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The remaining potential for energy savings in UK households

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ABSTRACT

Progress on improving energy efficiency of UK homes has stalled in recent years and the question arises how much more potential for further energy savings exist across the housing stock. Whilst there are some high-level estimates of the potential for buildings energy efficiency in the UK, a more granular assessment is needed to understand exactly where this potential lies and what form it takes. Our analysis fills this gap. It is based on the best available evidence on the remaining potential for energy efficiency improvements within UK residential buildings. Using UK government criteria for investment appraisal, we demonstrate that there is a significant resource of untapped energy-saving opportunities in UK homes. Specifically, our estimates suggest that: one quarter of the energy currently used in UK households could be cost effectively saved by 2035; and this could increase to one half if allowance is made for falling technology costs and the wider benefits of energy efficiency improvements. However, these estimates are sensitive to the assumptions made about capital, energy and carbon costs, and capturing this potential will require both significant policy change and large-scale investment.

1. Introduction

Improved energy efficiency has played a pivotal role in reducing the UK's energy use and carbon emissions. On a temperature corrected basis, total UK household energy use decreased by 19% between 2002 and 2016, despite a 12% increase in the number of households and a 10% increase in population (BEIS, 2016a). Per-household energy consumption fell by 37% between 1970 and 2015, with most of this decrease (29%) occurring since 2004 (BEIS, 2016a). Energy efficiency improvements in individual households have offset the 46% increase in the number of households, the 5.6 °C increase in average internal temperatures and the rapid growth in appliance ownership over this period, with the result that total household energy consumption has increased by only 7% in 45 years.

Although rising energy prices and the 2008 recession contributed to recent trends, the bulk of the reduction in per-household energy consumption can be attributed to public policies to improve energy efficiency. Of particular importance have been the major home insulation programmes funded by successive ‘supplier obligations’ such as the Carbon Emissions Reduction Target (CERT–2008–2012) and the Energy Company Obligation (ECO–2013 onwards) (CCC, 2017; CEBR, 2011; DECC, 2015; Odyssee, 2017; Rosenow, 2012). These imposed energy and carbon saving targets on electricity and gas suppliers and allowed them to recover the costs through a levy on household energy bills. Also important were the requirement for condensing boilers within the UK Building Regulations and the progressive tightening of EU standards on the energy efficiency of electrical appliances (CEBR, 2011). Evaluations of these policies have shown them to be highly cost-effective, both in terms of the cost savings to participating households and in terms of broader societal welfare (Lees, 2006, 2008; Rosenow and Galvin, 2013). This experience supports the argument that market forces alone cannot deliver all cost-effective investment in residential buildings, owing to multiple and overlapping market failures. Instead, policy intervention can be used to improve economic efficiency.

The UK Climate Change Act (2008) establishes a long-term target of reducing greenhouse gas (GHG) emissions to 80% below 1990 levels by 2050. To meet this target, the government has established five-yearly carbon budgets which restrict the amount of greenhouse gases UK can legally emit in each five-year period. In October 2017, the government published its Clean Growth Strategy (BEIS, 2017a) that set its approach to meeting the 4th (2023–2027) and 5th (2028–2032) carbon budgets and to ensuring that the UK maximizes the economic and environmental benefits of green technology. However, the full set of policies to deliver on those carbon budgets has yet to be developed (CCC, 2018). Since residential buildings account for approximately one quarter of UK carbon emissions, the remaining potential for improving the energy efficiency of those buildings is of considerable importance. Accurately assessing and effectively unlocking this potential will be critical to

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ensuring the UK follows the most cost-effective path to meeting its targets. Underestimating and neglecting this potential could cost the UK billions in unnecessarily high energy bills and higher cost energy supply.

In the past, multiple studies have indicated a large potential for improved energy efficiency in UK residential buildings. And this remains the case, despite the substantial improvements over the last 15 years. For example, in its impact assessment for the 5th Carbon Budget, the UK government concluded that residential buildings had the highest technical potential for carbon abatement across the economy, offering 32% of the total (DECC, 2016a). Much of this is due to the potential for improved energy efficiency. The government's analysis is corroborated by other studies, including the Infrastructure Transitions Research Consortium (ITRC, 2016) whose evidence fed into the National Needs Assessment.[1]

However, a more granular assessment is needed to understand exactly where this potential lies and what form it takes. Our analysis fills this gap. It is based on the best available evidence on the remaining potential for energy efficiency improvements within UK residential buildings. Using UK government criteria for investment appraisal, we demonstrate that there is a significant resource of untapped energy-saving opportunities in UK homes. Specifically, our estimates suggest that: **one quarter** of the energy currently used in UK households could be cost effectively saved by 2035; and this could increase to **one half** if allowance is made for falling technology costs and the wider benefits of energy efficiency improvements. However, these estimates are sensitive to the assumptions made about capital, energy and carbon costs, and capturing this potential will require both significant policy change and large-scale investment.

