

Small Devices, Big Loads

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Historically, major end uses such as space heating, water heating, space cooling, and lighting have dominated residential energy consumption. Over the past several decades, a range of electric products, including new electric products, have proliferated in homes. Collectively, the energy consumed by these products, referred to as miscellaneous electric loads (MELs), has become a significant end use since first coming to the attention of energy researchers in the late 1980s.¹

MELs include several broad categories of equipment:²

- Consumer electronics: Televisions, set-top boxes, personal computers and peripherals, monitors/displays, audio products, video products, video games, and telecommunications devices;
- Kitchen products: Microwave ovens, coffee machines, toasters and toaster ovens, and other electric kitchen appliances;
- Bath products: Electric spas and hot tubs, hair dryers, and curling irons; and
- Other: Ceiling fans, pool pumps, home security systems, vacuum cleaners, water bed heaters, aquaria, ground-fault circuit interrupters, hardwired smoke alarms, doorbells, well pumps.

Altogether, approximately 5 billion MELs* are in the 115 million U.S. households, i.e., more than 40 in an average household.^{2,3} Relative to prior estimates,⁴ the most recent estimate for the installed base of MELs is about 150% greater than in 1976 and 45% greater than in 1995.

The large increase in MELs has important ramifications for residential energy consumption beyond their direct impact on household electricity consumption. The heat consumed by MELs is dissipated indoors, which alters home heating and cooling loads, i.e., per the “Residential Cooling and Heating Load Calculation” chapter of the 2005 ASHRAE Handbook—Fundamentals.

Overall, the net effect is a decrease in the balance temperature for homes, decreasing heating loads and increasing cooling loads. Furthermore, the combination of higher internal loads with increasingly tight homes (low infiltration of humid air) tends to increase the sensible heat ratio experienced by air-conditioning systems.

Energy Consumption by Residential MELs

MELs consumed about 298 TWh of electricity, equal to 3.2

quads of primary energy in 2006.[†] This represents about 24% and 16% of U.S. residential electricity and U.S. primary energy consumption, respectively. Consequently, MELs account for a larger portion of residential electricity consumption than any other end use (Figure 1) and the second largest portion of residential primary energy consumption (about half of space heating).^{2,3}

In the average household, MELs consume just under 2,600 kWh per year. Although the average household has more than 40 MEL devices, a few devices dominate MEL electricity consumption (Figure 2). Specifically, televisions, PCs (including monitors and peripherals), set-top boxes, audio equipment, and ceiling fans account for a bit more than half of residential MEL energy consumption.²

Many MELs consume energy in multiple operational modes. Originally, most devices only consumed electricity when they were turned on. Today, most consumer electronics and an increasing number of other MELs, such as toasters and coffee makers,⁵ also consume energy when they are turned off and still plugged in. This operational mode is often referred to as standby mode. Typically, devices continue to draw some power in standby mode to display information and to enable the device to turn on in response to a signal from a remote, although the actual power draw in standby mode depends greatly upon the power electronics as well as the functionality provided. Overall, standby mode accounts for approximately 13% of residential MELs’ electricity consumption, but can account for the majority of the electricity consumed by some types of equipment, such as set-top boxes, audio equipment, and video equipment.²

In addition, some consumer electronics, notably PCs, monitors, printers, and copiers, can enter a low-power sleep (or even off/standby) mode after a period of inactivity via a power management function. Entering a low-power mode can decrease PC or monitor power draw by more than an order of magnitude and, as such, can realize significant savings. Often, however, power management features are not enabled and, consequently, sleep mode accounts for less than 1% of total MEL electricity consumption.²

Trends

Clearly, MEL electricity consumption has increased dramatically over the past few decades. Although prior estimates for MELs electricity consumption have significant uncertainty,

*Excluding indoor portable and outdoor lighting considered in TIAx (2008) and grow and halogen lights, torchiere lamps, and furnace fans considered in Sanchez et al. (1998).^{2,4}

†Excluding indoor portable and outdoor lighting considered in TIAx (2008).²

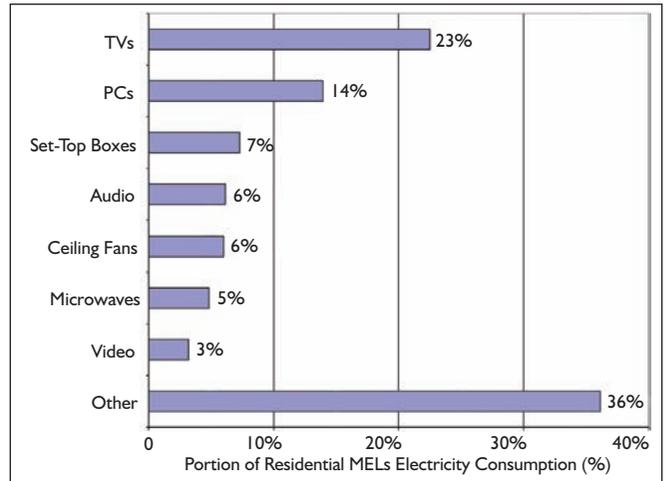
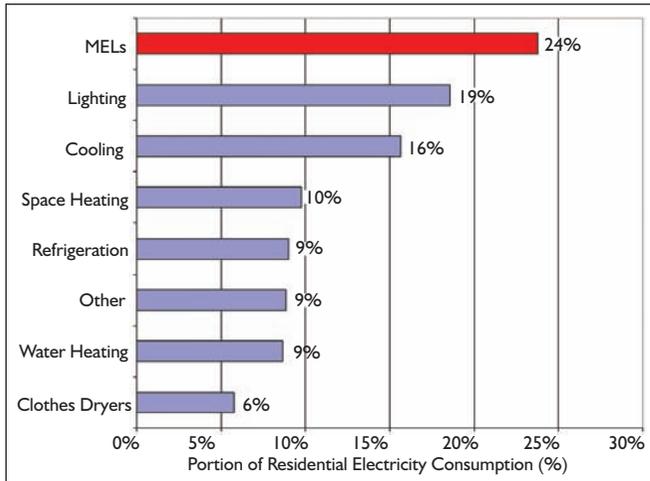


