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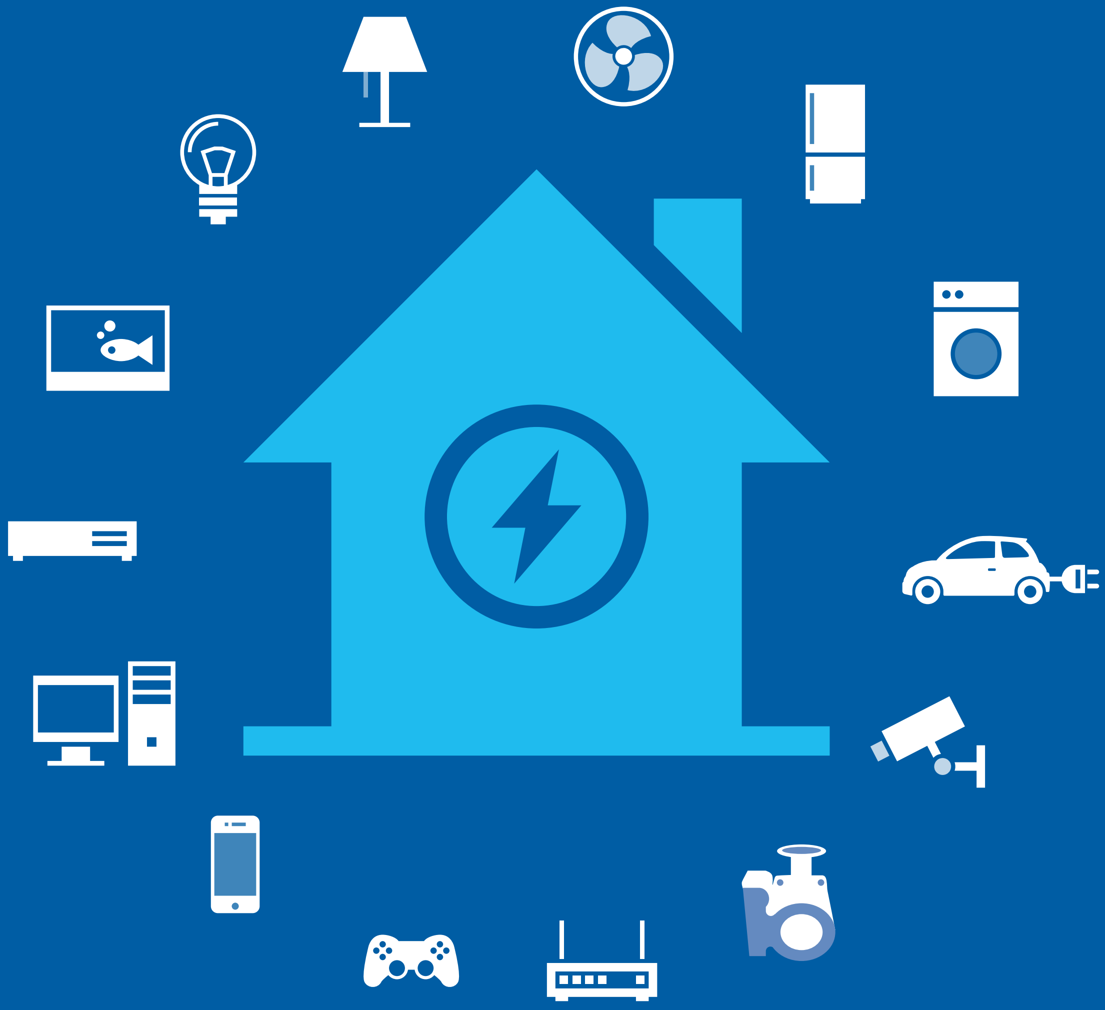
Home Idle Load:
Devices Wasting Huge Amounts of Electricity When Not in Active Use



NRDC

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About NRDC

The Natural Resources Defense Council (NRDC) is an international nonprofit environmental organization with more than 1.4 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, San Francisco, Chicago, Bozeman, MT, and Beijing. Visit us at www.nrdc.org and follow us on Twitter @NRDC.

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EXECUTIVE SUMMARY

ALWAYS-ON BUT INACTIVE DEVICES MAY COST AMERICANS $19 BILLION AND 50 POWER PLANTS' WORTH OF ELECTRICITY ANNUALLY

There has been a veritable explosion in the number of electronics, appliances, and other equipment plugged into, or permanently connected to, America's homes—65 devices on average in our study. Most are consuming electricity around-the-clock, even when the owners are not using them or think they have been turned off. This always-on energy use by inactive devices translates to approximately $19 billion a year—about $165 per U.S. household on average—and 50 large (500-megawatt) power plants' worth of electricity.[1]

Idle load or "baseload" consumption includes appliances and equipment in off or "standby" mode but still drawing power; in "sleep mode" ready to power up quickly; and left fully on but inactive. Much of this always-on energy provides little or no benefit to the consumer because most devices are not performing their primary function and home occupants are not actively using them.

All this electricity consumption contributes to the 1,375 billion kilowatt-hours of electricity used in U.S. homes annually and the nearly 1 billion tons of carbon dioxide pollution—15 percent of all U.S. greenhouse gas emissions—from burning fossil fuels to generate it every year.[2,3,4]

But if all homes in the United States reduced their always-on load for devices not being actively used to the level that a quarter of the homes in our study have already achieved, it would:

- **save consumers $8 billion on their annual utility bills;**
- **avoid 64 billion kilowatt-hours of electricity use per year; and**
- **prevent 44 million metric tons of carbon dioxide pollution, or 4.6 percent of U.S. residential sector carbon dioxide (CO_2) emissions from electricity generation.[5]**

To put this into perspective, the amount of saved electricity is the same amount consumed by all the residents of Arizona and Alabama in one year.[6]

The Natural Resources Defense Council partnered with Home Energy Analytics and the Stanford Sustainable Systems Lab to assess the impact of the growing cohort of always-on devices on consumer utility bills. We combined an analysis of usage data from electric utility smart meters with field measurements focusing on idle loads.

We found that idle load electricity represents on average nearly 23 percent of household electricity consumption in northern California homes.[7,8] Although the survey was conducted in California, always-on energy use is likely to be similar across the country because devices responsible for always-on loads do not vary significantly by region. However, they may represent less than 23 percent of total electricity use in regions with higher overall electricity consumption than California.

In this study, we define home idle load as the lowest power level of a home determined by utility smart meter hourly measurements. Home idle includes both continuous loads (always-on) such as devices that never go to sleep even when unused, and some share of non-continuous (intermittent) loads that need to cycle on and off regularly, like the refrigerator keeping food cold. The focus of this report is on the always-on part of idle. Early estimates, a decade or more ago, suggested that this always-on consumption might be 10 percent of total usage,[9] and a more recent report in 2010 estimated 20 percent.[10]

One reason for this latest finding of 23 percent is that many previously purely mechanical devices have gone digital: Appliances like washers, dryers, and fridges now have displays, electronic controls, and increasingly even Internet connectivity. In addition, conveniences like heated towel racks, toilet seats, and bathroom floors are growing in popularity and many continue to draw significant amounts of power when no one is using them.

