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# Adolescents and electricity consumption; Investigating sociodemographic, economic, and behavioural influences on electricity consumption in households

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## HIGHLIGHTS

- We examined causal drivers of sociodemographic influences on electricity consumption
- Sociodemographic influences can be explained by behaviour
- Influence of adolescents is mediated by their purchases of IT appliances
- It is necessary to also use behavioural information for policy planning

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## ABSTRACT

With respect to changes in the energy systems of many countries, electricity consumption in households is an important topic. Extensive research has investigated the various determinants of electricity consumption. However, insights into how specific sociodemographic, behavioural, and attitudinal determinants influence residential electricity consumption are still scarce. In this study, we used hierarchical regression analysis to systematically investigate these determinants (including household engagement in electricity saving) along with a wide range of other measures in a sample of German households (N=763). Special attention was given to households with adolescents and children by analysing the influence of the number of adolescents on electricity consumption in a path model. Our results indicate that sociodemographic influences can be explained by the purchasing and use behaviours of residents. Our findings also suggest that the use of behavioural information provides a more detailed picture of the conditions of electricity consumption and thus allows for more appropriate policy planning.



## 1. Introduction

Aims to reduce $CO_2$ emissions imply changes in the energy systems of many countries, for example, a substantial increase in the use of renewable energy and reductions in the use of fossil fuels (EEA, 2012). Households represent a major group of consumers of energy resources such as electricity (IEA, 2015). Moreover, there is a need to focus on the electricity consumption of younger people because future generations will be strongly affected by changes in our energy systems (Schreiner et al., 2005). Against this background, the use of electricity in households is an important political topic and hence an important topic in social science research.

Among others, variables such as floor area in $m^2$, income, and the age categories of residents have repeatedly been found to be correlated with electricity consumption and thereby might be seen as central drivers of it (Aydinalp et al., 2003; Beckel et al., 2013; Brounen et al., 2012; Jones et al., 2015; Wiesmann et al., 2011). For instance, electricity consumption seems to increase as the number of adolescents in a household increases (Brounen et al., 2012; Gram-Hanssen et al., 2004; Thøgersen and Grønhøj, 2010). However, there are other behavioural and motivational variables behind such age differences that could be addressed by soft policies. Residents have a crucial impact on their energy consumption (Swan and Ugursal, 2009) through behaviours such as their purchases (e.g. number and efficiency of appliances) and use of appliances (Bedir et al., 2013; Kavousian et al., 2013). Focussing on such behaviours should support policy planning for households.

Residential electricity consumption can be statistically

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explained by indirect (e.g. age, income, floor area) and direct (e.g. number and use of appliances) determinants (Bedir et al., 2013). This paper proposes a system that can help explain the influence of (indirect) sociodemographic and economic factors on electricity consumption by considering (direct) behavioural and motivational components simultaneously. We begin by discussing two types of policies that are aimed at reducing residential electricity consumption. These policies require differentiated knowledge about the determinants of electricity consumption. Therefore, we discuss findings on sociodemographic and economic aspects of electricity consumption. We hereby introduce problems that occur when the focus is on only this *indirect* perspective. Subsequently, we discuss which behavioural and motivational aspects are linked to electricity consumption from a *direct* perspective. We believe that sociodemographic and economic determinants are correlated with electricity consumption because they account for residents' behaviours and activities that have a direct causal relation to electricity use. On the basis of this idea, we propose a causal order for determinants of electricity consumption in households. We then statically investigate causal explanations (e.g. past purchasing behaviours) for statistical correlations between indirect determinants (e.g. age differences) and electricity consumption.

### 1.1. Structural and behavioural policies for fostering electricity savings in households

Han et al. (2013) and Steg (2008) proposed a structure by which to order interventions that are aimed at promoting energy saving in households. The authors differentiated between (1.) policies that address a structural level and (2.) policies that address a behavioural level.

