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Decomposing final energy use for heating in the residential sector in Austria ☆

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HIGHLIGHTS

- We did an Index decomposition analysis of the Austrian residential heating demand.
- Eight impact factors on heating demand have been identified.
- Rising comfort needs outweigh savings caused by technical improvements.
- Consumer behaviour has a major impact on residential final energy use for heating.
- Weather changes play a major role when analysing annual changes in energy use.

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ABSTRACT

In Austria a considerable number of measures have been implemented to reduce final energy use for residential heating since the 1990s. The aim of this analysis is to investigate, why – despite these implemented measures – final energy use for heating has not decreased in the expected way. The impact of eight factors on final energy use for heating is quantified by applying the Logarithmic Mean Divisia Index (LMDI I) method. The dataset covers the sector of private households in Austria for the period from 1993 to 2009. The main findings of the analysis are: (1) while technical improvements reduce final energy use for heating significantly, rising comfort needs nearly outweigh these savings. (2) Consumer behaviour reduces calculated final energy use considerably. (3) The extent of this reduction is declining significantly in the period observed. (4) The growing share of single-family houses has increased energy demand for heating in the observed period, though a reversal of this trend is detected from 2007 onwards. (5) The impact of growing floor space per person is the major effect revealed by the analysis. (6) Weather conditions have a major impact on annual fluctuations of energy consumption.

1. Introduction

The steadily increasing energy demand has led to the implementation of the EU Energy Services Directive (European Commission, 2006), which obligates Member States to save 1% of their final energy use per year through energy efficiency improvements until 2016. Moreover, overall energy efficiency should be improved by 20% until 2020, as announced by the Commission in its "third energy package" (European Council, 8/9 March 2007) and drafted in a revised Energy Services Directive (European Commission, 2011) in June 2011.

The Austrian energy savings target set by the current Energy Services Directive amounts to 80.4 PJ or 22.34 TWh in 2016 (Federal Ministry of Economy and Labour, 2007). Bottom-up and top-down methods have been developed to assess the progress made towards achieving this target (Austrian Energy Agency, 2012; European Commission, 2010). The calculated savings have been summarised in the 2nd National Energy Efficiency Action Plan (Austrian Energy Agency, 2011) and submitted to the European Commission in the summer of 2011. The Action Plan lists a considerable number of measures that have already been implemented to reduce final energy use in the residential heating sector in Austria. The reported calculated savings, assessed by means of bottom-up methods, amount to 49 PJ in total and 39 PJ for the residential building sector in 2010.

Considering these implemented measures and the resulting calculated savings, one could expect energy demand for heating not only to stabilise, but also to decline over the years. However, observed energy

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demand for heating does not support these expectations. Fig. 1 shows the final energy consumption of Austria by economic sectors and end-use categories for the years 1993 and 2009. Besides the agricultural sector, energy consumption has grown in all economic sectors between 1993 and 2009. The transport sector experienced the biggest increase and had by far the largest share in energy demand in 2009, followed by the industrial sector. In view of the increases in transport and industrial energy consumption, the final energy use of the residential sector declined in relative terms: while accounting for the largest share in energy consumption in 1993, residential energy consumption remained almost constant in absolute terms resulting in the third largest share in final energy consumption in 2009. However, data show that apart from transport, residential heating was by far the biggest energy end-use category in Austria in 2009, causing three quarters of private households' energy use and 18% of total final energy use.

Fig. 2 shows the annual development of residential energy demand for heating. Data reveal that final energy demand remained relatively constant from 1993 to 2009. Adjusted for climatic conditions, however, final energy use for heating even increased by 5% in this period.

Considering the significant energy consumption and the homogeneity of the private household sector (compared with other economic sectors like industry or services), room heating offers opportunities to effectively implement energy savings measures on a national level. The aim of this analysis is to explore the reasons why final energy use for residential heating has not declined between 1993 and 2009, although many energy efficiency measures had been implemented. The main factors influencing final energy use for heating are identified as well as their impacts on energy demand by applying the Logarithmic Mean Divisia Index (LMDI I) method.

The results shall provide reasoning on why energy demand for heating is not declining and thus exposing the scope of measures to be implemented by energy and climate policy to further stabilise or even reduce energy used for heating in the residential sector.

The article is organised as follows: Section 2 provides a review of studies applying the LMDI method on residential energy consumption. Section 3 describes the methodological approach, specifies the analysed effects and provides an overview on relevant data sources. Section 4 presents results and discussion. Section 5 concludes and outlines fields of further research.

