

The Main Drivers of Energy Consumption in Households

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Abstract. The aim of the paper is to define the main drivers of household energy consumption. Seeking to achieve this aim the main tasks are: to analyse theoretical issues of energy consumption drivers in households; to analyze and compare energy consumption trends in several EU member states; to define the main drivers of energy consumption and energy saving in households. The methods applied: correlation analysis, graphical analysis. The main findings of the paper are: the level of final energy consumption in the household sector per capita in Lithuania is significantly lower than in old EU member states; economic and technological factors are the main driving forces of final energy consumption in households however the impact of different factors vary between countries. In old EU member states the prices and share of R&D employers have impact on energy consumption reduction however in Lithuania because of low energy consumption per capita and low living standards the impact is opposite. The institutional indicators exhibited lower correlation with energy consumption indicators; however the Rule of Law indicator seems to be related to decrease in energy consumption in all countries.

Keywords: Energy Consumption, Climate Change Mitigation, Households, Drivers of Household Energy Consumption.

1. Introduction

There is evident environmental pressure from household's energy consumption and it is expected to increase even further. One of the key determinants of household energy consumption patterns is economic growth and especially growth of living standards in such countries such as China, India, Brazil, Indonesia etc. Many countries have implemented policies aiming at energy efficiency improvements. These policies which provide economic incentives to save energy play crucial role in driving energy consumption patterns in household. As energy consumption is growing in many EU member states though a lot of policies aiming at energy conservation in households were implemented it is important to analyse energy consumption trends and the main drivers of energy consumption between countries seeking to define the major issues of concern and to develop policies targeting these issues.

The aim of the paper is to define the main drivers of household energy consumption. Seeking to achieve aim the following tasks were defined: to analyse theoretical findings for the main drivers of energy consumption; to analyze and compare energy consumption trends in households of several EU member states and to define the main drivers of energy consumption and energy saving in households.

2. Theoretical background of energy consumption drivers in households

In standard economic models, individual decision-making is based on the assumptions of rational behaviour and self-interest, according to which individuals make choices that maximize their well-being or utility under the constraints they face. These assumptions are often supported by empirical evidence: people facing policy incentives will respond generally in a manner consistent with welfare maximisation. Pricing will induce a change in consumption decisions. The distribution according to economic status (household income) is only one criterion by which to examine distributional issues. The approach here seeks for the examination of other possible criteria, including cultural, psychological, institutional and other issues. As countries differ in terms of cultural values, institutional and social capital values etc. it is important to explore these issues in analysing energy demand drivers in households. Therefore, this paper is based on the idea that energy demand is essentially driven by economic and non-economic factors.

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Non-economic factors can be divided into: technological, policy and others. Others include cultural, psychological and institutional factors. The main economic factors driving energy demand in households are income and prices. Income is a key driver of residential energy demand and perhaps more important as such than what it would seem at first glance. If the relative price of energy increases, the reductions of demand are expected [1]. It is also known from basic economic theory that there is a close link between price elasticity and substitution possibilities. A household facing higher energy prices can typically use a whole array of different ways to lessen the impact of the price increase on their budget. Because these substitution possibilities vary across households the price elasticity's varies across the population. Therefore demand for energy is generally quite price-inelastic. The technological factors are usually being considered among the main drivers of energy consumption in households as advances in new technologies allow implementing modern energy systems, appliances, insulation equipments etc in households having direct impact on energy conservation in households. Attitudinal variables portray an individual's state of mind or feeling. A definition of "attitude" in social psychology is the valuation of a concept or an object [2]. Studies [2; 3; 4] summarise the literature related to environmental concerns, arguing that these concerns are only weakly correlated with socio-demographic and psychological factors. The impact of demographic variables on energy consumption can be detached from income influence; empirics suggest that energy consumption varies over the life cycle, between ethnic groups and inhabitants of different countries and their cultural practices. Therefore other factors: cultural, psychological, institutional have direct impact on household preferences and attitudes. It is obvious that demand for energy depends on the household's preferences for goods and services. Preferences vary across populations. What is more, demand differs between households of a given social class living in the same category of buildings. Importantly, even households with the same kind of equipment consume energy at different levels. EU barometer provides some information about attitudinal variables, such as the households' view towards "green" consumption across the EU which are varying across EU countries. Different preferences can help to explanation of this fact [3]. Policies aiming at overcoming market failures has impact on energy consumption in households as well.

