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Evaluating the applicability of integrated domestic energy consumption frameworks in the UK

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Abstract

Domestic energy consumption (DEC) has been traditionally understood using disciplinary perspectives, focusing on specific components of the energy consumption system such as technologies or costs. However, early attempts to encourage energy conservation demonstrated that these frameworks often miss important contextual factors such as cultural values and behavioural interactions with technologies. This evidence, combined with the present need for energy policies that can address environmental, social, and economic concerns, suggests that a broader perspective is needed. Integrated frameworks of DEC were first proposed over 20 years ago but very little has been said about the ideas proposed in these papers, whether it be critiquing their form or assessing their impact on theory and practice. This paper attempts to fill this gap by examining the influence of integrated frameworks in academic literature and in UK energy policy. It is argued that a common language could stimulate renewed interest in the integrated perspective and thereby help policy makers meet these diverse goals. To this end, a flexible agent-based framework is proposed to stimulate debate and clarify the role of an integrated approach to domestic energy policy.

Keywords: Domestic energy consumption; Integrated framework; Agent-based

1. Introduction

The oil crises of the 1970s mark a watershed for the energy policy of industrialised nations, as decision makers began serious assessments of the domestic sector and its role in achieving security of supply. The needs of energy policy have expanded since then to include environmental sustainability and market liberalisation (Helm, 2002b), ensuring that the domestic sector remains a central concern. For example, domestic electricity consumption in the UK has risen 3% per annum since 1970 driven largely by the proliferation of domestic appliances and smaller household units (i.e. more households) (Boardman et al., 1995). This continued growth places pressure on policy makers to meet this demand within a modern liberalised market while at the same time ensuring social equity in energy services, reducing dependence on foreign energy sources, and reducing the environment impacts of energy use (especially climate change) (DTI, 2003b). This last point is especially relevant as the recent enactment of the Kyoto Protocol commits 141 nations to reduced greenhouse gas emissions, reductions which may have a significant impact on the domestic sector.

Despite these diverse goals, policy measures in the domestic sector frequently have a narrow scope, concentrating on particular technical or economic measures. A brief example is the UK's Clear Skies and Major Photovoltaic Demonstration grant programmes which provide technology-specific grants for renewable energy and energy efficiency in households. While these programmes reduce the greenhouse gas emissions of participating households, the impact for the whole of the domestic sector seems limited, given limited rates of adoption and uncertain institutional support, such as export metering and tariff arrangements for renewable micro-generation. Therefore one must question if these

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small and specific policy measures will be sufficient to the address the challenge of growing energy use in the domestic sector and its role in climate change.

Within academia, think-tanks, and government there are a diverse range of frameworks to conceptualise domestic energy consumption (DEC) and these philosophies in turn shape the creation of analysis tools, policies, and even the public perception of energy issues. Traditionally, a disciplinary approach has been dominant with economists and engineers guiding most domestic energy policy. However there are limitations to such approaches that become more apparent when confronted with the multifaceted problems facing the domestic energy sector today. In response, an alternative to the disciplinary perspective has been proposed by a small body of literature. These "integrated" frameworks[1] attempt to rectify the short-comings of narrow conceptualisations of DEC, by outlining a complex web of interactions between technology, economics, society, culture, and other factors. However although they were first introduced nearly 20 years ago, very little has been written about the models themselves, questioning their scope and exploring their impact on policy and theory.

Therefore the aim of this paper is to review existing integrated models of DEC, investigate whether or not they are being adopted, and evaluate their current and potential role in energy policy. Though this topic is relevant to many western nations, the UK has been chosen as a reference case for part of the analysis and discussion. In Section 2, the integrated frameworks of DEC will be reviewed and contrasted with disciplinary approaches. A typology and definition for such models will also be proposed. In Section 3, bibliographic data is examined to see how integrated models have evolved in the academic literature. A recent UK energy policy document is also assessed to explore the model in practice. In Section 4, an agent-based integrated framework is proposed to address some of the challenges facing this approach and to highlight areas for future work.

2. The frameworks of domestic energy consumption

DEC refers to the energy consumption of a household unit within their dwelling and in the UK, this sector accounts for 28% of total delivered energy (DTI, 2003a). For the purpose of national and international assessments, DEC specifically means the energy used for activities such as lighting, space heating, water heating, appliance use (consumer electronics, white goods and so on) and cooking (IEA, 1997). For each of these applications, the amount of energy used and its subsequent impact is a function of not only the equipment employed and duration of use, but also the associated fuels, economic incentives, and even social and psychological perceptions of energy and energy services. Correspondingly, the literature on DEC largely consists of disciplinary models focused on a particular part of this demand cycle.

2.1. Disciplinary frameworks

DEC has been studied primarily by four disciplines—engineering, economics, psychology, and sociology or anthropology—with each subject bringing its own techniques, frameworks, and biases to bear on the problem. For example, *engineering* studies explore the technologies of the domestic sector and determine consumption by physical laws (e.g. heat transfer). Examples of this approach can been seen in heating (Anderson and Building Research Establishment, 1985), lighting (Stokes et al., 2004) and appliances (Hart and de Dear, 2004). While many policy instruments concentrate on this technical level (Shorrock and Dunster, 1997), the human behaviours which drive energy demand are often assumed from past records or estimated from statistical methods (e.g. Capasso et al., 1994). These assumptions may be acceptable for aggregate analyses but at smaller scales, "the individual consumer—and ... the random components of demand become very important" (Stokes et al., 2002, p. 4). Furthermore, behavioural responses to technical improvements are beyond the scope of the engineering model; for example a technical study of home heating in Ireland was unable to determine whether improved insulation would result in less fuel consumption (that is, maintaining the pre-insulation temperature) or a higher standard of living (that is, increasing household temperature) (Clinch et al., 2001; see Milne and Boardman (2000) for more discussion of this issue).

The *economic* approach also offers strong numerical analysis but as a social science, it introduces elements of human behaviour. Typically used to understand the impact of energy taxes, price effects and income levels on DEC (Baker, 1991; Greening et al., 1995; Ruffell, 1977), this conceptualisation views the household as a utility-maximising unit of production and consumption (Ironmonger et al., 1995). However empirical evidence has shown that households frequently fail to obey these assumptions of rational behaviour (Brechling and Smith, 1992; Cogoy, 1995; Fernandez, 2001; Kooreman, 1996). Whether this is caused by a lack of information (Kempton and Layne, 1994), the framing of decisions (Tversky and Kahneman, 1986) or the complex dynamics of the household unit (Johnson, 1971; Kooreman and Wunderink, 1997; Ulph, 1988; Wheelock and

[1] In this paper, the words "framework" and "model" are used interchangeably to avoid repetition but both refer to a conceptualisation of domestic energy consumption, and not necessarily a model in the sense of computer simulation.