Annually, always-on but inactive loads like these add 1,300 kilowatt-hours, or $165 to a household's electricity bills using the average national rate, and as high as $440 using the local utility's top tier-rate.[11]

Methodology

Our analysis used three sources of data from northern California to evaluate home idle load, with varying levels of detail: The largest data set of 70,000 homes contained only smart meter energy use data, with no other information on the homes or their occupants. It was used to calculate the 23 percent always-on share of total consumption. Roughly half of the homes were in a mild climate zone along the Pacific coast, and the remainder were in a more severe climate zone inland, but results did not vary significantly by location, ranging from 21 percent in inland climates to 24 percent along the coast.[12,13]

A smaller sample of 2,750 San Francisco Bay Area homes included information such as home size, age, and number of occupants and was used to better understand how idle load is influenced by these factors. Finally, we visited and performed a detailed audit of a subset of 10 Bay Area homes to identify which devices were responsible for the idle loads of the homes, evaluate their contributions, and assess opportunities for energy savings.

The results showed that idle load varied—sometimes dramatically—between homes of the same size, and between homes of similar age and number of occupants. This large variation suggests that purchasing more efficient products, or operating the same products in a more efficient manner, could yield significant energy savings in homes with higher-than-average idle loads. The huge array of devices that contribute to idle load today also indicates that a policy approach focused only on the largest uses would not be sufficient for substantially reducing idle load.

OTHER KEY FINDINGS:

- The average always-on load across the 70,000 northern California homes in the Stanford data set was 164 watts, or about 1,300 kilowatt-hours annually per home. This represents 23 percent of annual electricity consumption, on average, across the homes in the study. To put it another way, having 164 watts always on is the same as brewing 234 cups of coffee every single day for a year, which is more than 85,000 cups of coffee.[14]
- The in-depth audit of 10 San Francisco Bay Area sample homes showed there was an average of 65 electrical devices per home, 53 plugged-in and another 12 permanently connected to the home, such as furnaces and ground fault protected outlets. Of these 65 devices, around two-thirds (43) drew more than 1 watt of power each in the home's idle state.
- The largest electricity uses (heating and cooling, lighting, and refrigeration) accounted for just 15 percent of always-on electricity consumption. Consumer electronics (televisions, computers, printers, game consoles, etc.) accounted for 51 percent, with the remaining 34 percent attributed to other miscellaneous electrical load (MELs) such as recirculation pumps, fishponds, aquariums, and protected outlets in bathrooms, kitchens, and garages.
- Idle load varied widely, depending on device models. For instance, the idle load of printers ranged from 2 to 26 watts per home, and cordless phones from 1 to 12 watts.

WHAT'S TO BE DONE?

Fortunately, much can be done to significantly reduce always-on energy waste, both directly by consumers and device manufacturers and indirectly through policy action such as energy efficiency programs and standards.

A great deal of idle-load energy can be saved through no-cost or low-cost actions by motivated consumers, once they are informed about how energy and money are being needlessly wasted. These actions include identifying home devices that are always on even when unused; unplugging those that are rarely used, such as televisions and set-top boxes in guest rooms; and plugging others into power strips and timers, or "smart outlets," so that they draw power only when needed. Power settings also can often be adjusted on electronic devices so they automatically power down when unused.

However, few consumers will act unless they are alerted to energy waste and the steps to eliminate it. This is an opportunity for utility efficiency programs to make consumers more aware of their idle energy use and ways to curb it.

Ultimately, manufacturers should design all products with the goal of minimizing idle power so that consumers don't have to worry about idle energy waste and can purchase any device trusting that it will work efficiently, just as they believe minimum safety standards for other products, like vehicles, will protect them. Historically, many manufacturers rush products to market without optimizing energy use and, in particular, idle load. The solution lies in enacting energy efficiency standards so all devices minimize idle energy consumption, depending on the functions they perform in standby. Although there are some minimum efficiency standards that cover idle load energy consumption today, most products that contribute to idle load are not included.

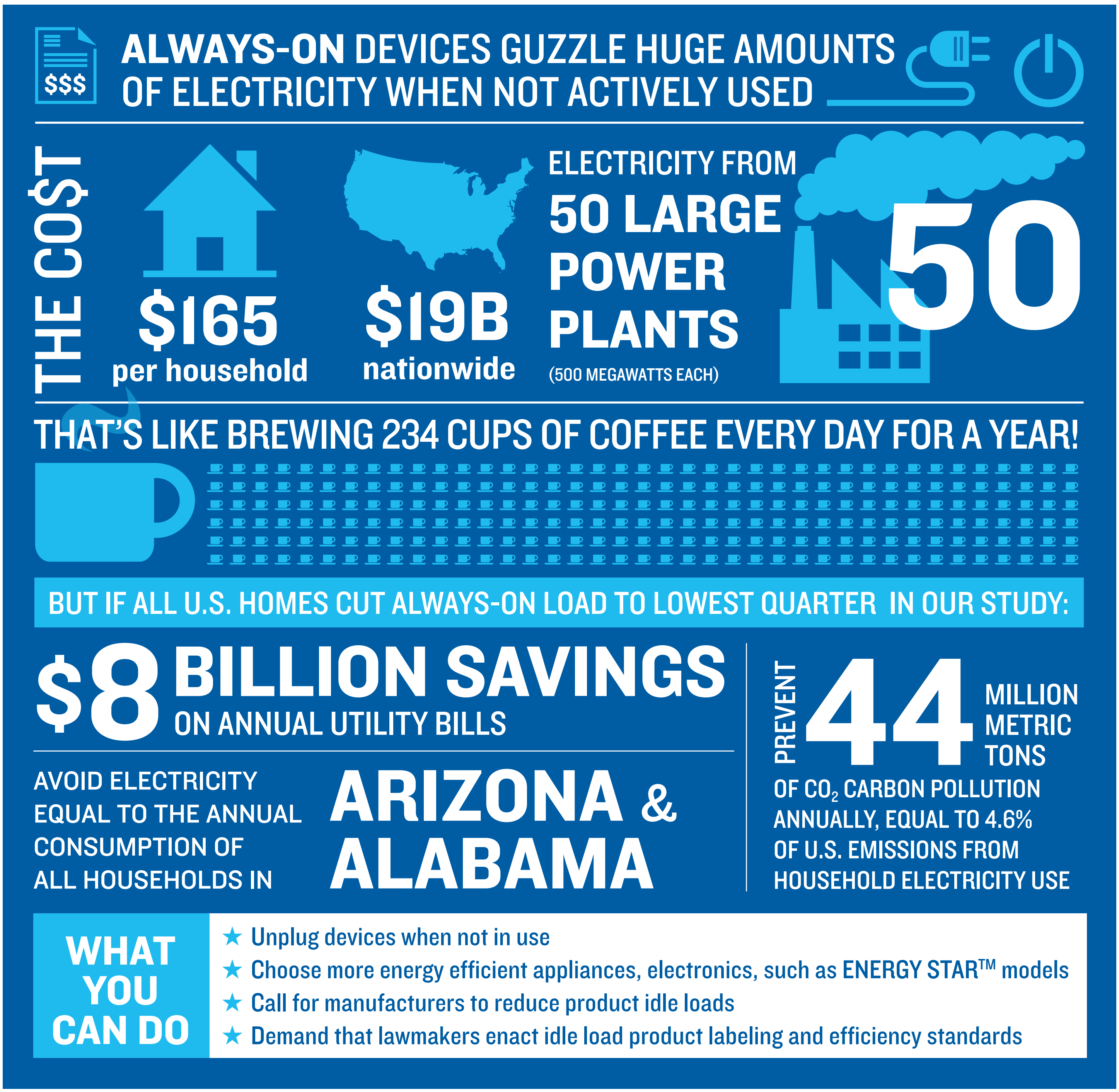
Requiring manufacturers to disclose idle load electricity use on consumer labels (e.g., "This product consumes 10 watts in standby, which may cost you $50 to $130 in electricity over five years") also would make consumers more aware of how their shopping choices can reduce their home electricity bills.

