



# Inequality of household carbon emissions and its influencing factors: Case study of urban China



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## ABSTRACT

When looking at emission reduction at the consumption side, the differentiation of energy consumers should be taken into account, since ignoring individual difference would easily result in social inequality and decrease of social welfare. Based on the framework of social practice model, this article estimated the quantitative distribution characteristics of urban household carbon emissions from different cities, and analyzed the influencing factors of household daily energy consumption and carbon emissions. The main results indicate that urban household carbon emission is close to 60/40 or 70/40 distribution, the economic features of different regions may contribute to such unequal distribution to a large extent. Space heating (in the north area) was found to be the largest CO<sub>2</sub> emission source among various daily energy use practices in the Northern cities. In general, it was found that household carbon emissions tend to increase with rising levels of income and ownerships of assets like car or house in particular; besides, individual cognition and household lifestyle would partly affect their energy selection and daily consumption behavior.

## 1. Introduction

In recent years, China has witnessed rapid urbanization, increasing domestic energy demand and continuously increased carbon emissions, direct and embedded carbon emissions from urban households contributed to a large proportion of such increase (Han, Xu, & Han, 2015). With the urgency of mitigating the growth of carbon emissions in China, current climate policies have mainly focused on emission reduction from the production side, with strategies being made for high emission industries and enterprises (Qi, 2012). However, simply taking the production angle for intervention will greatly weaken the overall effectiveness on emission reduction, due to the neglect of consumer factors (Steininger et al., 2014).

When looking at emission reduction from the consumption side, an accurate understanding of characteristics and relevant factors to household CO<sub>2</sub> emissions is especially necessary. Previous studies have sought to address this issue by using a variety of approach, most of these are concentrated on the national and provincial level, relying on broad energy consumption data to reveal CO<sub>2</sub> emissions and their provincial distribution in China (Ye et al., 2017). While the differentiation of energy consumers and their quantitative distribution characteristics should also be taken into account, since ignoring individual difference would easily result in social inequality and decrease

of social welfare (Schaffrin, 2013). Some studies on daily trip of residents have found that household carbon emissions tend to show the distribution characteristic of inequality, which means a small number of high emission population actually contribute a great proportion of carbon emissions, such as “60/20” (20% of high emission group contributing 60% of the emissions) or “50/10” distribution laws (Brand & Preston, 2010). But this is far from adequate to understand the differentiation of carbon emissions from the overall household energy consumption behaviors. And what's more, in the process of urbanization, the big size of the population has increased the complexity of this issue in China. Hence, in order to promote emission reduction at the consumption side, it is urgent to learn the distribution characteristics of household carbon emissions from different groups and identify the group who are crucial for energy conservation and relative policy interventions.

Driving forces behind household energy use behaviors are significant explanations of such distribution. The influence of socio-economic attributes such as income and occupation are proved to be existed on urban household carbon emissions in present studies of China. But few literature considered intrinsic factors from different individual (household) behaviors, including self-cognition and attitude. This paper estimates the distribution features of China's household carbon emissions induced by direct energy consumption and analyzes the

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influencing factors of carbon emissions both from the perspective of socio-economic and psychology. Considering the tremendous difference between urban and rural household energy utilization and high urbanization rate in China, in this research we only focus urban household energy use and its carbon emissions. It may contribute to the literature from three aspects: (1) focusing on carbon emission reduction from the perspective of consumption side, considering household/individual differences in energy consumption behaviors, which present more realistic and meaningful insight for policymakers; (2) revealing the distribution characteristics of urban household carbon emissions from daily energy use behaviors, and taking household differentiations into account; (3) uncovering the driving forces of household carbon emissions from the perspective of psychology, which makes it possible to combine the study of household energy consumption behaviors with social psychological perspectives.

The reminder of this paper is organized as follows. Section 2.1 reviews the recent researches on household energy consumption and carbon emissions. Section 2.2 describes the theoretical framework of this study. Section 3 reviews the method and dataset used in this study. Section 4 presents the results of quantitative distribution of household carbon emissions, with Section 5 further discussing the driving forces of emissions. Finally, conclusions and policy proposals are proposed in Section 6.

## 2. Research review and a theoretical framework

### 2.1. Research review

A large number of studies have looked into household direct energy consumption and its climate impacts. They are either concerned with household energy consumption and its direct impacts on carbon emission (Das & Paul, 2014; Nie & Kemp, 2014), or aim to evaluate both direct and indirect environmental impacts of household energy consumption by applying life cycle analysis, input output model, ecological (carbon) footprint methods, etc. (Brizga, Feng, & Hubacek, 2017; Feng, Zou, & Wei, 2011; Li et al., 2016; Liu & Wu, 2013; Yang, Fan, & Zheng, 2016). In general, these studies are mainly based on aggregated data and focus on the overall environmental impacts of household energy use, while it is difficult to identify the differentiation and diverse characteristics of different household groups in these analyses.

