

Electric Heating and the Effects of Temperature on Household Electricity Consumption in South Africa

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Executive summary

In the next several decades, energy use in emerging markets is expected to rise dramatically. From 2007 to 2035, energy consumption is expected to grow by 84% in non-OECD countries. However, despite these large predicted increases, little is known about how the electricity consumption profiles of middle and higher income households in developing countries respond to temperature changes. In addition, while much research in this area has focused on the marginal increase in energy demand caused by an increase in air-conditioning usage when temperatures reach higher extremes, less is known about the response to temperature increases at lower temperatures. This paper provides a comprehensive understanding of the effect of temperature on household electricity demand in South Africa. The analysis uses 132,375,282 hourly household electricity consumption observations from 2010 to 2013 for 5,975 households in Johannesburg to study the impact of temperature on electricity consumption.

In many OECD countries, gas constitutes the primary source of space heating. In the U.S., natural gas (49%) and fuel oil, kerosene, and propane (10%) constitute the bulk of primary space heating for households, with electricity the primary heating source for only 38% of households. The primary fuel source of heating in the UK is also gas, and only 10% of British households supplement with electrical heating in cold winter months. These figures may look different in developing countries. The poorest households acquire access to electricity well before gas heating. In South Africa, only 3% of households use natural gas as their primary source of heating, while 67% cite electricity as their primary source of space heating. Electricity is also the primary source of heating in Brazil. Poor insulation and unreliable infrastructure frequently found in lower-income countries can lead to higher levels of electricity consumption at low temperatures than in higher-income countries. This suggests that we may see significantly higher electricity consumption at lower temperatures in developing countries.

This analysis identifies two main results. First, households use substantially more electricity at cold temperatures than at medium temperatures. Across the entire temperature range 2-23°C, households

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consume 4.1% less electricity for every 1°C increase in outdoor temperatures. Consumption remains largely constant between 23-30.5°C, and then increases for temperatures greater than 30.5°C. Aggregating the effects across the distribution of temperatures, the heating response dominates the cooling response. Holding all else constant, an increase in temperatures of 3.25°C by mid-century would cause a decrease in electricity consumption of 1,093.4 kWh per year per household, or 6.2% relative to baseline levels.

Second, household temperature responses vary by season, and household temperature response becomes more muted after controlling for seasonal temperature variation. Particularly during the summer, household electricity consumption does not respond to temperature variation as strongly in the short-term. If households do not respond to daily fluctuations as much as they respond to increases in average seasonal temperatures, then current estimates that are based on large fluctuations in daily weather may overestimate the extent to which future temperature changes will increase energy consumption.

This result has meaningful implications for policymakers. Mornings and evenings experience both lower temperatures than hours in the middle of the day, as well as increased demand resulting from most people's daily movement patterns even controlling for temperature. Energy planners working to limit outages due to capacity constraints will need to incorporate both drivers into their forecasts. In addition, policy makers looking to reduce the need for capacity increases by reducing demand through energy efficiency improvements would therefore benefit from targeting energy efficiency programs towards heating appliances. As growing middle-class incomes in developing countries cause increased purchases of both heating and cooling appliances, it will be important to encourage energy efficiency improvements not only among air-conditioners but among electric heaters, as well.

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