3. Comparison of energy consumption trends and drivers in Lithuania, Netherlands, UK and Germany

The final energy consumption trends in households and the main drivers of final energy consumption were analysed in Lithuania, Netherlands, UK and Germany. The main economic drivers of final energy consumption in household selected in the study: energy prices and real disposable income. The main technological drivers of final energy consumption in households: the patents for high technologies per mill. of inhabitants, the share of population working in science and high technologies sector. The other drivers of final energy consumption in households: institutional indicators. The analysis of energy consumption trends in few EU member states were conducted by applying macroeconomic or top-down approach then the impact macroeconomic indicators on final energy consumption trends were investigated by applying correlation and regression analysis. The four states specific with rather similar geo-political situation were chosen for the analysis, namely Lithuania, the United Kingdom, the Netherlands, and Germany. The data from EUROSTAT, however, exhibited some divergence between these countries. For instance, the overall energy consumption decreased in Germany and Lithuania during 1990–2009 by some 7% and 54%, respectively. Indeed, the same figure for Lithuania falls to 11% if considering the period of 1993–2009. Meanwhile, the Netherlands and the United Kingdom experienced growth in the final energy consumption of 21% and 1%, respectively. The fall in energy consumption observed in Lithuania might be attributed to the complex post-communist transformations undergone there during the last decade of the 20th century. The household sector maintains an inelastic energy demand and thus non-decreasing share in energy consumption structure. As for the four states analyzed in this study, the household energy consumption accounted for some 30% of the final energy consumption with exception of the Netherlands where it shrunk down to 20%.

Indeed, the level of energy consumption in the household sector per capita is rather different across the analyzed countries (Fig. 1). As one can note, Lithuanian household consume less energy per capita comparing of those in United Kingdom, Netherlands, or Germany. However, it trends upward, albeit it is unlikely to approach level of the remaining states. Germany is specific with the highest household energy

consumption, namely some 0.8 tonnes of oil equivalent (toe) in 2009. These differences can be explained by different living standards in Lithuania and the remaining states where the rebound effect comes into effect.

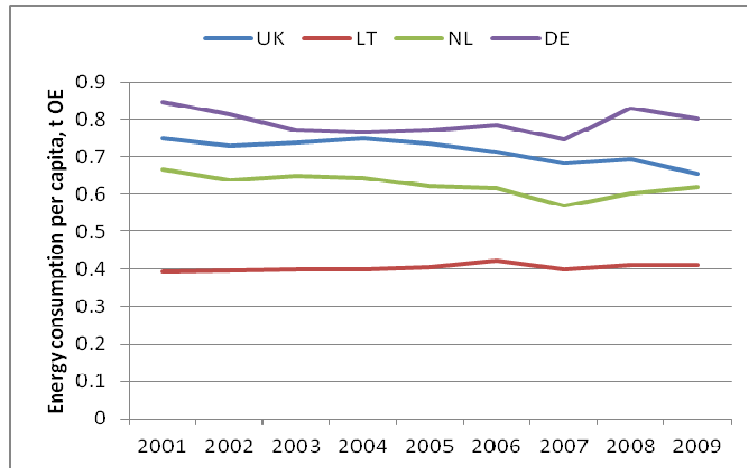


Fig. 1: Energy consumption per capita in households of the selected states, 2001–2009.

The correlation analysis was employed to research into the technological, social, economic, and institutional factors influencing energy consumption and GHG emission in households across the United Kingdom, Lithuania, the Netherlands, and Germany. The data come from EUROSTAT and Kaufmann et al. [5]. The technological indicators cover number of high-tech patents per million inhabitants and share of persons employed in the R&D sector. Electricity price in Euro per kWh and disposable income in PPS (EU-27=100) are the economic indicators. Finally, institutional and political environment is described by the Worldwide Governance Indicators [5]: government effectiveness, regulatory quality and rule of law. Government Effectiveness reflects perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Regulatory Quality reflects perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Rule of Law reflects perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence.