In recent years, there have been plenty of literature on household energy use behaviors and carbon emissions with the method of field survey or case study. In particular, the behaviors of traffic carbon emissions caused by urban daily travelling has drawn wide attention of the public, and scholars began to make a better understanding of the distribution characteristics of households' traffic carbon emissions. They adopted sampling investigation and analyzed the composition and quantity of carbon emissions from different individuals or families. For example, Brand and Preston (2010) concluded a "60/20" regularity of distribution of traffic carbon emissions in the UK, which indicated that about 60 percent of carbon emissions are produced by 20 percent of population (the high carbon emitters). Xiao, Chai, and Liu (2011) proved that the quantitative distribution of carbon emission in daily trip of residents in Beijing City basically meet the "60/20" law. Recent studies started to pay more attention to the distribution of carbon emissions in household daily energy consumption behaviors. For instance, Dominik et al. (2017) analyzed household carbon footprint in China, found that the highest income groups in cities contributed 19% of the total household carbon footprint, and made the conclusion of unequal household carbon footprint. In general, several studies have revealed the unequal distribution of individual (household) carbon contribution. However, so far in China it still lacks specific study on distribution characteristics of household carbon emissions, while it is very much necessary to learn such distribution features in order to better promote emission reduction of the consumption side with less loss of equity and social welfare.

It is of course also important to understand the driving forces that influence the individual differences in energy consumption, especially when learning the unequal distribution of their contributions to carbon emissions. Scholars have carried out extensive researches on the influencing factors of household energy choices. Econometric models are usually adopted to examine the impacts of social, economic and other elements on household carbon emission and an unequal distribution (Aldossary, Rezgui, & Kwan, 2015). Some studies found that the household carbon emission level is significantly related to household income, members' occupation, vehicle ownership, living location, etc. It seems common to find that income gap is the primary cause of the significant difference in emission levels among families. For instance, Zhang, Song, and Yao (2015) found that carbon emission is closely related to income in the study of household energy consumption in China, where carbon emissions of the poorest 10% population only account for 45% of the richest, and revealed significant socioeconomic differences between groups of emitters, which is the top 10% of emitters who produce 49% of total emissions. There is a general conclusion that the unequal distribution of carbon emission of different income groups commonly exists.

Besides examinations with such quantitative analysis, there are plentiful literature that have probed into household energy (saving) behaviors from the psychological and sociological perspectives. These kinds of researches are mainly based on specific theoretical system or framework explaining the consumer behavior (Becker, Seligman, Fazio, & Darley, 1981; Kaiser, Wolfing, & Fuhrer, 1999), which refers to individual attitude, cognition, behavioral intention and other individual factors. Cognitive factors are usually thought to be the main determinants of individual behavior, and the influence of attitude on energy saving behavior has been widely validated in previous studies (Kaiser et al., 1999; Nordlund & Garvill, 2002). Stem, Dietz, Abel, Guagnano, and Kalof (1999) put forward the theory of Value-Belief-Norm (VBN), revealing that different values can shape different lifestyles, then affect the final environmental behaviors through individual cognition, self efficacy and so on (Stem et al., 1999). Wang and Hou (2010) pointed out that improving the environmental attitudes and awareness of young people is conducive to improving the level of residents' environmental behavior. Recent researches rarely focus on household carbon emissions from the perspective of psychology, which makes it necessary to combine the study of household energy consumption behaviors with social psychological perspectives.

In summary, present studies of China mostly analyzed the household energy consumption or carbon emissions based on aggregated data, and estimated the influence of socio-economic attributes such as income, occupation and so on, while it still lacks an evaluation on the distribution of household carbon emissions and understandings on the influencing factors from the social psychological perspective. In this study, we made efforts to strengthen the economic literature that focusing on carbon emission reduction from the perspective of consumption side, considering household/individual differences in energy consumption behaviors, which present more realistic and meaningful insight for policymakers.

To examine household or individual energy behavior it may involve different perspectives across economics, social psychology, sociology, etc. (Liu, Spaargaren, Heerink, Mol, & Wang, 2013), so it is necessary to adopt a comprehensive framework to understand the issue in this research.

### 2.2. The social practices model for studying domestic energy consumption

To make a comprehensive analysis of distribution characteristics and influencing factors of household energy consumption and carbon emissions, we suggest using the 'social practice approach' (Spaargaren, 2003; Van Vliet, 2002), and trying to identify the energy emission sources and influencing factors in this framework.

The social practice model looks into possibilities for designated

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