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Energy efficiency policies for space heating in EU countries: A panel data analysis for the period 1990–2010

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HIGHLIGHTS

- Space heating demand between 1990 and 2010 modelled using a panel of 14 EU countries.
- The impacts of 260 efficiency polices affecting space heating demand are examined.
- Regulatory policies found to have had a greater success than financial or informative.
- High priority should be given to regulatory policies for space heating energy goals.

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ABSTRACT

We present an empirical analysis of the more than 250 space heating-focused energy efficiency policies that have been in force at the EU and national levels in the period 1990–2010. This analysis looks at the EU-14 residential sector (Pre-2004 EU-15, excluding Luxembourg) using a panel data regression analysis on unit consumption of energy for space heating (kWh/m^2/year). The policies are represented as a regression variable using a semi-quantitative impact estimation obtained from the MURE Policy Database. The impacts of the policies as a whole, and subdivided into financial, regulatory, and informative policies, are examined. The correlation between the actual reductions in demand and the estimated impact of *regulatory policies* is found to be stronger than the corresponding correlations with the respective impacts of *financial policies* and *informative* polices. Together with the well-known market barriers to energy efficiency that exist in the residential sector, these findings suggest that regulatory policy measures be given a high priority in the design of an effective pathway towards the EU-wide goals for space heating energy.
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1. Introduction

Lowering the absolute energy demand of buildings is a key policy goal of the EU. This is to be achieved mainly through improvements in end-use efficiency [1]. The indicative goal for Year 2020 is to lower primary energy demand within the EU by 20% relative to a business-as-usual scenario. This goal is part of the EU Climate and Energy Packet (known colloquially as the EU 202020 goal), and also includes the mandatory goals that by Year 2020 there should be a 20% share for renewables in the energy supply and a 20% reduction in greenhouse gas emissions (relative to the levels in Year 1990) [2]. For the residential sector, the energy savings target has been set at the higher level of 27% given the well-documented savings opportunities that exist in this sector [3]. The multifaceted motivations behind the overall energy savings goal include reducing dependence on fossil fuels imported from outside the EU, mitigating the volatility associated with oil prices, increasing competitiveness by reducing energy costs, stimulating employment in the construction sector, improving both the indoor and outdoor air quality *via* improved ventilation and decreased emissions of combustion gasses, reducing noise pollution, and mitigating climate change. However, studies have shown that the EU is on target to meet only half of its Year 2020 overall energy savings goal [4]. In addition, the negotiations surrounding the Energy Efficiency Directive [5] have highlighted that it is not possible to lower EU Primary Energy Demand by more than 17% using the measures agreed in the directive, meaning that a *de facto* 3% watering down of the savings through efficiency target has occurred.

Over the last decade, the European Commission has introduced a package of measures aimed at achieving the Year 2020 goal of a 20% reduction in primary energy demand. These measures include the Energy Performance of Buildings Directive (EPBD) [6], the

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Nomenclature

CH — Percentage of dwellings with central heating installed
Delay1 model — A model used in this work in which the implementation of efficiency policies has been delayed by 1 year, to determine if there is a time lag in their impacts
EEW — Energy Efficiency Watch Project
EP — A time series variable constructed for the purpose of the present work to represent the residential sector heating-focused Efficiency Policies that are in place. *EP* is also subdivided into financial, informative and regulatory policies in this work
EPBD — EU Energy Performance of Buildings Directive
ESD — EU Energy Services Directive
HAC — Heteroskedasticity and Autocorrelation Consistent Standard Errors
HDD — Heating Degree Days
High-, Medium- or Low-impact policy — A policy listed in the MURE Policy Database that is estimated to reduce demand by >0.5%, 0.1–0.5% or <0.1%, respectively. See SQI
Laspeyres decomposition — A method of index decomposition in which model variables are each in turn changed to their final year (Year 2010) values, while the other model variables are kept at their base year (Year 1990) values. This allows the individual impact of a variable-on-demand to be estimated
LSDV — Least-Squares Dummy Variable-fixed effects panel data regression model
MURE Policy Database — An online database of all national and EU-wide sector-level efficiency policies that have been introduced in the EU-28 countries and Norway since the 1970's
NEEAP — National Energy Efficiency Action Plan
SQI — Semi-quantitative impact. The name given to the *ex post* or *ex ante* evaluations of each of the policies in the MURE database. See High-, Medium- or Low-impact policy. These rankings are used in the present work to construct the *EP*, Financial, Informative and Regulatory policy variables
Unit consumption of energy for space heating ($kWh/m^2/year$) — A time series variable constructed for the purpose of this work that represents the sum of each energy carrier used for heating divided by total floor area. The unit is the square metre. Unit consumption is an established indicator of energy efficiency progress, as it tracks changes in energy use related to efficiency improvement and is not influenced by changes in either population or dwelling size
VIF — Variance Inflation Factor. A statistical tool to detect the multicolinearity of a number of explanatory variables
WAP — Weighted Average Price. A time series variable constructed for the purpose of the present work that aggregates the prices of different energy carriers for heating into a single price weighted according to the proportion of each energy carrier in the heating mix
Wald (F)Test — A parametric statistical test used to examine the combined significance of a number of explanatory variables
Wu-Hausman test — A statistical hypothesis test used to examine a model for endogeneity