Ensuring that electronics, appliances, and other equipment consume only as much energy as necessary when unused presents a huge opportunity to save energy and money. The technology exists to do far better than having nearly 23 percent of Californians' electric consumption powering devices not being actively used. Eliminating this energy waste also decreases the number of fossil fuel–burning power plants necessary to generate electricity, thereby reducing harmful air pollutants and carbon emissions that threaten our health and the environment.

Given that these plants account for nearly 40 percent of U.S. carbon pollution, smarter energy use can have a measurable impact on overall emissions. It also would help states comply with emissions reduction targets under the government's Clean Power Plan, which would set the first-ever limits on this dangerous pollution. In addition, optimizing energy use helps eliminate the need to build new expensive energy infrastructure, saving utilities and their customers money.

In the meantime, consumers can take these steps in their homes and businesses:

1. Optimize the efficiency of their current devices;
2. Buy more efficient appliances, electronics, and miscellaneous devices, such as those labeled ENERGY STAR™, whether replacing old ones or purchasing new types;
3. Urge lawmakers to enact idle load labeling so shoppers can avoid products that have high idle loads; and
4. Insist that all devices be required to meet idle load efficiency standards so there is no need to worry about models needlessly wasting energy, the same way regulatory mechanisms ensure that our vehicles are safe to drive and foods are safe to eat.



STUDY OBJECTIVES

Past studies of residential electricity consumption have estimated "always-on" or "standby" consumption to represent between 10 and 20 percent of total home electricity use.[15,16] However, the increase in the number of devices in homes; the shift from appliances with purely mechanical controls to ones with digital displays and controls; and the new, always-on electrical consumption associated with network connectivity in the growing number of Internet-connected devices, from TVs to refrigerators to light bulbs, all suggest that idle energy may be increasing.

Always-on load is an important issue because by definition it is the energy consumed when devices are unused—and therefore providing little value to the owner. A general principle of energy efficiency is that a device should draw only as much power as the task at hand requires. In idle state, most devices are not providing their primary function. For example, a cable or satellite TV set-top box draws nearly as much power in the middle of the night as when recording or playing a show. When unused, devices should be in very-low-power mode, consuming just enough energy to perform their limited tasks in these modes, such as waiting for reactivation from a remote control, voice, or network signal. Existing technology can do this using very little power, and its implementation across all devices that draw electricity in our homes presents an opportunity for large reductions in customers' utility bills and in the carbon pollution caused by the electricity-generating power plants across the nation.

Several field studies have been conducted on plug-in equipment energy use in recent years: Chetty et al. 2008,[17] Bensch and Pigg 2010,[18] Baylon et al. 2012,[19] Greenblatt et al. 2013,[20] Kwatra et al. 2013,[21] etc. However, most of these studies focused on the total energy consumption of individual devices, such as TVs, computers, or game consoles. Few separated out the energy consumed when devices were unused (idle or standby) and those that did, evaluated only specific devices, not the entire home. Therefore, there is limited understanding of the overall idle load in U.S. households.

To help address this gap, NRDC partnered with Home Energy Analytics and the Stanford Sustainable Systems Lab to combine smart meter data analysis with field measurements focusing on idle loads. The study aimed to:

- develop an estimate of total idle power (in watts) and annual idle energy use (in kilowatt-hours per year) on a household and national basis;
- identify which products in the home are consuming idle power;
- assess the range of household idle load energy that was observed and estimate the savings that could be achieved if best practices were adopted; and
- develop a set of recommendations, aimed at consumers and policymakers, for reducing idle loads.

Smart meter data analysis is a new way to measure and analyze at a scale and accuracy level not previously possible. The recent deployment of smart meter technology by many American utilities offers new insights into the electricity consumption of homes. As of July 2014, 50 million smart meters had been installed in the United States, covering more than 42 percent of all households.[22] This new technology measures the electricity consumption of individual dwellings at hourly intervals (or more frequently), providing valuable insights into electricity usage patterns of millions of U.S. consumers for the first time. Among other things, the analysis of this new data reveals how much energy is consumed by homes when occupants are asleep or away.

This study focuses on residential idle electricity, commonly referred to within the electric power sector as baseload, and highlights the always-on portion of it. However, many of the findings apply to office buildings and other commercial sectors as well, because they use much of the same or similar equipment. Also, given our budget and time constraints, this study focuses on electricity consumption alone and does not include natural gas or other heating fuels. Heating fuels have idle loads of their own, such as pilot lights, older hot water heaters, and particularly hot water recirculation pumps that waste both electricity and heating fuel.

METHODOLOGY

DEFINITIONS

This report uses various terms to describe the power state, or operating mode, of homes and devices within them. There is no universally accepted standard terminology, so this report uses the following definitions:

Device On: The device is providing its primary function. This can be further subdivided into "on-active" when the home occupant is actively using the product, and "on-inactive" when the device is on but the occupant is not operating the product. For example, a TV is in on-active mode when people are watching it, and on-inactive when it is showing a program but no one is watching it (and it could be switched off with no impact on the user).

Device Sleep: This includes all low-power modes in which the device is using less power than in on mode, but more than in off/standby mode. For the sake of simplicity, this includes the following sub-modes grouped together under "Sleep": modes in which the device can resume its primary function in a shorter period of time than in standby, such as "instant on" or "quick start" on TVs; modes in which devices remain connected to the network while in a low-power mode, such as "connected standby" on game consoles; and modes in which a device can be reactivated by a trigger other than remote control, such as a network trigger ("networked standby") or a voice command (as for Microsoft's Xbox One).

Device Off/Standby: The device is in the lowest power state in which it can be reactivated by a button or remote control.

Home Idle: This is the total power used by all devices in the home—whether in off/standby, sleep, or on mode—at the time when the home reaches its lowest power level over a month, as measured by hourly smart meter data. Home idle includes continuous (always-on) loads, as well as some share of intermittent loads (like refrigerators) captured by hourly smart meter reading.

Home Active: This term covers all times when the home is not in its minimum power mode and some devices are being used.

Figure 1: Home Idle and Active Modes

HOME IDLE

HOME ACTIVE

ALWAYS-ON LOADS

Continuous power use by:

- Devices consuming power even in "off" or "sleep" mode
- Devices left on overnight (e.g., set-top boxes, computers, printers)
- Infrastructure appliances using power continuously, such as GFCI outlets

INTERMITTENT LOADS

Power use by devices that are not always-on, but are active frequently enough for some of their energy use to be captured by the lowest hourly smart meter measurements, such as:

- Refrigerators and freezers
- Furnaces and air-conditioners
- Aquarium heaters
- Humidifiers/dehumidifiers

ACTIVE LOADS

Power use by devices when actively used, such as:

- Lighting
- Kitchen and laundry appliances
- TVs, computers, and other consumer electronics

Note: GFCI (ground fault circuit interrupter) outlets are those with a green LED and Reset/Test button, found in bathrooms, kitchens, garages, and outdoor locations as required by the electrical code.

