



*Strengthening local capacity
in the economic analysis
of environmental issues*

The Economy and Environment Program for Southeast Asia (EEPSEA) was established in May 1993 to support training and research in environmental and resource economics across its 10 member countries (i.e., Cambodia, China, Indonesia, Lao PDR, Malaysia, Myanmar, Papua New Guinea, the Philippines, Thailand, and Vietnam.) It aims to strengthen local capacity for the economic analysis of environmental issues so that researchers can provide sound advice to policy makers.

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The Impact of Climate Change and Income on Electricity Consumption: A Study from China

China is the largest consumer of energy and the largest emitter of greenhouse gases in the world. To reduce the country's reliance on fossil fuels and its impact on the world's climate, the Chinese central government is working to reduce coal consumption and to increase the share of electricity supplied from new and renewable sources. To help shape this policy, the government needs to be able to forecast electricity demand and to understand the factors that affect it.

To help with this vital work, a new EEPSEA study has assessed the major factors that determine household demand for electricity and has made forecasts of China's future electricity demand. The study is the work of Wang Chunhua of the University of International Business and Economics, Beijing. The study finds that climate change, income, and urbanization will have a significant impact on electricity consumption. It recommends that future electricity supply planning should take these factors into account, along with the impact of regional differences in income growth and weather conditions.



A summary of EEPSEA Research Report No. 2017-RR11: "Residential Electricity Consumption in China: The Roles of Weather and Household Income," by Wang Chunhua. Comments should be sent to: Dr. Wang Chunhua, School of International Trade and Economics, University of International Business and Economics, 10 Huixin Dongjie, Chaoyang District, Beijing 100029, China.
Tel: (86-10) 6449-3581. Fax: (86-10) 6449-3042.
Email: chunhua.wang@rocketmail.com; wangc@uibe.edu.cn

The Chinese energy challenge

China's energy demand has increased dramatically in the past three decades. From 1991 to 2014, the country's total electricity consumption grew by 780%, reaching 5,638 gigawatts (GW). China's electricity supply depends heavily on coal-fired power plants; coal power accounts for about 78% of the country's total electricity production. The burning of coal is the main source of greenhouse gases and other air pollutants such as sulfur dioxide and particulate matter.

In terms of household energy use, residential electricity consumption has increased over the years. It stood at 8.6% of the total electricity consumption in 1991 and had risen to 12.7% by 2014. It is expected that the demand and share of residential consumption will continue to rise for a long time as the economy grows and household incomes increase.

The overarching aim of this study was to examine the impacts of weather and household income growth on residential electricity consumption and to forecast electricity demand at the national and regional levels.

Information on electricity use and the weather

Two sets of information on household electricity consumption were used in the study. The first was a subsample of the data from the urban household survey, which was administered by China's National Bureau of Statistics.

This information details the amount of electricity consumed by households over this time period and provides about 30,000 observations per year from most of China's provinces.

The second set of electricity consumption data came from household data records from 66 cities in five provinces (i.e., Anhui, Guangdong, Jiangsu, Liaoning, and Shanxi) from 1992 to 2009. These cities are located in the northern, northeastern, eastern, and southern parts of China and experience quite different weather patterns. These household records supplied information on several key variables including income, electricity consumption (in kWh), expenditure on electricity (in current CNY), and the number of people in each household.

Weather data was obtained from the China Meteorological Data Sharing Service System. Since the 1950s, this organization has been recording minimum and maximum daily temperatures, precipitation, wind speed, and other factors from 820 weather stations in China. The study used this information to calculate daily mean temperatures (the mean of daily minimum and maximum temperatures) across China.

A number of different interviews were also undertaken. These provided information on people's views about the past, present, and future of residential electricity consumption in China. These perspectives helped the research team construct their data, understand their results, and assess their study's policy implications.

Simulating the effects of climate change

To assess how climate change would affect residential electricity consumption in China, the research team carried out a simulation analysis for the cities and provinces for which they had information. The simulation was based on the Hadley 3 model. Low-emission and high-emission scenarios were considered for the periods 2040–2069 and 2070–2099. Under the high-emission scenario, there would be four times as many days with temperatures above 30°C by the end of the century as there were in 2009.

