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Development of a modelling framework in response to new European energy-efficiency regulatory obligations: The Irish experience

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A R T I C L E I N F O

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A B S T R A C T

Momentum has been building for an EU-wide approach to energy policy in which energy end-use efficiency is regarded as one of the main planks. Member States are already obliged to plan for the achievement of energy savings targets in respect of the period 2008–2016 and they now face additional economy-wide targets for 2020. Efficiency investments are widely regarded as capable of improving industrial competitiveness, security of energy supply and the abatement of greenhouse gas emissions. Nevertheless, the design of policy packages may involve trade-offs between these objectives. The challenge for energy modellers is to quantify future energy savings associated with combinations of efficiency measures. This paper draws on the international experience in energy modelling and tracks recent progress that has been made towards a harmonised European framework for verification of savings. It points to the significant development work that remains to be done, particularly to enable an increased reliance on bottom-up evaluation methods. One significant gap in our knowledge relates to the required adjustment of technical savings due to behavioural factors such as rebound effects. The paper uses one country (Ireland) as a case study to demonstrate how a framework is being developed to respond to these new requirements.

1. Introduction

In recent years, energy policy in the European Union has been evolving towards a common strategy on energy in which security of fuel supply, environmental sustainability and competitiveness are pivotal. In this context, policies to promote improved energy efficiency can cost-effectively contribute to all three goals, for example by

- lessening Europe's dependence on imported oil and gas;
- abating fossil fuel-related greenhouse gas (GHG) emissions;
- stimulating development of new technologies; and
- reducing the cost of energy services such as heating and transport.

The potential value of such policies is enormous. For example, the EU Green Paper on Energy Efficiency (European Commission, 2005) identifies scope for savings equivalent to €60–100 billion per annum of energy expenditure and for the creation of up to 1 million new jobs across the community. The subsequent EU Green Paper on Energy (European Commission, 2006a) discusses how best to unlock this potential. It includes proposals for an action plan aimed at achieving a 20% overall improvement[1] in efficiency by 2020, thereby avoiding an estimated 390 million tonnes of oil equivalent (Mtoe) per annum of primary fossil fuel use and 780 Mt of associated CO_2 emissions.

The action plan itself (European Commission, 2006b) identifies residential and commercial buildings as having the largest efficiency savings potential (154 Mtoe) followed by the transport sector (105 Mtoe) and manufacturing industry (95 Mtoe). It identifies a number of legislative measures currently in force which address efficiency standards for energy-consuming products[2] as well as the taxation of electricity and fuels. Similarly, in respect of buildings, it refers to the EU Energy Performance of Buildings Directive 2002/91/EC, which requires Member States to establish minimum building energy performance standards and to introduce mandatory building energy performance certification.

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[1] These figures include savings in energy transformation as well as in end-use but they exclude any mitigating effects of structural changes or of autonomous efficiency improvements.

[2] These include the Eco-Design Directive 2005/32/EC, the Labelling Directive 92/75/EC (which provides for implementing Directives on various product categories) and the Energy Star Regulation.

The action plan acknowledges, however, the need for amendment and/or stricter enforcement of the legislation in some cases.[3] It also discusses the need for a co-ordinated approach in implementing the Energy Services Directive ('ESD'). This legislation (OJEU, 2006) requires Member States to plan for a cumulative energy savings target of 9% for the non-emissions trading sectors, within which public sector buildings, procurement practices and transport are expected to play an exemplary role. Each Member State is obliged to produce a national energy-efficiency action plan (NEEAP) in which target savings associated with policy measures are calculated against a hypothetical 'without measures' counterfactual forecast over the period 2008–2016. While the targets are not legally binding, the action plans must be submitted to the Commission for scrutiny and comment. The first versions were due by the end of June 2007, with updates required in June 2011 and again in June 2014. Those that were submitted in 2007 were allowed to rely substantially on high-level approaches such as the 'ODEX' indices which have been developed under the European Commission's ODYSSEE project.[4] This reliance has been criticised by Horowitz (2008) although, as Bosseboeuf and Lapillone (2009) have suggested, a careful comparison of historic trends in technical and observed ODEX could provide a basis for forecasting policy impacts. In any case, all future NEEAPs will be significantly improved with increasing use of empirically derived bottom-up approaches such as *ex-ante* and *ex-post* analysis of measures, the analysis of utility bills and meter data, direct measurement of energy loads, or engineering estimates.