DATA SOURCES

We used three sources of data to analyze idle loads. First, we partnered with the Stanford Sustainable Systems Lab, which analyzed usage data from 70,000 Pacific Gas & Electric (PG&E) customers, including homes both in mild coastal climates and in more severe inland Central Valley climates. This analysis used hourly smart meter data for the entire home. It contained no device-level data nor any socioeconomic information, but it allowed us to estimate the idle load share of total electricity for a large sample. The second data set, analyzed by Home Energy Analytics, contained whole-house hourly information for 2,750 Bay Area homes. This didn't contain device-level information either, but it had some additional information on each home such as size, number of occupants, and age of the home, which allowed us to analyze the influence of each factor on idle load. Last, we performed detailed energy audits in 10 homes to better understand which devices contributed to the home idle load. This included taking an inventory of all electrical devices, plugged-in and hardwired, and taking power measurements in idle mode for as many of these devices as possible.

Table 1 summarizes these three sources of data.

These data sets are not meant to be statistically representative of the United States or even California. However, they are large enough to provide valuable insights into the magnitude and causes of home idle energy consumption.

HOW HOME IDLE WAS CALCULATED

By measuring electric power use every hour, or sometimes every 15 minutes, smart meters offer a new and convenient way to determine household-level idle loads for all homes in a utility's service territory, without requiring household visits. To determine idle load from smart meter measurements, we looked for the lowest daily meter reading for each home that occurred frequently over each month, excluding outliers possibly caused by missing data or temporary service interruptions. We took the minimum reading over one month because on any single day, there may be one or a combination of loads that are active throughout the day, such as if not all occupants are asleep at the same time, and if there is always someone at home during the day. This is very unlikely to occur over an entire month. We call this metric "Monthly Minimum Hourly Power" (abbreviated as Minimum Power henceforth). For the purpose of this report, we averaged this monthly minimum over a period of 12 months to derive a single value per home, independent of seasonal variations.

This Minimum Power metric includes all continuous or always-on loads, as well as some non-continuous or intermittent loads that are active often enough to be recorded on all minimum hourly intervals. The largest intermittent loads that are partially captured in the minimum power metric are compressor refrigeration appliances, such as refrigerators and freezers. Other intermittent loads that

Table 1: Three Data Sets Used in This Study

Source	Sample Size	Description	Value
Stanford Sustainable Systems Lab smart meter data set[23,24]	70,000 northern California homes	Sample of PG&E customers from two climate zones: zone 3 (coastal, including San Francisco) and zone 13 (Central Valley, including Fresno), covering the period from August 2010 to July 2011.	Minimum Power metric as a share of total power consumption, but no other information (such as home size)
Home Energy Analytics smart meter data set	2,750 Bay Area homes	Smart meter data with additional appliance information provided by home occupant via the Home Energy Analytics (HEA) web application. The data for each home covered the 12-month period preceding the date when the resident joined the HEA program, in order to provide a baseline before program intervention. The data set spans November 2009 to October 2014.	Information such as home size, age, and number of occupants, used to better understand how idle load is influenced by these factors
Comprehensive home audits	10 Bay Area homes	Detailed on-site investigation of the idle load of selected homes (manual, labor-intensive process). Audits performed in September 2014.	Insights into which devices are responsible for the majority of home idle load

may cycle on and off very frequently include furnaces and air conditioners, aquarium heaters, poorly insulated hot water heaters, wine coolers, covered in water heaters, and not that common anyway, particulate filters, dehumidifiers, humidifiers, air fresheners, sump pumps, attic fans, and dog bed heaters. Some intermittent loads clearly need to operate 24/7, such as refrigerators. They can be made more efficient, but their energy consumption cannot be reduced as dramatically as always-on loads. Rough estimates suggest that intermittent loads represent between 20 and 30 percent of the Minimum Power metric in northern California, on average, as shown in Appendix A. **We therefore discounted Minimum Power by 25 percent to estimate a home's always-on load, excluding intermittent loads.**

Our data were limited to northern California. Idle load may be higher in harsher climates, cold or hot, where HVAC (heating, ventilation, and air-conditioning) systems, electric blankets, engine warmers, and other heating- and cooling-related loads may be active throughout the day and night. However, devices responsible for idle load in mild climates are also found in more severe climates because people tend to buy similar appliances, electronics, and other devices everywhere. The higher heating and cooling loads found in cold and hot climates would only add to the idle loads identified in northern California by this study.

Northern California homes also use natural gas as the primary fuel for water and space heating. The average U.S. home would use a higher proportion of electricity for water and space heating than the homes in our study, resulting in a higher total electricity use. Idle may therefore be a lower *share* of total use outside of northern California, but we expect that the *amount* of idle energy use would be roughly the same.

There are other possible algorithms for calculating home idle, such as the average of daily minima (the lowest recorded smart meter reading each day) or a certain percentile of daily minima, and each potentially could yield a somewhat different idle load result for a given home. We chose the Monthly Minimum Hourly Power metric because we believe it provides a more realistic estimate of always-on load. Analyzing which metric provides the most relevant estimate of idle load using hourly smart meter data is beyond the objective of this report, but it is an important subject for further research, and we encourage government agencies and utilities to commission this work to define a standard algorithm and metric that can be used for energy policy purposes, such as setting idle load reduction goals and tracking progress.

KEY FINDINGS

HOME IDLE LOAD

Per research and analysis conducted by the Stanford Sustainable Systems Labs, idle load was 218 watts on average across the 70,000 homes in PG&E's service territory. We estimated the always-on share of this idle load to be 164 watts.

Over 22 hours of inactive use per day, this hourly consumption of 164 watts adds up to 1,300 kilowatt-hours of annual always-on energy use.[25] This represents **23 percent** of the average annual residential energy consumption of the PG&E customer homes analyzed, as shown in Figure 2.

Always-on but inactive devices cost the average northern California household **between $210 and $440** per year in electric bills ($210 using the lowest tier [Tier 1] local PG&E rate, and $440 using the top PG&E tier [Tier 4] for users whose monthly usage reaches the Tier 4 threshold, as explained in Appendix B). **This is between $1.30 and $2.60 in annual electricity cost for every watt of always-on load.**

The 70,000 homes analyzed in the Stanford data set were in two areas of PG&E's service territory shown in Figure 3: a coastal area including San Francisco, Oakland, and a large part of the Bay Area (California's climate zone 3, mild coastal climate) and a Central Valley area including Fresno (climate zone 13, inland climate), which has higher cooling and heating loads due to hotter summers and colder winters. The idle energy variations we observed between these two areas were relatively minor, with average idle load (including both always-on and intermittent) varying from 203 watts and 35.6 percent of total electricity use in the Bay Area to 233 watts and 31.0 percent of total electricity use in the Central Valley. Both idle and total electricity use are higher inland, but the difference in idle use is less than the difference in total use, the latter being driven largely by air conditioning in summer. Idle is therefore a lower share of the total inland. Factors other than climate, such as differences in disposable income, may also contribute to the disparity, but the lack of socioeconomic information in the Stanford data set precluded our ability to analyze this.

