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Energy Policy

An integrated analysis of households' electricity consumption in Israel

Yuval Damari, Meidad Kissinger*

Department of Geography and Environmental Development, Ben Gurion University of the Negev, Israel

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ABSTRACT

Recent decades have witnessed a growing interest in the conservation of electricity of the household sector as consumption rates grow constantly worldwide. To date, consumption based studies have either focused on households' overall use of electricity at the national or specific group level, or analyzed specific socio-spatial consumption shaping factors. Studies that followed the first approach can signal the magnitude of electricity consumption, analyze trends and explore the contribution of advancing various measures. Studies that followed the latter approach can be used as a base for advancing consumption behavioral changes based on specific circumstances. This manuscript integrates both approaches for the case of the state of Israel, it therefore allows examining the effect of different variables on electricity consumption of the entire population. The manuscript presents an analysis of electricity consumption of 30,000 households. By quantifying the overall use of electricity by households influenced by different socio-spatial shaping factors, the manuscript identifies the share of specific types of households and various lifestyles (e.g., young families, wealthy households) out of the overall national use of electricity. Such analysis can then support policy measures by aiming to the socio-spatial characteristics of specific types of households, which can contribute the most to advancing the overall national energy efficiency efforts and can also identify future scenarios of household electricity demand which can then be addressed in the future.

1. Introduction

Worldwide, the use of electricity has been constantly rising in recent decades following population and economic growth (BIO Intelligence Service, 2012; UN, 2007; Moll et al., 2005; Michaelis and Lorek, 2004; O'Neill and Chen (2002)). The use of electricity contributes to humans' well-being and prosperity (through large variety of applications such as lighting, indoor climate control, cooking, use of various appliances and much more). However, the reliance on limited unrenewable resources (i.e. fossil fuels) and the various local (e.g., air quality) and global (i.e., GHG emissions) human health and environmental implications emphasizes the need to advance different more efficient use of electricity. Despite the substantial achievements in energy efficiency in the past decades, energy demands keep rising constantly, and electricity consumption rises accordingly (European Environment Agency, 2012; De Almeida et al., 2011; Zacarias-Farah and Geyer-Allély, 2003; Al-Mumin et al., 2003; Lam, 1998).

This manuscript focuses on the State of Israel household sector. Like many other countries, the state of Israel is exploring measures to increase energy efficiency. Main efforts are directed to reduce production related emissions by changes in electricity fuel mix (increasing the share of natural gas instead of coal) and by advancing renewable

sources of energy. While efforts to advance more efficient use of electricity (i.e., reduce consumption) are in place to some extent, overall electricity consumption continues to rise (Israeli Electrical Company, 2016). Overall, the Israeli households sector consumes over 30% of the overall produced electricity (Israeli Electrical Company, 2016), a demand that has annually grown by 3% per year over the last decade (The Israeli Electricity Authority, 2017).

It has been widely acknowledged in recent years that advancing a sustainable electricity system - one that will support a long term secured supply with minimum negative implications - involves an integrated production and consumption approaches (Donato et al., 2015; UN, 2007; Moll et al., 2005; Princen et al., 2002; Cohen and Murphy, 2001). The first advances alternative and more efficient modes of production (e.g., renewables, more efficient fuel mix), while the latter advances reduction of electricity demand by changing behavior, and advancing more efficient use of electricity (e.g., behavioral changes, more efficient electric appliances, green building).

Consumption based studies have either focused on households' overall use of electricity at the national or specific group level (e.g., De Almeida et al., 2011; Park and Heo, 2007; Narayan and Smyth, 2005; Zacarias-Farah and Geyer-Allély, 2003; Lam, 1998) or analyzed specific consumption shaping factors (e.g., Grolinger et al., 2018; Wang et al.,

2017; Morris et al., 2016; Jones and Lomas, 2016; McLoughlin et al., 2012; Sanquist et al., 2012; Bartusch et al., 2012; Abrahamse and Steg, 2009; Yohanis et al., 2008). Studies that followed the first approach can signal the magnitude of electricity consumption and its environmental implications, analyzed trends and explore the contribution of advancing various measures. Studies that followed the latter approach can be used as a base for advancing consumption behavioral changes based on specific circumstances. Factors examined in the literature include demographic (e.g., household size and age); socioeconomic (e.g., income levels, and electrical appliances ownership); or physical (e.g., building structure, climate, geographical location). We argue here that advancing households' electricity efficiency policy measures can benefit from the integration of both approaches. However, to the best of our knowledge such integration between the two approaches has been very limited.

This manuscript objective is to illustrate the integration of both approaches for the case of the state of Israel's household sector. By analyzing for the first time Israeli households' overall use of electricity influenced by different socio-spatial shaping factors, it will be possible to identify the share of specific types of households and lifestyles (e.g., young families, wealthy households, small apartments) out of a studied entity (e.g., nation, city) overall use of electricity. It will then be possible to address specific measures to the most significant groups and to relate the appropriate measures to each group.

