Energy Policy 63 (2013) 833–844

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

Harnessing social networks for promoting adoption of energy technologies in the domestic sector

Catherine S.E. Bale [a,d,*], Nicholas J. McCullen [b,1], Timothy J. Foxon [c,d], Alastair M. Rucklidge [b], William F. Gale [a,d]

[a] Energy Research Institute, Energy Building, School of Process, Environmental and Materials Engineering, Faculty of Engineering, University of Leeds, Leeds, LS2 9JT, UK
[b] Department of Applied Mathematics, University of Leeds, Leeds, LS2 9JT, UK
[c] Sustainability Research Institute, School of Earth and Environment, Faculty of Environment, University of Leeds, Leeds, LS2 9JT, UK
[d] Centre for Integrated Energy Research, University of Leeds, Leeds, LS2 9JT, UK

HIGHLIGHTS

- We model energy-technology adoption of households connected on a social network.
- Adoption depends on both personal and social benefits to the household.
- We investigate interventions that a local authority could take to increase uptake.
- Increased uptake results from both threshold and network intervention scenarios.
- Insights should be incorporated into design of local-level domestic interventions.

ARTICLE INFO

Article history:
Received 20 December 2012
Accepted 5 September 2013
Available online 26 September 2013

Keywords:
Modelling
Local authorities
Domestic sector retrofit
Social networks
Residential
Energy efficiency

ABSTRACT

This paper presents results from modelling work investigating the effects of social networks on the adoption of energy technologies in the domestic sector. This work concerns ideas on social network interventions which have been successfully applied in other domains but which have seldom been applied to energy policy questions. We employ a dynamical multi-parameter network model where households are represented as nodes on a network for which the uptake of technologies is influenced by both personal benefit and social influences. This is applied to demonstrate the usefulness of this type of model in assessing the likely success of different roll-out strategies that a local authority could pursue in promoting the uptake of domestic energy technologies. Local authorities can play a key role in the retrofit of energy-efficiency and low-carbon energy-generation technologies in order to realise carbon reductions and alleviate fuel poverty. Scenarios are modelled for different local authority interventions that target network interactions and uptake threshold effects, and the results provide insights for policy. The potential for the use of this type of modelling in understanding the adoption of energy innovations in the domestic sector and designing local-level interventions is demonstrated.

1. Introduction

Much recent work in complex systems theory has highlighted the role of social networks in influencing individual behaviours (Barabási, 2003). However, the implications of these ideas have not been fully exploited in the context of the adoption of domestic energy technologies and energy-demand-reducing behaviours. In a recent review paper, Wilson and Dowlatabadi (2007) call for integrated approaches to modelling domestic energy decision-making that better characterise heterogeneity and can be used to help design interventions aimed at influencing behaviours. Models based on individual behaviour tend to assume rational choice or reflect only individual psychological motivations (Nye et al., 2010), whereas approaches that address the social context of decision-making tend to be more qualitative (Shove, 1998). In response to this need, we have conducted new interdisciplinary modelling work to demonstrate the value of a quantitative approach combining personal and social motivation factors.

* Corresponding author at: University of Leeds, Energy Research Institute, School of Process, Environmental and Materials Engineering, Faculty of Engineering, Energy Building, Leeds, LS2 9JT, UK. Tel.: +44 113 343 8250; fax: +44 113 246 7310.
E-mail addresses: c.s.e.bale@leeds.ac.uk (C.S.E. Bale), n.mccullen@physics.org (N.J. McCullen), t.j.foxon@leeds.ac.uk (T.J. Foxon), a.m.rucklidge@leeds.ac.uk (A.M. Rucklidge), w.f.gale@leeds.ac.uk (W.F. Gale).
[1] Present address: Energy and the Design of Environments (EDEn) Research Unit, Architecture and Civil Engineering, University of Bath, Claverton Down, Bath, BA2 7AY, UK.

0301-4215/$ - see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.enpol.2013.09.033

We present results from a simulation of energy-innovation diffusion on a social network, employing real-world data. In the model, households are represented as dynamical nodes (connection points) on a network who choose whether or not to adopt an energy technology (or energy-efficiency measure) depending on both personal benefit and social influences. (For simplicity, we treat the household as a single decision maker, though in reality, people within the household may vary according to individual personal and social benefit.) Building on our previous work exploring the general mathematical features of a simpler version of this model (Bale et al., submitted for publication; McCullen et al., 2013), the present work develops the model to the point where it can be used to compare potential roll-out strategies available to a local authority aiming to increase uptake of energy technologies in the domestic sector. We examine interventions using social networks to promote adoption ('network interventions') and also those reducing barrier(s) to adoption ('threshold interventions'). This provides preliminary insights for policy design and highlights the potential for further work.