While this study was focused on northern California, we expect that idle loads are similar nationally. Using the average national rate of 12.5 cents per kilowatt-hour, always-on but inactive devices cost the average American household **$165** annually, which is roughly **$1.00** in annual electricity cost for every watt of always-on load.

Figure 2: Always-On Load Represents 23 Percent of Residential Energy Consumption in Northern California

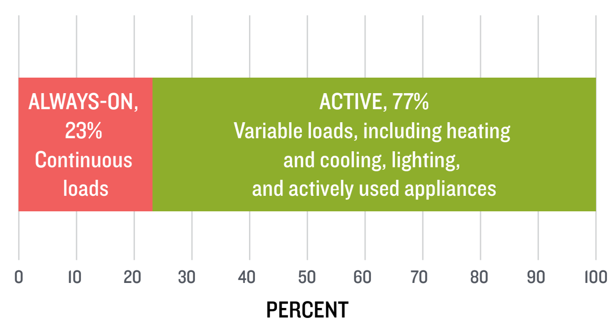


Table 2: Comparison of Idle and Total Electricity Consumption in the Two Climate Zones Analyzed

	Zone 3 (coastal)	Zone 13 (inland)	Average
Idle (watts)	203	233	218
Always-on (watts)	152	175	164
Always-on share of annual	**24.3%**	**21.1%**	**22.5%**
Total (kWh/y)	5,027	6,647	5,837

Figure 3: Location of Homes in Stanford Data Set

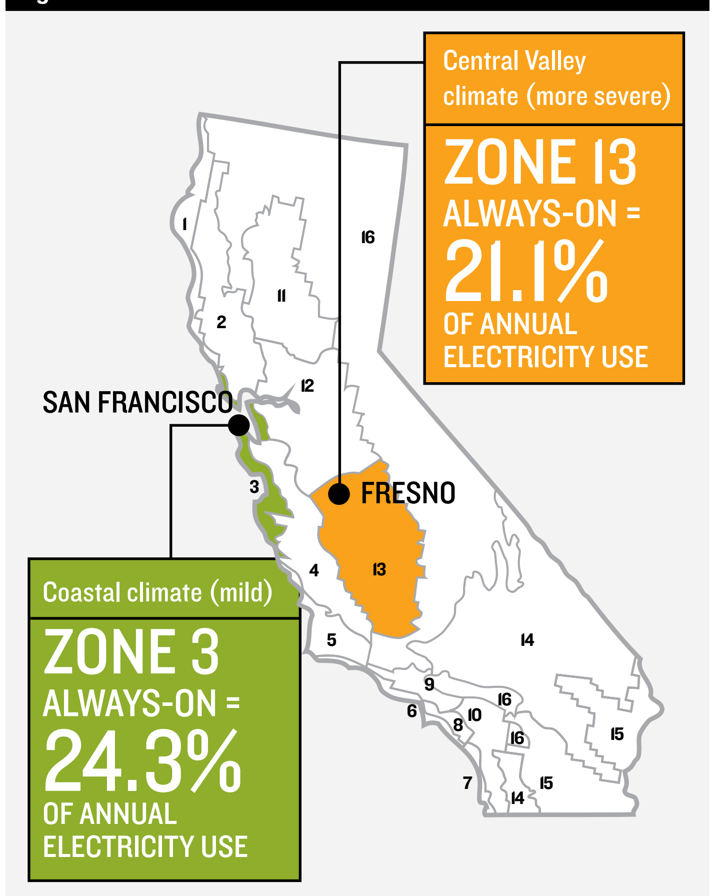
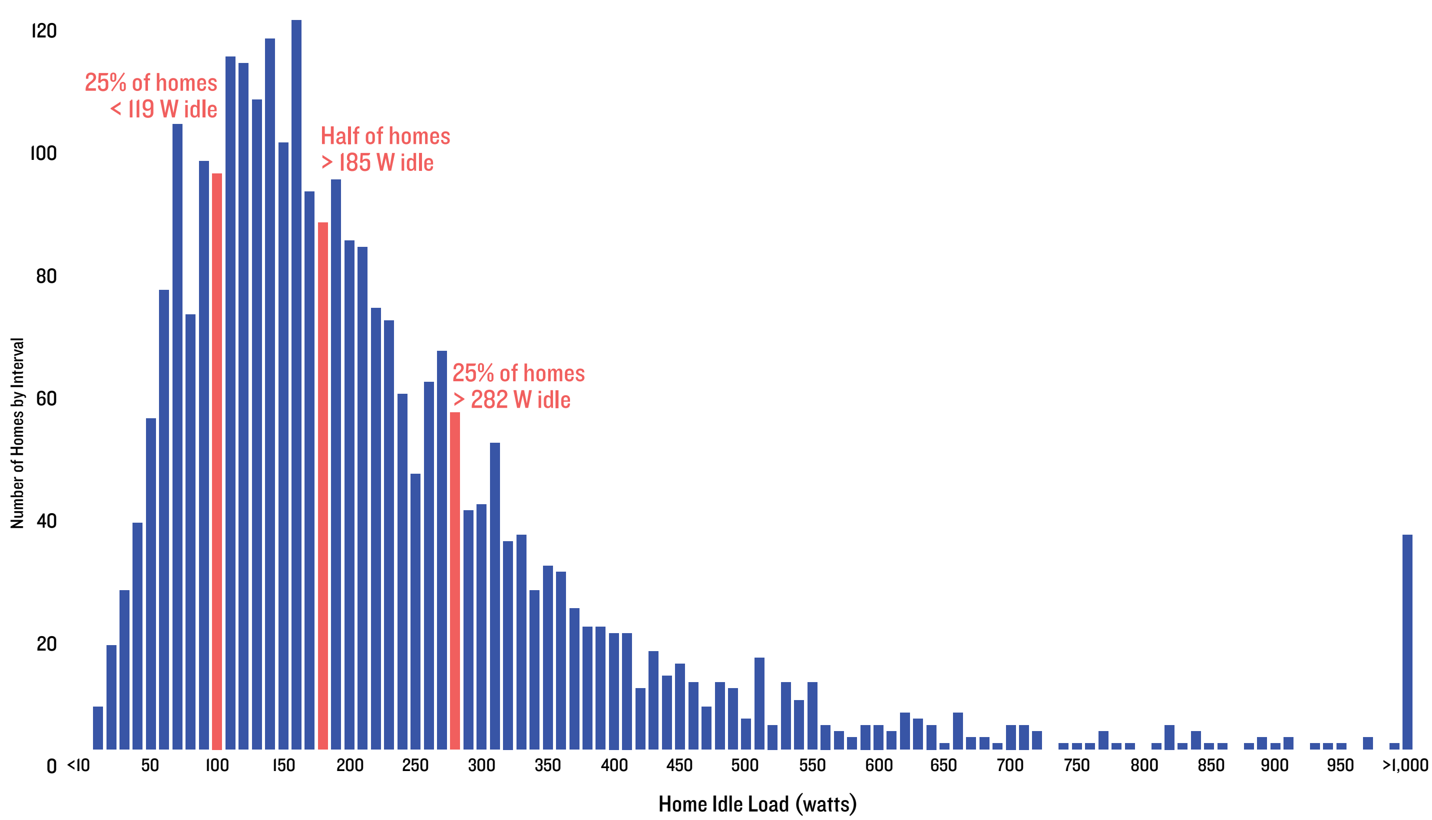


