Empowering Large-Scale Energy Efficiency as a Utility Generation Resource: Getting Appliance Loads Right

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Background

Pacific Northwest National Laboratory (PNNL) supports the Department of Energy's focus on environmental responsibility by identifying and developing environmentally-friendly alternatives to the status quo. In keeping with those objectives, PNNL is evaluating the potential for large-scale investment in building-sector energy efficiency to offset the need for additional power generation at a level that would satisfy utility industry specifications for new baseload power resources. We will examine the case of energy efficiency as an alternative to new baseload power for representative regulated electric utility service territories.

We use the industry-standard ProMod model by Ventyx to model the electric grid of selected representative utility service territories. ProMod is a data-driven electricity dispatching model that provides realistic resource dispatching behavior and permits modeling to determine impacts on reliability, load shapes, peak demand, and power plant emissions, among other measures. Using ProMod we will simulate sustained large-scale investment in building-sector efficiency measures within selected utility service territories and estimate the impacts these measures have on reliability and emissions in comparison to investment in new baseload power plants.

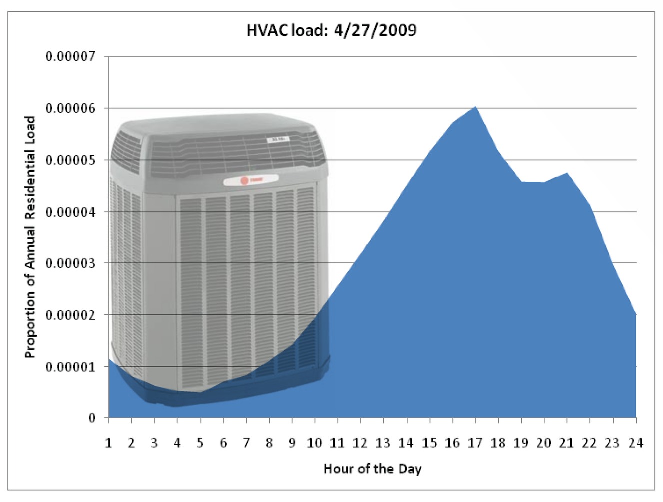
For example, we would posit that a utility could construct a twin-unit AP 1000 nuclear plant for an overnight capital cost of $15 billion including financing costs, which would produce 2200 MW of baseload capacity with a 90% capacity factor for 40 years. We would compare this investment with similar investment in energy efficiency improvements carried out in the time period analogous to the plant construction time period, and then measured over the 40-year life of the power plant. Our examples will consider several plant construction options smaller than a nuclear power plant.

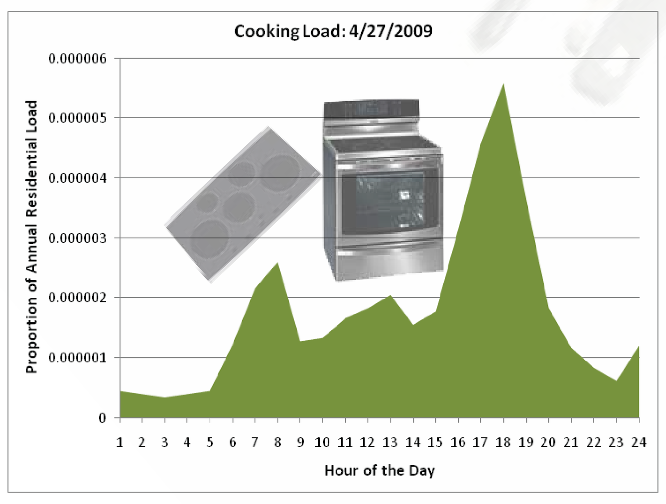
Methodology

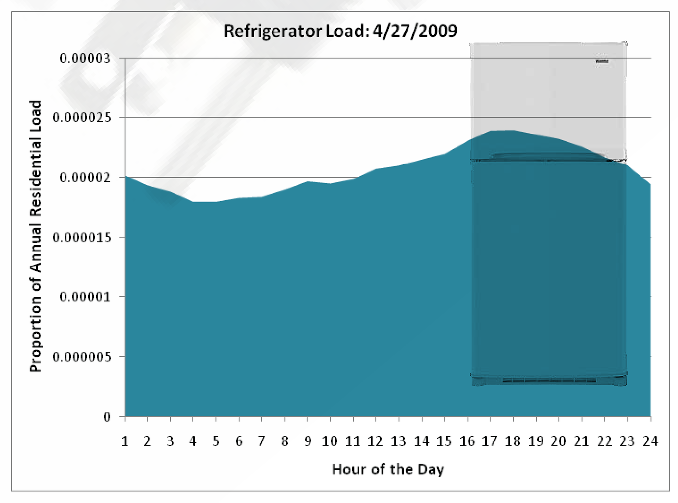
In order to support this project, a method of deriving end-use-specific load curves from a total utility load curve was developed. These load curves show the amount of energy used by each of 11 categories of residential appliances. The temperature-dependent portion of the residential load was separated out by subtracting off the minimum load for that hour of the day; this load was assigned to heating, ventilation, and air conditioning (HVAC) systems. The curves for the other appliances were based on data from the National Energy Modeling System (NEMS) and the California Residential Appliance Saturation Survey (CA-RASS).