Subject to the operational success of the ESD, the Commission also envisages the possibility of additional legislation to establish a White Certificate scheme whereby member States could sell any verified energy savings ('negajoules') in excess of their regulatory target.[5] The international trading of compliance obligations should, in principle, promote greater economic efficiency. However, the cost effectiveness of any such scheme ultimately relies on the establishment of an equitable basis for quantifying the (business as usual) counterfactual, taking due account of gross-net adjustments. From a preliminary analysis conducted under the auspices of the EMEEES[6] project it is evident that there remain both practical and theoretical obstacles to harmonisation of NEEAPs. Improved methods of bottom-up energy demand modelling may hold the key to overcoming these. Moreover, while European Union Directives have been finalised for a 20% reduction in greenhouse gas emissions, and a 20% penetration of renewable energy by 2020, the European Commission is currently developing (Koskimäki, 2009) the third element of the energy-climate package, namely the 20% energy-efficiency target, i.e. achieving energy savings of 20% relative to projected 2020 primary energy supply. These initiatives can only serve to increase the importance and potential benefits of improved modelling.

The focus of this paper is on improved modelling needed at Member State level to meet the requirements of the ESD in terms of projecting, monitoring and evaluating energy savings associated with measures. It discusses the relative advantages and shortcomings of existing models in quantifying future savings related to energy-efficiency measures. It also includes some consideration of how to adjust the engineering-derived estimates of policy effectiveness to take account of factors such as

- direct or indirect rebound effects;
- free rider effects and the double-counting of policy impacts;
- autonomous energy-efficiency improvements (AEEI); and
- the extent of non-compliance with product or building performance regulations.

The paper draws on the literature available on rebound effects to discuss how such adjustments may be used in the development of appropriate modelling frameworks. The authors take Ireland as a case study of a developing modelling capability that is progressively adapting to the needs arising from the ESD requirements. Ireland's draft action plan as initially submitted to the European Commission (DCENR, 2007a) contains quantitative savings targets arising from a mix of technical measures (for example building regulations) together with 'softer' measures such as voluntary agreements among industry participants. In common with the NEEAPs of other Member States, the assessment of savings associated with specified measures was developed in advance of any detailed guidelines arising from the EMEEES project.

The remainder of the paper is organised as follows. Section 2 provides a brief taxonomy of existing energy-efficiency models, and their applicability to the evaluation of the types of measures typically specified in Member State action plans. In doing so, it reviews a selection of the literature on rebound effects and other gross-net adjustments. Section 3 describes the ongoing development of the Irish NEEAP in the context of the 2007 Government White Paper on Energy (DCENR, 2007b). It also discusses efforts being made to strengthen the country's associated data gathering and modelling capability. Section 4 presents preliminary results from an analysis of residential gas consumption in Ireland, also outlining proposals for further research. Section 5 draws some preliminary conclusions and points to the next steps required.

2. Modelling of energy-efficiency polices

2.1. Taxonomy of energy models

Taxonomic classifications of energy demand models have been proposed *inter alia* by Weyant and Hill (1999), Canes (2002) and Huntington and Weyant (2004). One major division is between so-called 'top-down' models which are typically based on macro-economic social accounting matrices, and 'bottom-up' models which can describe in greater detail the expected impact of changes in technology or input costs within particular product markets. Tol (2000) highlights and explains the apparent discrepancy between predictions arising from these different approaches. Wei et al. (2006) suggest that the class of bottom-up energy models can usefully be sub-categorised as either supply-side (considering the impact of efficient technologies on the supply and conversion of energy) or demand-side (the impact of end-user lifestyles on energy consumption). MARKAL and EFOM are representative of the first type, whereas MEDEE and LEAP (which we discuss in Section 3.2) are examples of the second type.

Arguably, bottom-up models are more appropriate for incorporating the immediate and direct impacts of specific energy-efficiency policies, which generally target savings at a

[3] Barbaso (2008) outlines plans by DG-TREN to overhaul several of these directives during 2008/2009.

[4] This continuing programme aims to develop standardised measurement and reporting methods for a network of energy efficiency agencies operating across EU27 plus Norway and Croatia. The ODEX for a particular economic sector (e.g., industry in Ireland) is typically presented as an annual time series showing the historic trend in average energy intensity at a notional constant structure, www.odyssee-indicators.org.

[5] Such schemes have been frequently discussed in the literature. For example, Bertoldi and Rezessi (2008) explain the underlying principles; Waide and Buchner (2008) discuss applications in the context of energy utility regulation, while Meyers and Kromer (2008) identify issues concerning effective monitoring and verification. Sorrell et al. (2009) discuss how such schemes could interact with existing policy instruments such as the EU emissions trading scheme.

[6] http://www.evaluate-energy-savings.eu/emeees/en/events/final_conference.php.