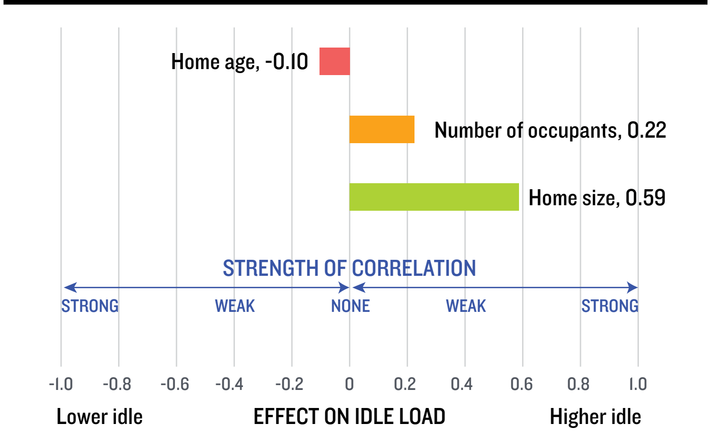
Figure 4: Distribution of Home Idle Loads in the Bay Area (Measured from Smart Meter Data for 2,750 Homes)



These averages conceal a large range of idle loads for the homes analyzed, as shown in Figure 4. Note that the analysis in the rest of this section is focused on the subsample of 2,750 homes in the Bay Area for which more detailed information was available than for the larger PG&E data set.

As Figure 4 illustrates, half of the homes in our sample consumed more than 185 watts in idle (which is equivalent to just over 1,600 kWh annually, or the yearly consumption use of three new medium-size refrigerators). One-quarter consumed more than 282 watts, and 1.3 percent of homes used a whopping 1,000 watts or more in idle. At the other end of the scale, about one-quarter of homes sipped less than 119 watts in idle.

Figure 5: Correlation of Factors Affecting Idle Load



How dependent is idle load on factors such as home size, age, and number of occupants?

In order to determine if there was a relationship between idle load and variables such as home size, age, or number of occupants, we analyzed correlations within the HEA data set that included this data for each home.[26] We found that idle load had little relationship with how recently a home was constructed, as shown in Figure 5. There was a slightly greater but still limited correlation with the number of occupants, and a more significant but still not very strong relationship to the size of the home. It would have been interesting to assess the effects of resident affluence, because this could well be a stronger driver of idle load. However, the available information did not allow us to do so. (Zip codes can be a proxy for income, but the HEA data set for 2,750 homes didn't have enough zip code diversity to analyze this, and the Stanford data set for 70,000 homes did not include zip code information with which to estimate median household income).

Idle load varied considerably even among homes of comparable size. Figure 6 shows that homes in the top quartile (the top 25 percent in idle load level out of 100 homes) used two to three times higher idle energy than homes in the bottom 25 percent), regardless of home size. Figure 7 illustrates the distribution of idle load normalized for house size.

The wide range of idle loads for homes of similar sizes suggests significant opportunities for reductions in those with highest always-on usage. If all homes in our sample had an idle load of 80 watts per 1,000 square feet (the benchmark that a quarter of the homes already achieve), idle energy would be reduced by 42 percent on average across all homes, and total residential electricity consumption would be cut by 14 percent.

While this analysis is focused on the Bay Area and is not statistically representative of the national condition, we believe it is relevant for the rest of the state and nation because consumers across the country buy devices similar to those in our northern California sample. Idle loads in other states may even be higher due to additional climate-related idle loads, and to the lack of appliance efficiency standards such as those in place in California for products with rechargeable batteries.

Nationally, if all homes reduced their idle load to 80 watts per 1,000 square feet, corresponding to an average reduction of 42 percent, it would save Americans **64 billion kilowatt-hours of electricity annually**, equivalent to the output of **21 large coal-fired power plants** (500 megawatts), avoiding **44 million metric tons of carbon pollution** while saving Americans **$8 billion** annually in electricity bills.

Figure 6: Idle Load Ranges by Home Size

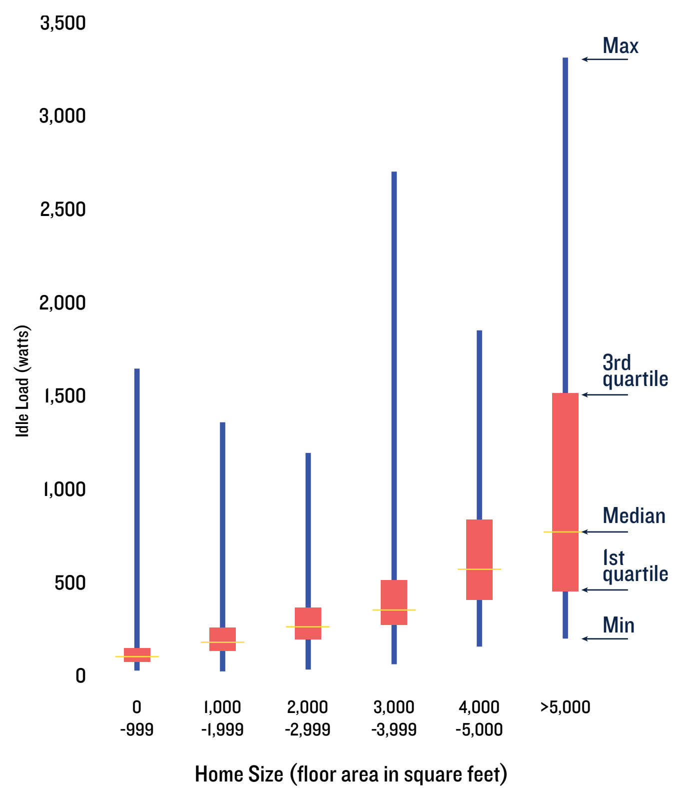
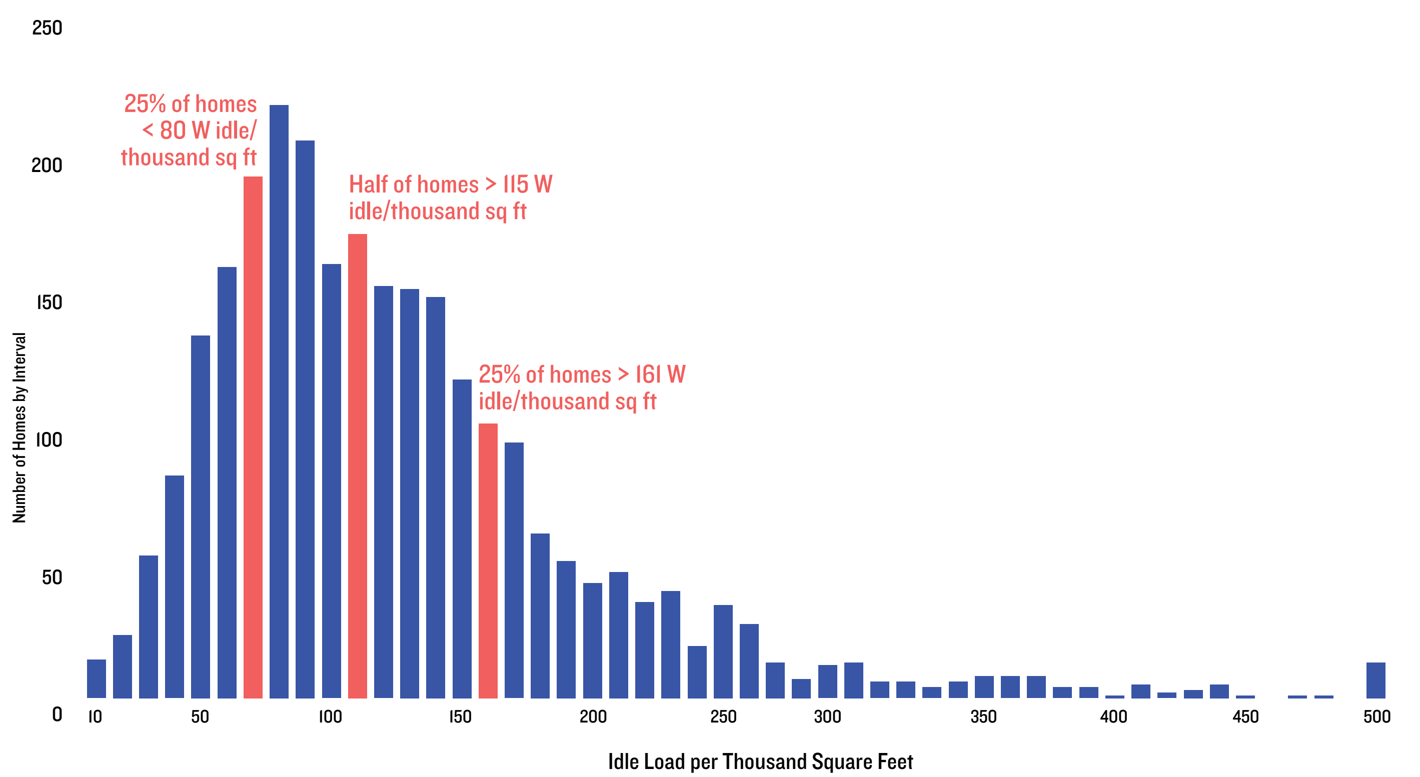