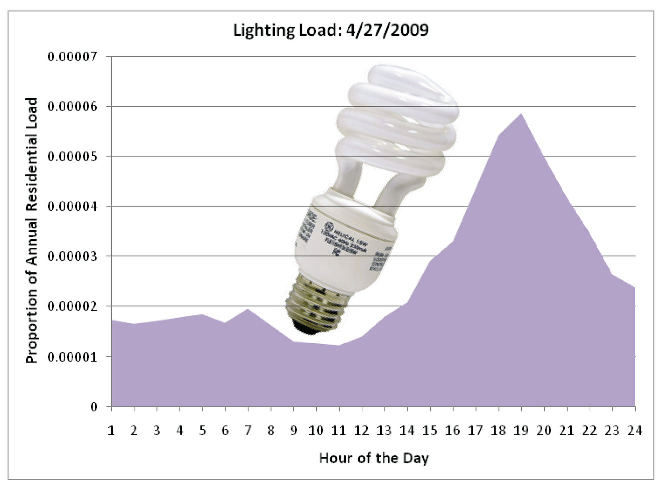
Results

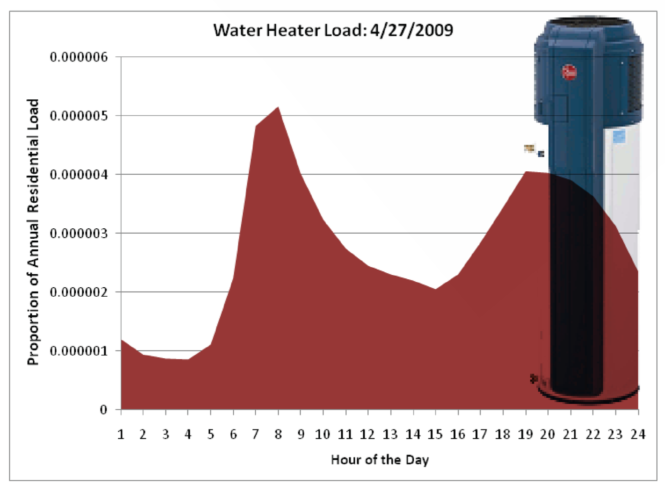
Residential end-use load curves were successfully developed from a utility-wide load curve using a novel methodology. The disaggregated load curves showed several expected trends: loads were highest during the summer, when air conditioning loads are especially high; peaked in the morning and evening, when residents were more likely to be home; and peaked later on weekends than weekdays.