Energy Services Directive [7], the Eco Design Directive [8], and the Energy Labelling of Products Directive [9]. These are policy measures that seek to drive technical innovation, the diffusion of efficient technologies, and the creation of a market for efficiency. More recently, additional policies that aim to improve or enhance the aforementioned factors have been introduced or debated, namely, the recast of the EPBD [10], the Energy Efficiency Directive [11], and the proposed Energy Taxation Directive [12]. These EU directives are transposed into national policy legislation by the respective countries and complement the energy savings measures that individual countries have introduced to varying degrees since the 1970's [13,14].

A study that looked at 30 years of experience in OECD countries with polices for increasing energy efficiency [15] revealed that most Western European countries have undergone substantial energy intensity reductions, distinct from structural changes, since 1973. These authors report that many policies and programs have been adopted to increase energy efficiency, and some have clearly "made a difference". The most influential policies have been energy codes, industrial voluntary agreements, pricing initiatives, and financial incentives adopted at the national level, while EU-wide appliance labelling and standards, and the new vehicle CO_2 emissions intensity agreement also have had impacts. However, they conclude that it is very difficult to estimate what fraction of the overall energy efficiency improvement can be attributed to specific policy initiatives and what fraction is linked to other factors, such as market forces and on-going technological change.

Although thorough descriptions of the efficiency policy options in existence and their theoretical bases in terms of dealing with the well-known market barriers to efficiency are available in the literature [14,16–23], most of these studies do not quantify *ex post* the effects of individual or portfolios of efficiency policies. Gillingham and colleagues [18] have commented that most of the policy evaluation studies have been *ex ante*, and while they are useful for understanding future policies, they do not demonstrate that a policy has been effective. From a policymaker's perspective and considering the widely recognized market barriers to energy efficiency, it is of interest to know how well the existing and previous efficiency policy frameworks have succeeded in reducing energy demand. Previous studies of this issue, which included some *ex post* analyses, e.g., [24], have compared a projected baseline energy demand to the actual demand outfall and postulated that the difference is due to policy-driven energy efficiency improvements and the use of less-energy-intensive products. This approach is similar to the findings of indicator-based efficiency evaluations [25]. Vine and co-workers [26] reported that the combination of mandatory labelling which was introduced in the EU in 1992 and other efficiency policies, improved the efficiency of refrigeration appliances by 10% from 1992 to 1996. Hoicka et al. [27] showed that financial rewards can increase both the levels of participation and outcomes in efficiency programmes. As part of the IPCC 4th assessment (AR4) chapter on mitigation options for residential/commercial buildings, a qualitative evaluation of 60 *ex post* efficiency case studies was carried out [28]. Appliance standards, building codes, tax exemptions, and voluntary labelling were found to be the most effective policy instruments for reducing demand.

Using a panel of 48 of the states in the USA, Horowitz [29] examined empirically whether states with strong commitments to energy efficiency have lower levels of energy intensity than those with weak commitments, and found that this was indeed the case. He also found that energy efficiency programmes have a transformative effect on other macroeconomic variables, such as electricity price, income per capita, and technological change,

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