All of these indicators were correlated with energy consumption per capita indicators covering the period of 2001–2009. Table 1 presents the results of correlation analysis.

Table 1: Correlation between main drivers of energy consumption in households

	Energy consumption in households, ktne			
	UK	Lithuania	Netherlands	Germany
The patents for high technologies per mill. of inhabitants, units	0.91	0.46	0.67	0.05
The share of population working in science and high technologies sector, %	-0.84	0.7	-0.64	-0.81
Electricity prices for households, Eurocent	-0.88	0.58	-0.81	-0.57
Real disposable income, EUR	0.8	0.78	0.24	0,39
Government effectiveness	0.94	0.49	0.84	0.56
Regulatory quality	-0.03	0.06	0.47	0.08
Rule of law	-0.68	0.64	-0.55	-0.3

The correlation analysis showed that number of high-tech patents positively impacted growth of energy consumption per capita in households of the United Kingdom ($r=0.91$, $p<0.05$) and the Netherlands ($r=0.67$, $p<0.05$), whereas correlation was insignificant for the remaining two states. Electricity price was negatively

correlated with energy consumption in the United Kingdom ($r=-0.88$, $p<0.05$), Germany (0.64 $p<0.05$) and the Netherlands ($r=-0.81$, $p<0.05$), whereas positive correlation was observed in Lithuania ($r=0.58$, $p<0.1$). The reciprocal link between electricity price and energy consumption confirms that price remains an effective instrument for energy consumption control. As for Lithuania, one may assume that energy consumption per capita is rather low here in terms of the West Europe states and may rise in spite of price regulation.

The share of R&D employees and energy consumption per capita was negatively related in the United Kingdom ($r=-0.84$, $p<0.05$), Germany -0.81 , $p<0.05$) and the Netherlands ($r=-0.64$, $p<0.1$). Therefore, technical innovations are successfully applied in these states to reduce energy intensity. Meanwhile, Lithuania exhibited probably the manifestation of spurious correlation ($r=0.67$, $p<0.05$) due to the on-going energy consumption adjustments. The significant negative relation between the share of R&D employees and GHG emission was identified in all states except Lithuania.

There was no significant correlation found between income and energy consumption in the Netherlands and Germany. However, the positive relation holds for Lithuania and the United Kingdom.

The investigated political and institutional indicators, indeed, exhibited lower correlation with energy indicators. Government Effectiveness indicator was directly correlated with both of the energy indicators in the United Kingdom and the Netherlands. The Rule of Law indicator was reciprocally related to energy consumption in United Kingdom. As for Lithuania, the positive link was determined between these indicators. Thus, only the Rule of Law indicator seems to be related to decrease in energy consumption.

The carried out analysis, however, has some limitations. Due to the limited data availability we employed correlation rather than regression analysis. Therefore only linear interactions between the selected indicators were analyzed. Furthermore, simultaneous correlation does not allow lagged effects. Thus some of the observed correlations might be a result of spurious correlation.

4. Conclusions

The relative importance of the factors that affect residential energy demand remains debated. Though the energy prices and income affect demand; the role of attitudinal variables is more uncertain and needs to be more investigated.

Demand for energy responds to income and price, but the response varies substantially across studies. The income elasticity is likely to be lower than unity, even in the longer run. It is much lower in the short run.

The level of final energy consumption in the household sector per capita in Lithuania is significantly lower than in United Kingdom, the Netherlands, or Germany because of lower income per capita and lower living standards.

The analysis of the main drivers of final energy consumption in Lithuania, Netherlands, UK and Germany indicated that economic and technological factors are the main driving forces of final energy consumption in households however the impact of different factors vary between countries.

In old EU member states the prices and share of R&D employers have impact on energy consumption reduction however in Lithuania because of low energy consumption per capita and low living standards the impact is opposite.

Institutional indicators exhibited lower correlation with energy consumption indicators; however the Rule of Law indicator seems to be related to decrease in energy consumption in all countries.

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