Figure 7: Distribution of Idle Load per Home Size (Measured from Smart Meter Data for 2,750 Homes)



DEVICE IDLE LOADS

To better understand which devices contribute to the idle load of homes and what can be done to reduce their energy consumption, a detailed audit of 10 Bay Area homes was performed. Six of the homes were chosen to represent a range of idle load intensities out of the 2,750 Bay Area homes in the HEA data set and are reasonably typical of average Bay Area homes. The other four are those of NRDC staff members, family, or other energy efficiency experts so they may have lower energy consumption and idle load than the Bay Area average. The sample includes both single-family and multifamily homes, and homes occupied by both owners and renters. While it is too small to be statistically representative, it provides insights about the number and types of devices that contribute to idle load. Appendix C provides more information on the characteristics of the 10-home sample and the nearly 650 devices found in them.

The auditor asked the occupants to place their homes in the state they typically leave it in when going to bed at night. Devices were then inventoried and their power measured in whichever state they were in: off/standby, sleep, or on. We call the power draw of the device in this state the **device's idle load**. Plug-in devices were measured using a power meter; hardwired devices were measured at the meter by switching the appropriate circuit breaker off and on, or estimated from separate measurements in the case of GFCI outlets. Devices that automatically power down after a period of inactivity were measured in their powered-down state. This may not represent the exact state of each device in home idle mode as measured by the Minimum Power metric, but we believe it is very close, especially for the major contributors to idle load in each home.

Figure 8 shows the idle load of one of the 10 homes as an example, illustrating the devices that each contribute an idle load of 1 watt or more when the home is in an idle state, such as when residents are asleep or away from home. (The idle loads of all 10 homes are shown in Appendix C.)

Audit Results: Example of One of the 10 Audited Homes

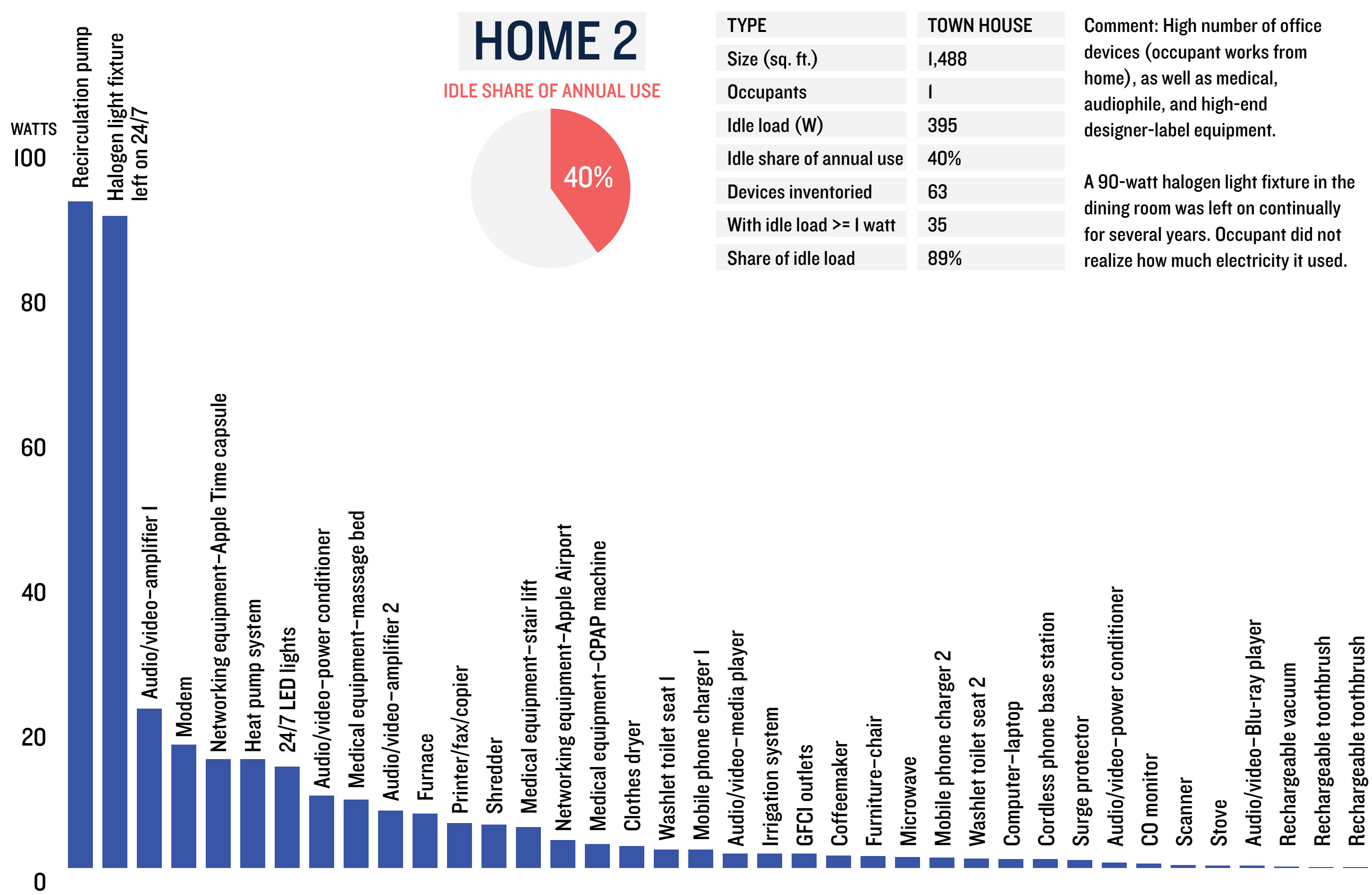
This home is a town house of typical size. Its idle load is higher than the average for the Bay Area (395 watts idle versus the average of 218 watts). However, this sample house is slightly below average for both the number of devices per home (63 vs. 65) and the number of devices with an idle load higher than 1 watt (35 vs. 43).

