ELSEVIER

Energy Policy 29 (2001) 113–124

ENERGY POLICY

www.elsevier.com/locate/enpol

# Cost-benefit analysis of domestic energy efficiency

J.Peter Clinch*, John D. Healy

*Department of Environmental Studies, University College Dublin, Richview, Clonskeagh Drive, Dublin 14, Ireland*

Received 26 January 2000

**Abstract**

There are a number of driving forces behind energy efficiency. In recent times, the Kyoto Protocol has been the most prominent in bringing energy efficiency to the fore. In some countries, the domestic sector has been highlighted as an area which has a significant potential for improvement. However, prior to the implementation of large-scale energy-efficiency programmes, it is important to evaluate whether they make economic sense. Heretofore, most economic evaluations of energy-efficiency programmes have concentrated purely on the associated costs of the programmes and the energy savings that result. At best, reductions in environmental benefits are also estimated, but rarely are other benefits calculated, such as increases in the levels of household comfort and improvements in human health. This paper endeavours to provide a template for *ex ante* economic evaluations of domestic energy-efficiency programmes. A comprehensive cost–benefit analysis of a programme to retrofit various energy-efficiency technologies and heating upgrades to the Irish dwelling stock is taken as a case study. The study demonstrates how energy savings, environmental benefits, and health and comfort improvements may be assessed. In so doing, it provides insights into the methodological difficulties and solutions for assessing the social efficiency of large-scale domestic energy-conservation projects. 

*Keywords:* Cost–benefit analysis; Domestic energy efficiency; Energy-assessment modelling

## 1. Introduction

Behind energy efficiency, there lies an array of so-called 'driving forces'. In recent times, the Kyoto Protocol has been the most prominent in bringing energy efficiency to the fore. The Gothenburg Protocol on the reduction of acidification precursors also provides an incentive for European countries to improve energy efficiency and thereby reduce environmental emissions. In some countries, the domestic/residential sector has been highlighted as an area with considerable potential for improved energy efficiency. Improving energy efficiency in the domestic sector also has the potential to contribute to the resolution of a number of other social ills, principal of which are high rates of winter mortality which result from poor thermal standards of housing and the existence of fuel poverty, i.e. the inability to heat the home to an adequate (safe and comfortable) temperature, owing to low household income and poor household energy efficiency.

However, prior to the implementation of energy-conservation measures in the domestic sector, it is important to assess whether such interventions are socially efficient. There are a number of studies which have endeavoured to evaluate monetarily the benefits of domestic energy conservation. The seminal work of Pezzey (1984), along with other notable studies by Henderson and Shorrock (1989) and van Harmelen and Uyterlinde (1999), show the clear net benefits of individual retrofitting technologies. At the macro level, Arny *et al*. (1998), Blasnik (1998), Brechling and Smith (1994) and Goldman *et al*. (1988) demonstrate the benefits of comprehensive retrofitting programmes. However, most studies tend to evaluate energy savings alone. At best, environmental emissions (usually in the form of $CO_2$) are quantified, but the other potential benefits of domestic energy-efficiency programmes, such as improvements in health and comfort, tend to be omitted from any cost–benefit analysis. The chief difficulty, succinctly identified by Blasnik (1998), is that "although many of these benefits have been demonstrated to exist, most have never been fully quantified

* Corresponding author. Tel.: + 353-1-269-7988; fax: + 353-1-283-7009.

*E-mail addresses:* peter.clinch@ucd.ie (J.P. Clinch), john.healy@ucd.ie (J.D. Healy).

0301-4215/01/$ - see front matter 
PII: S0301-4215(00)00110-5

because of considerable methodological issues in assessing them".

The research presented in this paper attempts to advance the literature on the economic evaluation of domestic energy-efficiency programmes by carrying out a comprehensive evaluation of a range of costs and benefits using an example. It thereby develops a template for carrying out *ex ante* analyses of large-scale domestic energy-efficiency programmes. In so doing, it provides insights into the methodological difficulties and solutions for assessing the social efficiency of such programmes.

## 2. Case study

Ireland is an interesting case study of domestic energy-conservation opportunities for a number of reasons. Firstly, the rate of fuel poverty in Ireland, at 12%, appears to be the highest in northern Europe (Whyley and Callender, 1997). Secondly, the rate of excess winter mortality in Ireland, at 15%, is the highest in northern Europe[1] and may be the result of poor thermal efficiency in the dwelling stock (Eng and Mercer, 1998). Finally, Ireland is having extreme difficulty in meeting its agreed target for stabilisation of greenhouse gas emissions under the Kyoto Protocol (Clinch and Convery, 1999). This paper describes the *ex ante* economic evaluation of a programme to bring the thermal standards of the Irish housing stock up to the latest (1997) Irish building regulations over a 10-year period. This involves retrofitting the 1.2 million dwellings built prior to 1997 with various energy-efficiency technologies and heating upgrades, further details of which are provided below.

## 3. Methodology

A computer model was developed to calculate some of the programme's physical costs and benefits.[2] The model takes a similar approach to those attempts to model the energy performance of the residential sector in the UK (BRE, 1998) and Belgium (Hens *et al*., 1998). The Energy-Assessment Model (EAM) was based on the UK's Standard Assessment Procedure (SAP) but tailored considerably to meet Irish conditions. The EAM is a 'bottom–up' model incorporating 1824 representative dwelling models, each representing a percentage of the national dwelling stock. The latest available data relating to the specifications of the dwelling stock (such as floor area, insulation levels, heating equipment and so forth) was obtained in order to derive 'representative' dwelling models. These models are a combination of eight dwelling types, six categories of insulation and 19 types of heating systems. These were run successively through the Model's energy-assessment procedure to yield information on national energy consumption, costs, internal temperatures, emissions, etc. The energy-saving measures include lagging jackets, roof insulation, draught-sealing, wall insulation, central heating and 'low-emissivity' double-glazing.

A cost-benefit model (CBM) was fitted to the EAM to facilitate the conversion of the physical estimates into monetary amounts. A literature review was carried out in order to ascertain suitable coefficients to enable the calculation of the value of reductions in environmental emissions. Reductions in morbidity and mortality were evaluated separately and then included in the CBM with appropriate estimates for the value of statistical life being chosen via a review of the literature on the subject. The CBM allowed for costs and benefits to be evaluated at a range of discount rates. There is a huge literature on discounting and space does not permit an in-depth discussion of appropriate measures; suffice to say that there is no agreement on which particular number is appropriate. In practice, the discount rate used to evaluate public projects is chosen via the political system. The Irish Government recommends a rate of 5% be used to reflect the opportunity-cost of capital (Department of Finance, 1994). For the purposes of this research, a range of discount rates varying between 0 and 10% were used with the Department of Finance's rate of 5% being considered the key rate for the purposes of drawing implications for government policy. The CBM facilitated further sensitivity analyses of each benefit and cost of the Programme.

## 4. Costs of the proposed energy-efficiency programme

The costs of the energy-efficiency programme are comprised of materials and labour costs.

### *4.1. Materials*

The following energy-efficiency measures were chosen and priced (net of tax) with the assistance of quantity surveyors on the basis of cost-effectiveness:

- Fitting of lagging jacket.
- Roof insulation (and roof insulation upgrade).
- Draught-stripping.
- Cavity-wall insulation.
- Central heating.
- Heating controls upgrade.
- Low-emissivity double-glazing.

[1] See Clinch and Healy (2000a).

[2] This work was undertaken with Ciarán King and is detailed in Clinch *et al.* (2000).