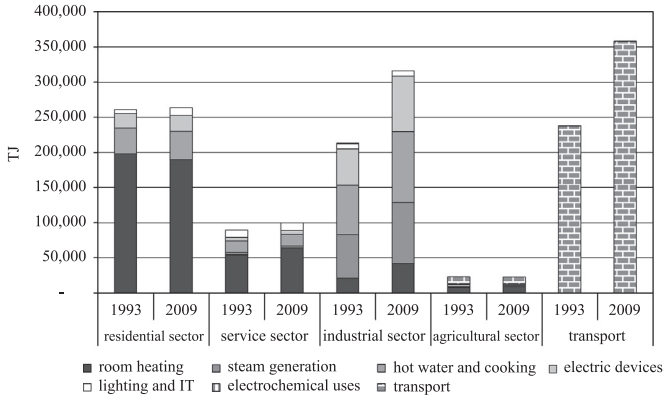

Fig. 1. Final energy use by end-use categories and economic sectors in Austria in 1993 and 2009.
Source: Statistics Austria (2011).

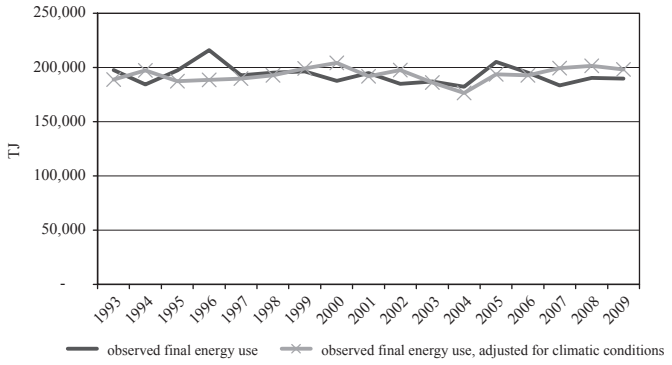

Fig. 2. Final energy use for heating in the residential sector in Austria from 1993 to 2009.
Source: Statistics Austria (2011).

2. Literature review and research gap

To the best of our knowledge, only one LMDI analysis has been performed for Austria so far. The International Energy Agency published decomposition results recently (International Energy Agency, 2011), including decomposition results for space heating per capita for 18 IEA member countries. They decomposed energy consumption per capita into four influencing effects, such as the dwelling size effect, the occupancy effect, the efficiency of conversion effect and the energy intensity effect. Besides this analysis only Kratena and Meyer (2007) undertook a decomposition analysis for Austria so far. They did a decomposition analysis on CO_2 emissions of various economic sectors in Austria. The residential sector was studied as a whole, without any detailed examination of energy demand for heating. Changes in the level of convenience or the structure of households have been analysed only implicitly.

On an international level, decomposition analysis is a widely used method: Ang and Zhang (2000) identified a total of 124 decomposition analyses performed before 2000, mostly focusing on industry. Nevertheless, decomposition analyses of the residential sector are rare; we found five in scientific literature, all of them applying LMDI in its additive form, which are briefly described next.

Achao and Schaeffer (2009) performed a decomposition analysis of the residential electricity consumption in Brazil for the period 1980–2007, with no particular focus on electricity demand for heating. Chung et al. (2011) decomposed total residential energy use in Hong Kong for the period 1990–2007, without subdividing total residential energy use into further categories. Donglan et al. (2010) analysed total residential CO_2 emissions in China for the period 1991–2004, subdivided into urban and rural emissions, without particularly focusing on energy demand for heating.

Rogan et al. (2012) decomposed a 10% sample of residential natural gas consumers in Ireland from 1990 to 2008. As the analysis focused on gas demand, it included the consumption for heating as well as the gas demand for hot water preparation. They quantified five effects including the activity effect (changing customer numbers), the intensity effect (changing consumption per dwelling), the building regulations effect, the weather effect, and the size effect (dwelling size). The effects were estimated for two sub-sectors: permanently occupied and at least temporarily vacant dwellings. Furthermore, they distinguished between five dwelling types: detached, bungalow, apartment, semi-detached, and terraced. The most significant impacts on natural gas consumption revealed by their analysis were the changing customer numbers and the increased consumption per dwelling.

Zhao et al. (2012) analysed the driving forces influencing total residential energy consumption in urban China, subdivided into private transportation, electrical appliances, central heating, and other energy using activities. The four categories were further divided into 17 energy using products: private vehicle, motorcycle, 10 electrical appliances, central heating, activities using coal, natural gas, coal gas, and liquefied petroleum gas. The decomposition analysis focused on the influence of changes in energy prices