2. Background

2.1. Shifting from a supply to demand approach

While most efforts to advance sustainable energy systems in general and electricity in particular still focuses on production, the interest in demand side management has grown in recent years (McLoughlin et al., 2012; Hubacek et al., 2012; De Almeida et al., 2011; Brandon and Lewis, 1999). Consumption is determined by several factors including economic, social and physical elements. Household consumption has important implications on the level and rates of production. Therefore, consumption affects the rate and volume of resource usage (OECD, 2008). By examining the major consumers in the economic system rather than only the producers, we are actually examining the motivation for production (Satterthwaite, 2008).

Several studies and reports have advanced a national analysis and international comparisons of electricity consumption (e.g., IEA, 2017; De Almeida et al., 2011; Park and Heo, 2007; Narayan and Smyth, 2005; Zacarias-Farah and Geyer-Allély, 2003; Lam, 1998). While valuable and provide a much needed basis for international comparison and identification of expected processes of change following economic development, this type of analysis does not consider the variance of consumption inside the population between different groups. Following the above limitation some studies have analyzed the overall use of electricity by a selected group of households to either examine the consumption of the specific group or analyze the effect of certain characteristics on consumption (e.g., McLoughlin et al., 2012; Sanquist et al., 2012; Bartusch et al., 2012; Abrahamse and Steg, 2009; Yohanis et al., 2008; Bin and Dowlatabadi, 2005; Al-Mumin et al., 2003; Brandon and Lewis, 1999). However, these studies usually use small samples and are unable to translate the small group consumption into national figures. i.e. to analyze the share of specific studied group out of the overall national electricity consumption.

2.2. Exploring drivers of consumption

While measuring and analyzing the overall use of electricity as presented above is important, several studies have explored the drivers i.e. the shaping factors behind households' consumption patterns. For example, Zacarias-Farah and Geyer-Allély (2003) examined the electricity demands by households in the OECD to find that the two main

drivers for growing demands are economic growth and demographic changes. This finding is supported by studies in other regions (e.g., Ewing and Rong, 2008, Lenzen et al., 2006, O'Neill and Chen, 2002). Rising disposable incomes have enabled consumers to purchase more electrical appliances and bigger houses. Demographic trends (such as declining number of occupants per household and growing population) have caused an increase in per capita dwelling area which causes a greater demand for energy. Total electricity consumption was found to be higher in detached homes rather than in apartments, and in households with kids (McLoughlin et al., 2012). Elderly occupants were also found to raise the electricity demand (Guerra Santin et al., 2009; Lenzen et al., 2006, O'Neill and Chen, 2002).

Income is found highly correlated to household electricity consumption (Guerra Santin et al., 2009; Moll et al., 2007; UN, 2007; Lenzen et al., 2006; Michaelis and Lorek, 2004; Zacarias-Farah and Geyer-Allély, 2003; Spangenberg and Lorek, 2002; Brandon and Lewis, 1999; Lam, 1998). As energy costs are a small portion in the overall household budget, the constraint of income is felt by low income households (Michaelis and Lorek, 2004). Wealthier households tend to have more living space per capita and this causes extra need for heating/cooling and lighting thus increasing the demand for energy (Yohanis et al., 2008; Michaelis and Lorek, 2004). Large disposable income enables consumers to purchase more electrical appliances hence intensifying the demand for energy (McLoughlin et al., 2012; Michaelis and Lorek, 2004; Zacarias-Farah and Geyer-Allély, 2003). However, some researchers find that the energy requirements per capita have high variance in equivalent income levels and therefore more variables should be taken into consideration (Lenzen et al., 2006).

In regard to household size, people living under a shared roof usually tend to consume less energy per capita for heating and cooling. They also tend to use the same electrical consuming devices which, per capita, are lower than households with a small number of people (Tukker et al., 2010). Therefore, a growing population and a reduction in household size are bringing an increase of overall use of energy and related emissions (Liu et al., 2003). Climatic conditions are found to highly affect the energy requirements through the demand of electricity for cooling living spaces and in several parts of the world for heating as well (Donato et al., 2015; Kennedy et al., 2009).

In light of the complexity of analyzing the action of consumption, drivers and options for mitigation, we emphasize in this manuscript the importance of integrating the two methods common today; group analysis and national consumption patterns. This integration allows us to examine a groups' behavioral characteristics of consumption and evaluate its influence at the national level.

2.3. The case of the state of Israel

To this day, no detailed account was conducted on the electricity consumption of households in Israel. As an OECD members state, Israel is considered as a wealthy country with a strong economy, characterized by high GDP levels, high rates of educated population, relative low rates of unemployment, and well based infrastructures. However, different from most OECD countries in terms of its socio-demographic characteristics it is still possesses high birth rates, low workforce productivity, large socio – economic gaps and highly centralized markets (CBS, 2017).

The state of Israel was established as a country of immigrants and as such the population is diverse in terms of ethnicity, religion and culture. In term of religion, the Jewish population is the majority (74.7%) followed by the Muslims (17.7%), Christians (2%) and a Druse (1.6%). Since the establishment of Israel, a total of 3.2 million immigrants have arrived, 43% since 1990. The two largest waves of immigration were from the former Soviet Union and Ethiopia.

The overall Israeli population is approximately 8 million people (CBS, 2017). An average Israeli household consists of 3.32 persons (as for 2015). As in other parts of the world, this figure has been steadily