Figure 1 (left): U.S. residential electricity consumption by major end uses in 2006. Figure 2 (right): MELs consumption by device.^{††}

most notably in estimates of annual operating usage, a comparison of the most recent estimate for MEL electricity consumption with a study done ten years ago⁴ suggests that MEL electricity consumption per household in 2006 is approximately 2.2 and 1.3 times greater than in 1976 and 1995, respectively.

Predicting the future trajectory of residential MEL electricity consumption is challenging, in large part due to the rapid changes in the characteristics of consumer electronics (which currently account for more than half of MEL electricity consumption). The U.S. Department of Energy's Energy Information Administration projects that residential MELs will continue to grow briskly and account for approximately 36% of residential electricity consumption circa 2020.³ On the other hand, scenario-based, bottom-up projections for key MELs predict more moderate growth in key MELs over the same period, with the potential for per household MEL electricity consumption to actually decrease in a high-efficiency scenario.²

Important trends that will influence the future electricity consumption of MELs include: growth in display sizes and installed base (TV, monitors, and other displays), potential deployment of high-efficacy display technologies, future voluntary and mandatory standards for consumer electronics energy consumption (including requirements to enter low-power modes), continued growth in the number of devices with features that require a stand-by mode, networking of more devices (in turn, increasing their time on), and further growth in portable devices (which typically consume much less electricity than nonportable devices).²

Finally, in low-energy homes, i.e., homes with a high-performance building envelope, fenestration, space-conditioning and water-heating equipment, lighting, and appliances, MELs can account for about half—or more—of household electricity

consumption.^{2,6,7} Consequently, MELs could be a major barrier to realizing low-energy homes in the future.

References

- Greenberg, S. and A.K. Meier. 1988. "The Much-Neglected 'Miscellaneous' Energy in Homes." *Proceedings of the ACEEE 1988 Summer Study on Energy Efficiency in Buildings*. American Council for an Energy-Efficient Economy.
- TIAX. 2008. "Residential Miscellaneous Electric Loads: Energy Consumption Characterization and Savings Potential in 2006 and Scenario-based Projections for 2020." Final Report by TIAX LLC to the U.S. Department of Energy, Building Technologies Program.
- EIA. 2006. "Annual Energy Outlook 2006 with Projections to 2030." U.S. Department of Energy, Energy Information Administration. Report #:DOE/EIA-0383(2006). <http://tinyurl.com/5dvvs4> (or www.scag.ca.gov/rcp/pdf/publications/1_2006AnnualEnergyOutlook.pdf).
- Sanchez, M.C., et al. 1998. "Miscellaneous Electricity Use in the U.S. Residential Sector." Lawrence Berkeley National Laboratory Final Report. LBNL-40295. <http://tinyurl.com/5nzt43> (or <http://enduse.lbl.gov/Info/LBNL-40295.pdf>).
- Nordman, B. and J.E. McMahon. 2004. "Developing and Testing Low Power Mode Measurement Methods." PIER Project Final Report prepared for the California Energy Commission (CEC). Report P-500-04-057. <http://tinyurl.com/5h4jmd> (or www.energy.ca.gov/reports/2004-10-13_500-04-057.PDF).
- Anderson, R. 2007. Personal communication. "Building America Stage 1 Technology Packages and Critical Path Performance Specifications." National Renewable Energy Laboratory.
- Hendron, R. and M. Eastment. 2006. "Development of an Energy-Savings Calculation Methodology for Residential Miscellaneous Electric Loads." *Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings*. <http://tinyurl.com/6ejn8a> (or www.nrel.gov/docs/fy06osti/39551.pdf).
- Cymbalsky, J. 2007. Personal communication. U.S. Department of Energy, Energy Information Administration. June.

^{††}Percentages shown in Figure 1 are calculated based on the sum of non-MELs end use—specific values in EIA (2006) and MELs values from TIAX (2008). The difference between this sum and the top-down value for total residential electricity consumption from EIA (2006) is likely due to uncertainties in the electricity consumption estimates for all end uses.^{2,3,8}

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