These simulations show that climate change would have a highly variable effect across China, even for cities within the same province. It is predicted that climate change would have the most significant impact on Guangdong province, where many cities will have many more days with mean temperatures higher than 30°C.

The study found that the mean annual electricity consumption of an urban household in the five provinces (Anhui, Guangdong, Jiangsu, Liaoning, and Shanxi) was 1,303 kWh from 1992 to 2009. Overall, the average level of electricity consumption has increased over the years. For example, an urban household consumed 1,766 kWh of electricity in 2009. This was nearly triple the amount used in 1992.

It was also apparent that residential electricity consumption was lowest in the northern provinces and highest in the southern provinces.

The difference may be the result of varying income levels and weather patterns, among other factors. Southern provinces usually have hotter weather; thus, more electricity is needed to cool buildings in the summer.

The impact of temperature on electricity use

High and low temperatures are associated with significant increases in residential electricity consumption. For example, it was found that one more day with temperatures higher than 30°C (and one day less in the category of 9°C–12°C) can cause a household to consume 0.54% more electricity in a year. This translates to about 7 kWh of electricity for a representative household over the period 1993–2009. It was also found that one more day with daily mean temperatures between –6°C and –3°C would cause a household to consume 0.18% more electricity.

The impact of climate change

Simulation analysis revealed that climate change would significantly increase the residential consumption of electricity in Chinese cities. In the sampled cities from the five provinces, the mean increase by the end of the century would be 10% in the low-emission scenario and 20% under the high-emission scenario.

Specifically, under the low-emission scenario, urban households would increase electricity consumption by 3.75% annually for the period 2040–2069. This annual increase will go up to 10.03%

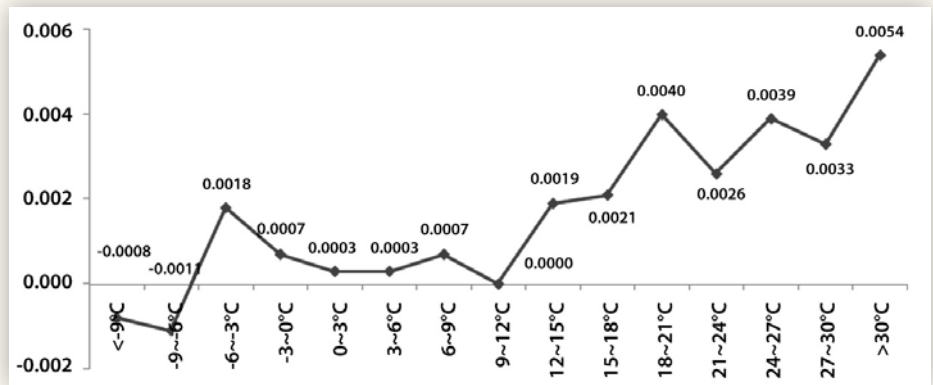


Figure 1. The impacts of weather on residential electricity consumption
Note: The y-axis refers to the estimated coefficients.

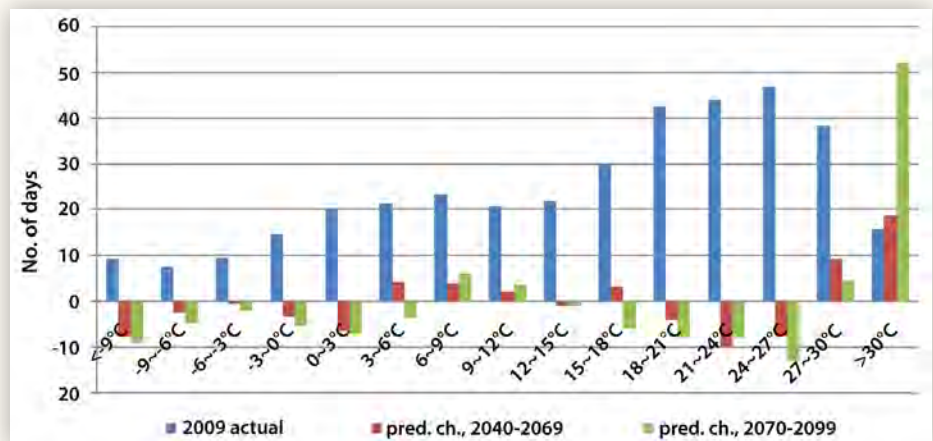


Figure 2. Distribution of annual daily mean temperatures in 2009 and predicted changes in distribution (Emissions Scenario A2)

