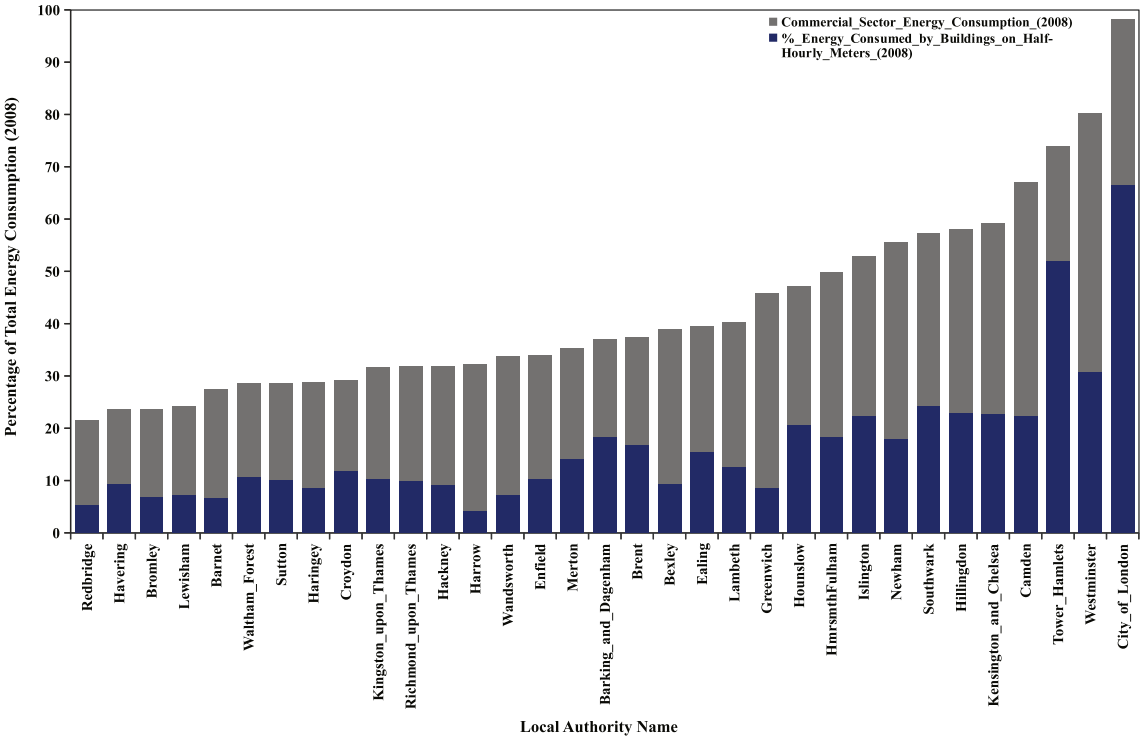

Fig. 1. Percentage share of non-domestic energy consumption per local authority [2008].

set by governments. A secondary reason is that large-scale assessment of non-domestic sector is often infeasible or difficult due to the sheer diversity of use, activities, and ownership structures within it. Notable studies in the UK that have contributed towards analyzing and understanding the energy consumption patterns of the non-domestic sector are: The N-DEEM model [3,4] supported by extensive energy audits of a large sample of buildings in the UK by Mortimer et al. [5] and by the development of non-domestic database by Bruhns et al. [6], Steadman et al. [7]. The authors of this work have recently extended their work by mapping UK's energy and property

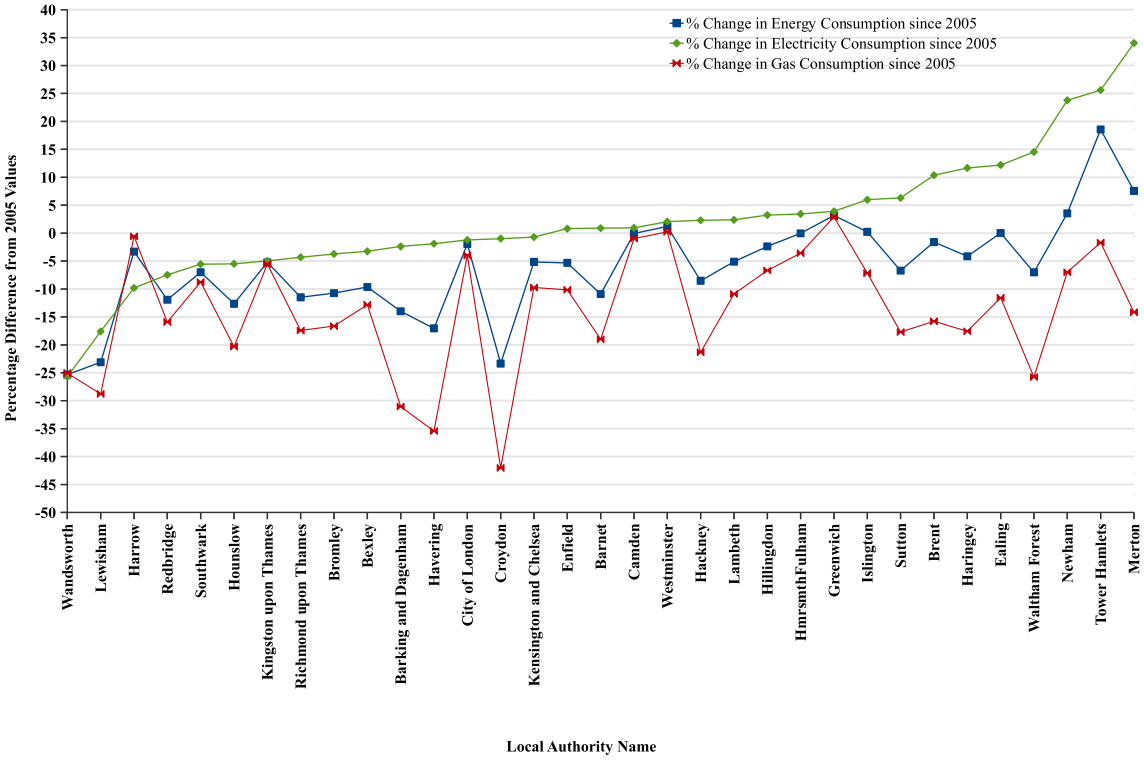

Fig. 2. Percentage change in energy and electricity consumption since 2005 per local authority.