(1) For instance, on a structural level, EU legislations have raised topics such as energy labelling and standards that affect energy performance. Altogether, such programmes have led to an increase in the percentage of higher energy classes (A+, A++, A+++) in white appliances (e.g. refrigerating appliances, stoves, and washing machines). Furthermore, information technology is the area with the most rapid increase in households' end-uses of electricity (Bertoldi et al., 2012). The EU Commission has recently issued regulations on how many watts (e.g. 1–2 W) certain IT appliances are allowed to consume (when they are not directly being used) and standards for the automatic switch to the stand-by mode. However, energy labels are still missing for communication appliances such as mobile phones. Here, regulations addressing Ecodesigns or energy labelling are in the planning stage (Bertoldi et al., 2012).
(2) Policies on a behavioural level often involve programmes that address residents' voluntary behaviours. Such interventions require intensive information about behavioural and motivational determinants (Swan and Ugursal, 2009). For instance, Ölander and Thøgersen (2014) concluded that information is more effective when it directly triggers certain actions. They also recommended programmes that address social norms in energy saving (e.g. comparing personal energy saving behaviours to others' behaviour), and they recommended that such interventions be combined with information about energy savings.

Different sociodemographic groups (e.g. different age or gender groups) might react differently to the same campaign. For instance, a study reported that gender is an important predictor of the use of information about public transport. Male participants seemed to use information that was provided about transportation less than female participants (Farag and Lyons, 2012).

To sum up, structural policies (e.g. regulating the energy efficiency of appliances) and behavioural policies (e.g. providing information) can be effective. However, the success of policies is highly dependent on knowledge about the target group.

### 1.2. Sociodemographic and economic aspects; indirect influences

In previous studies, residents' age has repeatedly been discussed as a relevant sociodemographic factor that "influences", or perhaps more appropriately, is simply correlated with electricity consumption (Brounen et al., 2012; McLoughlin et al., 2012). Several investigations have reported that when the number of adolescents in a household increases, residential electricity consumption increases as well (Brounen et al., 2012; Gram-Hanssen et al., 2004; Thøgersen and Grønhøj, 2010). For instance, in a sample of 300,000 households in the Netherlands, teenagers ($>12$ years old) consumed more energy, especially electricity, than household members of other age groups (Brounen et al., 2012). Accessed data from the year 2000 from over 50,000 households indicated a significant, positive influence of the number of teenagers (13–19 years old) on the electricity consumption of households (Gram-Hanssen et al., 2004). An analysis of more recent (2007) electricity consumption data from 237 Danish households found that electricity consumption increased with the number of teenagers (14-20 years old) living in a household (Thøgersen and Grønhøj, 2010).

Income has frequently been identified as a positive predictor of electricity consumption (Jones et al., 2015; Swan and Ugursal, 2009). However, high correlations between the determinants income, house characteristics, and number of residents may lead to methodological problems such as multicollinearity (Swan and Ugursal, 2009). This is reflected by ambiguous results across studies. Sometimes income has been found to be the better predictor of electricity consumption than floor area in $m^2$ (e.g. Bartiaux and Gram-Hanssen, 2005). Other findings have shown that the influence of income becomes nonsignificant when house characteristics such as floor area in $m^2$ are controlled for (e.g. Thøgersen and Grønhøj, 2010). Either way, income and floor area in $m^2$ are factors that are strongly interrelated (Bartiaux and Gram-Hanssen, 2005).

Rent or purchase prices of dwellings are usually calculated in relation to floor area in $m^2$. Therefore, floor area in $m^2$ is highly correlated with income and is often used as an economic predictor of electricity consumption (Bedir et al., 2013). Extensive reviews have identified this measure as a good predictor of residential electricity consumption (Bedir et al., 2013; Swan and Ugursal, 2009). For instance, a study in the US multiplied the floor area of dwellings with indicators of poor insulation to improve the prediction of electricity consumption (Kavousian et al., 2012, 2013). It is important to note that calculations such as this can be applied only for countries that use electricity for heating and air conditioning. In these countries, a larger floor area is also correlated with a larger number or more extensive use of heating and air-conditioning appliances (Parti and Parti, 1980; Swan and Ugursal, 2009). In Germany, however, it is not common to use electricity for heating (except the electricity used for heating pumps; co2online, 2014), and air conditioners are less widespread than in other countries; thus, floor area should not contribute as much to electricity consumption in Germany. However, a larger floor area always permits a larger number of appliances (e.g. more lighting), thus resulting in a positive correlation between floor area in $m^2$ and household electricity consumption (Bartiaux and Gram-Hanssen, 2005; Yohanis et al., 2008).

In our review of the literature, we found that several authors had identified the number of residents as one of the most important determinants of residential electricity consumption (Bedir et al., 2013). Most studies agree that there is a nonlinear relation