The paper is structured as follows. The following section presents our methodology for estimating the remaining technical and economic potential for energy efficiency measures in UK households, while Section 3 summarises the data sources employed and the assumptions made. Section 4 presents the results of the modelling exercise as three scenarios with varying levels of ambition, and indicates the potential development of energy and cost savings over time. Section 5 discusses some of the uncertainties in the analysis, as well as the type of measures required to unlock the identified potential. Section 6 concludes with some policy recommendations.

2. Methodology

We estimate the *lifetime energy savings* associated with different levels of deployment of energy efficiency technologies in UK households over the period to 2035, together with the *net present value* of those energy savings. In valuing these energy savings, we consider both the avoided energy costs and the wider benefits of reduced energy consumption, such as reduced greenhouse gas emissions and improved air quality.

Our estimates for the technical and economic potential of different types of energy efficient technology are based upon analyses by the UK Committee on Climate Change (CCC), while our estimates of the costs and benefits associated with those technologies are informed by policy appraisal guidance (called the Green Book) provided by the UK Treasury and UK Department of Business, Energy and Industrial Strategy (BEIS, 2018). In particular, our calculation of the costs and benefits of energy savings employ a spreadsheet toolkit provided by the Interdepartmental Analysis Group (IAG, 2015). Hence, our analysis does not rely on new modelling tools, but instead explores the implications of the assumptions and tools employed by UK government departments and UK government agencies.

We model four groups of technologies: heating efficiency; appliance efficiency; heat networks; and individual low-carbon heating systems. Heating efficiency encompasses building fabric, heating controls and efficient boilers. Efficient appliances include fridges and freezers, washing machines, dryers, ovens, televisions and lighting.[2] Heat networks include schemes in high density areas that are powered from a number of sources (e.g. gas-fired combined heat and power, industrial waste heat, energy from waste). Finally, low carbon individual heating systems include air-source and ground-source heat pumps (with and without heat storage) and biomass boilers. Heat networks and low carbon heating systems are included in the analysis, since they can significantly reduce final energy demand as well as carbon emissions.[3] For example, heat networks may be driven by gas-fired combined heat and power (CHP) schemes that are more efficient than separate provision of electricity and heat. Similarly, they may be driven by waste heat from power plants and industrial facilities, or by latent heat from sewage or rivers.

All scenarios are modelled relative to a baseline scenario. The baseline shows total household energy demand increasing to 2035, owing to the assumption of no energy efficiency improvements in the existing stock (27 million dwellings), together with the construction of five million new dwellings over that period. The baseline scenarios published by the UK government and CCC include the impact of replacing existing boilers with more efficient condensing boilers when the former are retired. Here, these energy savings have been removed from the baseline and shown separately within our constructed scenarios. The latter also include the energy savings from energy efficiency measures, together with those from deploying heat pumps and heat networks in new dwellings - relative to the use of gas heating in the baseline scenario.

We develop three scenarios representing progressively more ambitious levels of technology deployment. These are termed the *limited ambition*, *cost-effective* and *technically possible* scenarios respectively. Each scenario assumes a different level of technology deployment in existing buildings, but the energy performance of new buildings is assumed to be the same. The first two scenarios use the same assumptions for the capital cost and lifetime of different energy efficiency measures, together with the level of adoption of various behavioural measures, while the third scenario assumes the adoption of all technically feasible measures, regardless of costs. Supply chain constraints are not considered in any of the scenarios. The assumptions underlying each scenario are as follows:

1. *Limited ambition*: This includes all energy efficiency measures that can be installed by 2035 based on a continuation of current policy deployment projections as set out in formal policy appraisals. This level of deployment is broadly consistent with the UK Government's central projections for energy and emissions, published in 2016 (DECC, 2016c).[4] Equipment is not replaced before the end of its natural life. On the whole in this scenario, estimated energy cost savings (based on BEIS' central scenario for energy prices), discounted over the lifetime of the measures, exceed the associated capital costs. We use a discount rate of 3.5% in line with official guidance (BEIS, 2018). In that year, the Committee on Climate Change (2016b) estimated that 85% of the carbon savings in

[1] The National Needs Assessment brought together a coalition including industry, investors, environmental, legal and professional bodies, and politicians and opinion formers to deliver a 35 year view of the changing demands on infrastructure services.

[2] Strictly speaking lighting is not an appliance but for the purpose of this exercise it has been included in the appliances category.

[3] Some low carbon heating options increase energy demand while reducing emissions, while others reduce both. Their net effect in the scenarios assessed in this paper is to reduce energy demand, as can be seen in Figs. 2 and 3.

[4] A 2016 version of the Updated energy and emissions projections was published in March 2017, where final energy demand in the residential sector in 2035 is 2.9% higher than in the 2015 version, mainly owing to lower than previously projected savings from efficient electrical appliances.