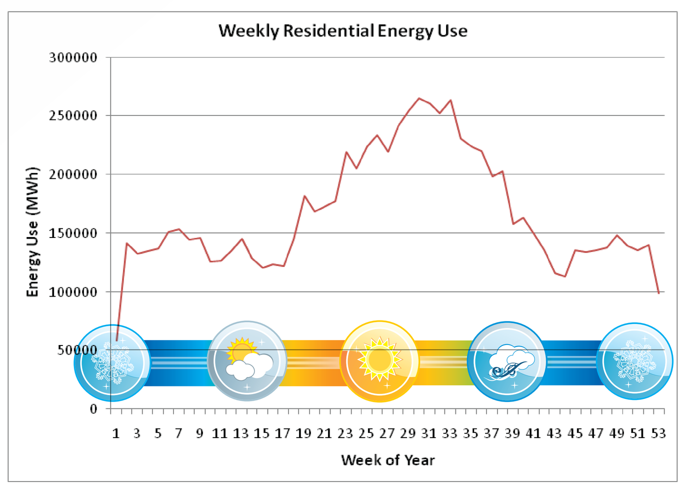


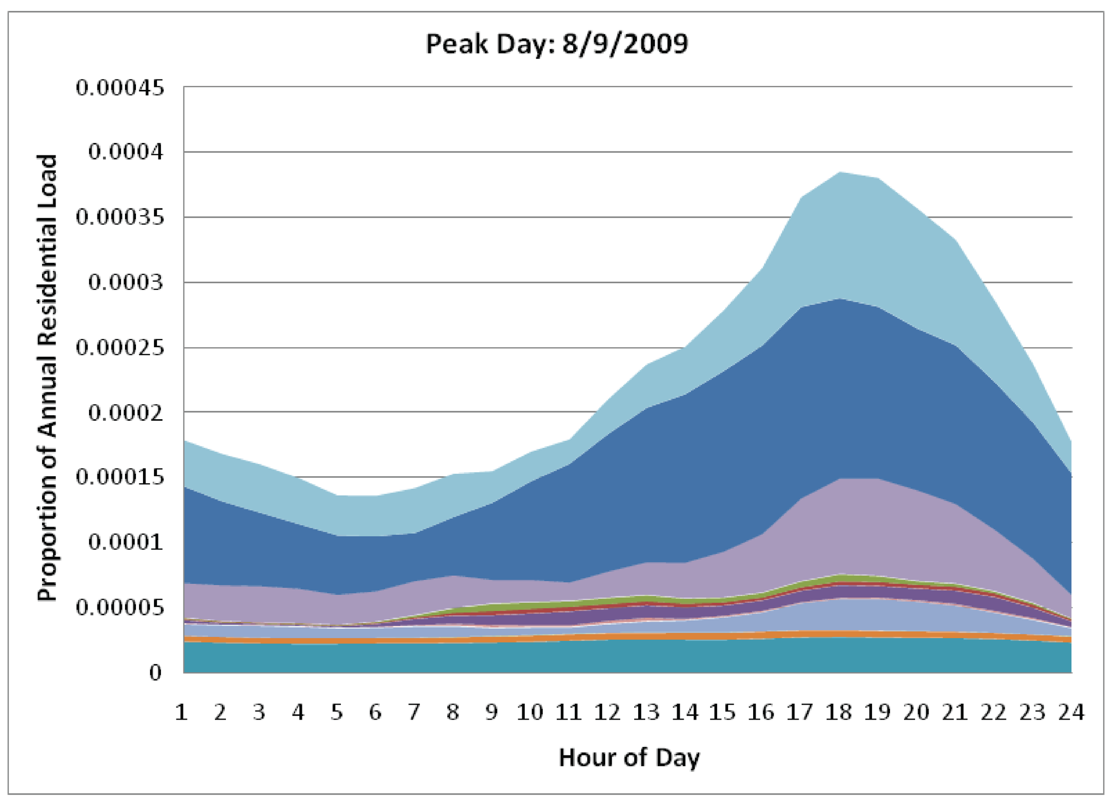


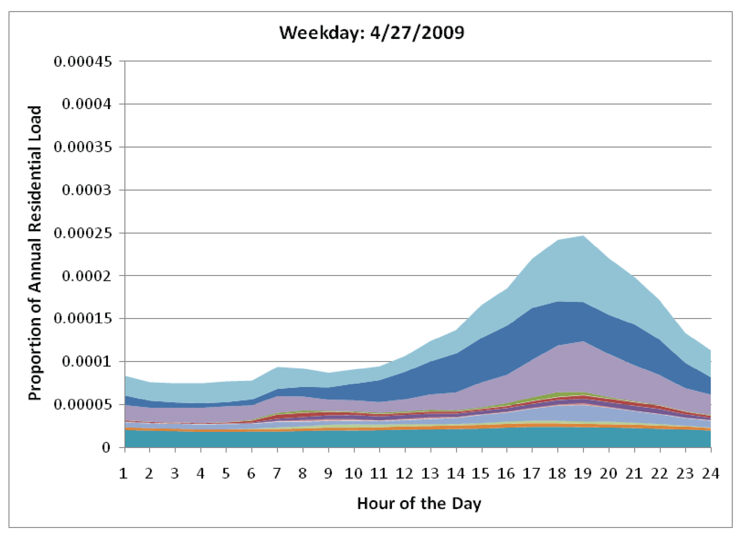


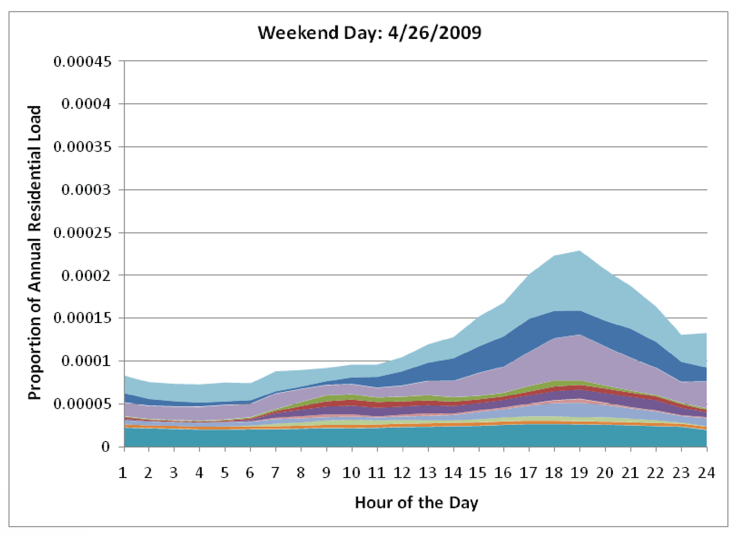












Legend

- Other
- HVAC
- Lighting
- Cooking
- Water Heaters
- Clothes Dryers
- Dishwashers
- TVs
- Clothes Washers
- Freezer
- Refrigerators

Conclusions

The load curves produced in this study will be very useful to the broader project for which they were produced. They are easy to modify, which will allow researchers to investigate the effects of an energy efficiency program using ProMod. Future studies will consider what level of energy savings can realistically be obtained from an energy efficiency program, and whether that program would be cost-effective in comparison to construction of a new power plant.

alternative

generation

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