The objectives of the paper are to:

1. evaluate the potential for applying social network theories to energy policy using a network model for the adoption of energy technologies in the domestic sector;
2. apply the model to explore different strategies that could be implemented by a local authority;
3. identify those interventions that are likely to lead to the highest uptake, providing insight for policy implementation;
4. inform data gathering to enable refinement of this type of model to make it useful as a decision support tool for local authorities.

In Section 2, we discuss the empirical challenges that we aim to address and the theoretical approaches on which we draw. In Section 3, we discuss the methodology of the modelling work, including the data used, assumptions, and related limitations. We then, in Section 4, discuss the results from modelling different interventions that a local authority could take. In Section 5, we discuss the insights for local-level policy based on the outputs from the model and areas for further research.

2. Empirical challenges and theoretical approaches

2.1. Local authority decision-making

Local authorities have a significant role to play in the adoption of technologies that reduce domestic energy consumption. This role can be either direct, through the provision of free installation programmes (e.g. Wrap Up Leeds (Leeds City Council and Yorkshire Energy Services, 2012)), or indirect, through energy advice services (e.g. Actio2n Woking (Woking Borough Council, 2012)). Often, initiatives are tailored in an ad hoc manner to suit a given funding scheme, and are limited by available finance (Bale et al., 2012b). Nonetheless, local authorities still have to make choices as to how best to engage with residents on any given initiative. For a simple intervention such as offering free or reduced-cost insulation, local authorities can choose from a range of roll-out strategies, each of which may deliver different adoption rates. This suggests that local authorities need tools in order to be able to assess which strategies would be most successful.

Local authority initiatives (both in the UK and elsewhere) aimed at installing domestic energy-efficiency measures represent a significant opportunity for achieving carbon reductions in line with national targets (Comodi et al., 2012; Hoppe et al., 2011; Sheldrick, 1985). Large-scale retrofit of energy-efficiency and renewable and low-carbon generation technologies in domestic properties (together termed 'domestic energy technologies') will be required in order to meet the UK's legally-binding target of reducing greenhouse gas emissions of 80% by 2050 (compared with 1990 levels) (Great Britain, 2008). In addition, energy-efficiency measures can provide benefits to local residents by tackling fuel poverty and improving health and wellbeing (Clinch and Healy, 2001).

Insulation levels in domestic properties in Great Britain present one opportunity for improvement; it is estimated that, at the start of January 2012, only 60% of homes with lofts had loft insulation of at least 125 mm and 59% of homes with cavity walls had cavity wall insulation, while only 2% of homes with solid walls had solid wall insulation (Department of Energy and Climate Change, 2012). Local authorities have a unique role to play in encouraging adoption of energy-efficient measures in the both the social and private domestic sectors (Committee on Climate Change, 2012) as they are both a trusted source of information (which energy companies tend not to be (Bale et al., 2013)) and have local knowledge of the needs of their residents and communities (which central government does not). In this paper, we examine how local authorities may be able to maximise this influence by harnessing or enhancing existing social networks to promote adoption of domestic energy technologies such as insulation or photovoltaic (PV) panels.

2.2. Social networks

The importance of social network influences on behaviour is well recognized outside of the energy policy domain, and network interventions can be used to accelerate behaviour change (Valente, 2012). In this paper, we define network interventions as purposeful efforts to use social networks to accelerate the increase of adoption of energy technologies in domestic properties. By 'social network', we refer to all inter-household interactions that are relevant to energy either face-to-face or online (although the latter currently account for only a small proportion of actual total interactions (King, 2012; Southwell et al., 2012)).

Network interventions have been used successfully for tackling health-related issues (Valente, 2010), and much theoretical work exists on various diffusion processes on networks (Watts, 2002). Yet the insights from social network theory have so far been under-exploited in the area of energy policy. The role of social networks and network interventions in the spread of information on energy technologies and behaviours, and the subsequent adoption rates of both, is a relatively new area for research. There are some early examples of such ideas in the literature e.g. Coltrane et al. (1986), Darley and Beniger (1981), and, in relation to climate change, Maibach et al. (2008). In addition, there has been some recent empirical work on the role of social networks in the diffusion of energy innovations (Fell et al., 2009; McMichael and Shipworth, 2013; Michelsen and Madlener, 2013).

2.3. Modelling diffusion of innovations on a network

Diffusion of innovations (Rogers, 1983) is a social communication process that influences individual adoption of a specific innovation. The theory has been applied in the context of domestic energy consumption (Wilson and Dowlatabadi, 2007). The spread of ideas or technologies has been widely studied across different domains as diffusion on networks (Valente, 2005). One of the most commonly studied network diffusion processes is the spread of infection by a single contact where transmission occurs from one individual to another, but, for a consumer product (or behaviour) to spread, empirical studies show that many people wait for a proportion of their social group to precede them in the process