in the period 2070–2099. Under the high-emission scenario, most cities would have more days with extremely high temperatures. This will cause residential electricity consumption to grow by an even larger percentage. In this scenario, in the the period 2070–2099, consumption would increase by 20.45% annually.

Generally, the simulations suggest that the highest increases in electricity consumption will happen in the southern provinces such as Guangdong, while the lowest increase will take place in the northern province of Shanxin.

The impact of urbanization and population movement

Urbanization and other changes in the spatial distribution of

China's population will also have an impact on the demand for electricity. In cities, electricity consumption per capita is usually higher than that in the rural areas. As a result, the continuing urbanization process will increase electricity demand.

Recent migration trends also show that the population growth rate in Southern China is much larger than that in the northern parts of the country. As the residents in the southern provinces usually consume more electricity per person, this migration trend will bring about a net increase in electricity consumption. Thus, the forecasted electricity consumption growth rate would, in all likelihood, be higher than that of the mean impact reported in this study, particularly in provinces in Southern China such as Guangdong.

The impact of electricity price rises

The above issues show that predictions over the long-term are challenging due to the wide variety of issues involved. Various socioeconomic factors also complicate any forecasts relating to electricity consumption.

For example, the study found that if the social costs of carbon dioxide and other pollutant emissions are considered, the price of electricity in China has a lot of room to increase. If it increases by 100% by the end of the century, then demand for electricity could decrease by 23%. This will help offset the consumption increase that climate change is predicted to cause.

The impact of income growth

However, it is also expected that China's household income has great potential to increase in the near future. The central government wishes for citizens to double their per capita disposable income by 100% between 2010 and 2020. Such an increase would make electricity use grow by about 20%.

Note that in response to increasingly higher temperatures, residents may adopt alternative building technologies and standards, such as better housing insulation and double-glazed windows. The energy efficiency of heating and cooling

technology should also improve in the coming years. These factors should moderate the steady compound growth of electricity consumption.

The conflicting impacts of increasing household incomes, rising energy prices, and improved energy efficiency may offset each other to some degree. However, it is clear that future household income growth will bring significant challenges for policy makers, and that they will have to put policies in place to meet growing demand for electricity.

Policy implications

The findings of this study have important policy implications and will be helpful to policy makers and power utility providers in several ways. They should be used to inform debates about the impacts of climate change in China and on the electricity market reform. In particular, the estimates will be useful when discussing the long-term planning of electricity supply in various regions of the country. The results also have implications for policies on coal consumption and the production of carbon dioxide and other pollutants from coal-fired power plants.

For example, China usually runs short of electricity in cold winters and during hot summers in specific regions. The simulation analysis implies that such shortages would, in the future, be most critical in Southern China during hot summers. This finding should inform future policy and

investment decisions. The study also shows that future electricity supply planning should consider the urbanization process and regional differences in income growth.

The Chinese central government is currently trying to let the market, not the government, be the determining force in setting electricity prices. However, the study recommends enforcing regulations so that demand-side issues and consumer behavior can be taken into account. The empirical results of this research should be used to help design such regulations. For example, regions experiencing increasing electricity demand caused by climate change should be provided with more electricity. Regulations should allow prices to fluctuate over a wider range in such regions. To capitalize on the potential for renewable energy systems to reduce electricity consumption, the government should also consider providing incentives so that households are willing to install rooftop solar systems and use other renewable and energy-saving technology.

EEPSEA, SEARCA Building,
College, Los Baños,
Laguna 4031
Tel/Fax: +63 49 501 3953

Email: admin@eepsea.net

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