Figure 8: Idle Load of One of 10 Audited Homes

TYPE	TOWN HOUSE
Size (sq. ft.)	1,488
Occupants	1
Idle load (W)	395
Idle share of annual use	40%
Devices inventoried	63
With idle load >= 1 watt	35
Share of idle load	89%

Comment: High number of office devices (occupant works from home), as well as medical, audiophile, and high-end designer-label equipment.

A 90-watt halogen light fixture in the dining room was left on continually for several years. Occupant did not realize how much electricity it used.



In this home, the highest idle load identified is a recirculation pump used to keep water hot in pipes throughout the home, to reduce hot water wait times. This pump costs the resident $93 annually using U.S. average electricity rates, and the cost could be as high as $240 in the highest tier of the local utility's tiered rate. However, a recirculation pump does not need to be on 24/7, such as in the middle of the night when everyone is asleep, or during weekdays when no one is home. It can be put on a timer to only run at times when occupants are likely to use hot water, or it can be upgraded to an "on-demand" model.[27] This would save not only electricity, but also considerable natural gas (often used for water heating) by reducing significant heat losses in pipes during continuous hot water recirculation.[28] In other homes, other devices were the major idle loads, as shown in Appendix C.

This home's second-highest load, "24/7 lights," was a 90-watt halogen light fixture that was being left on continuously in the dining room. The occupant did not realize how much electricity it used. After being informed, he switched off the light for the periods when he was sleeping or away from home. Lighting is not typically included in a home's idle load, except in cases where the lights are left on continuously.

The other 33 devices contributing to the home's idle load collectively consumed 167 watts, or 42 percent of the home's total idle load.

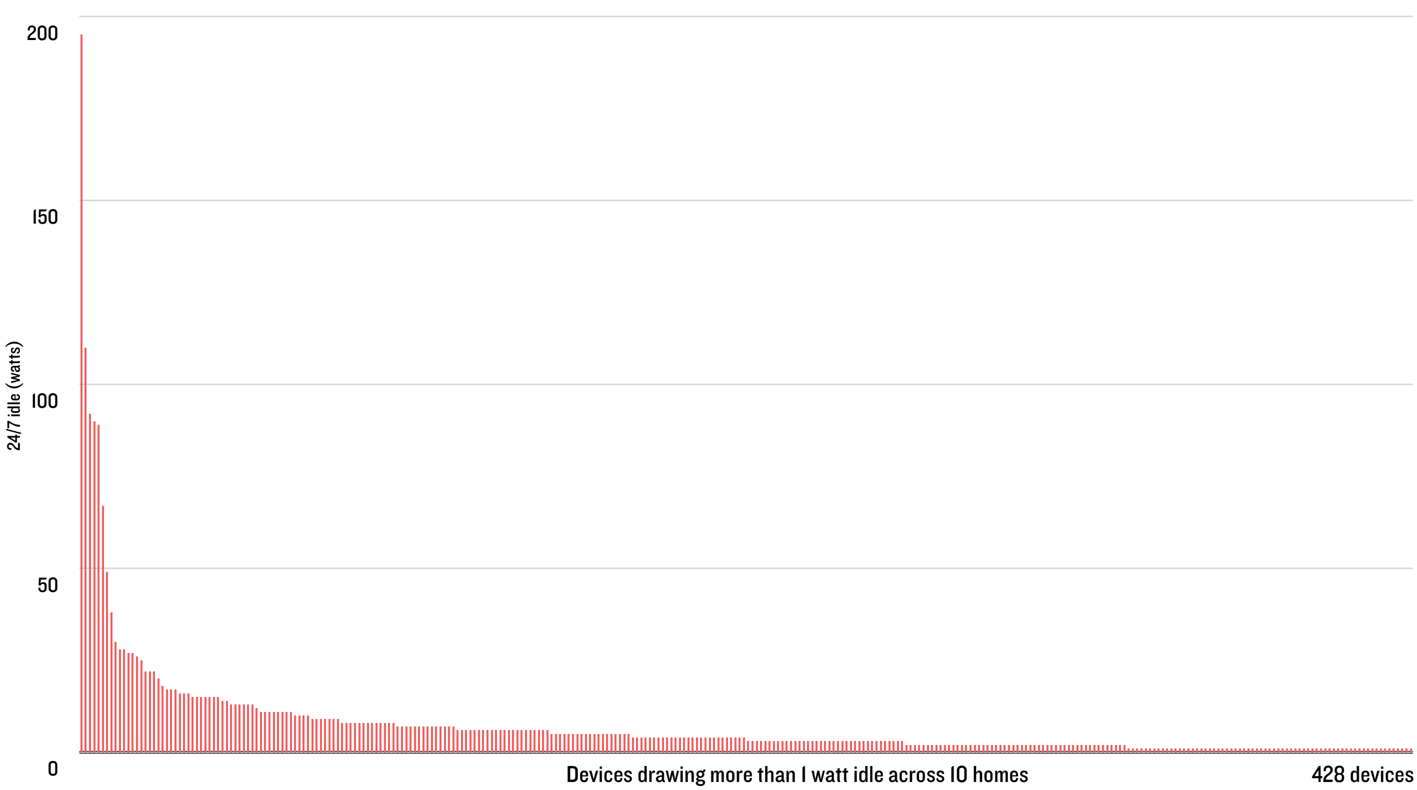
The audit accounted for 89 percent of the idle load measured from the smart meter. The other 11 percent may have been caused by refrigeration or by devices that were not identified during the audit. Across our 10-home sample, audits identified 70 percent of home idle measured from the meter.

Aggregate Results Across 10-Home Sample

The audits of 10 homes found an average of 65 electrical devices in each home: 53 plug-in devices and 12 items permanently connected to the building's wiring, such as GFCI outlets, furnaces, and air conditioners. Of the 65 devices, 43 drew at least 1 watt of power in the home's idle state. The actual number may be higher, however, because we were unable to measure every device in each home. For example, the plugs of some devices were inaccessible, and some residents asked us not to unplug certain equipment like set-top boxes, which prevented us from measuring that electricity use.

Across all 10 homes, we identified a total of 648 electrical devices, 428 of which drew 1 watt or more in idle. Six of those each drew more than 50 watts continuously. Another 350 devices each continuously drew 12 watts or less, but collectively were responsible for 43 percent of total idle load. Figure 9 illustrates the **"long tail"** of these miscellaneous devices—that is, the large number of devices that use little

Figure 9: Long Tail of 428 Idle Devices Contributing to 23 Percent of Residential Electricity Consumption in California

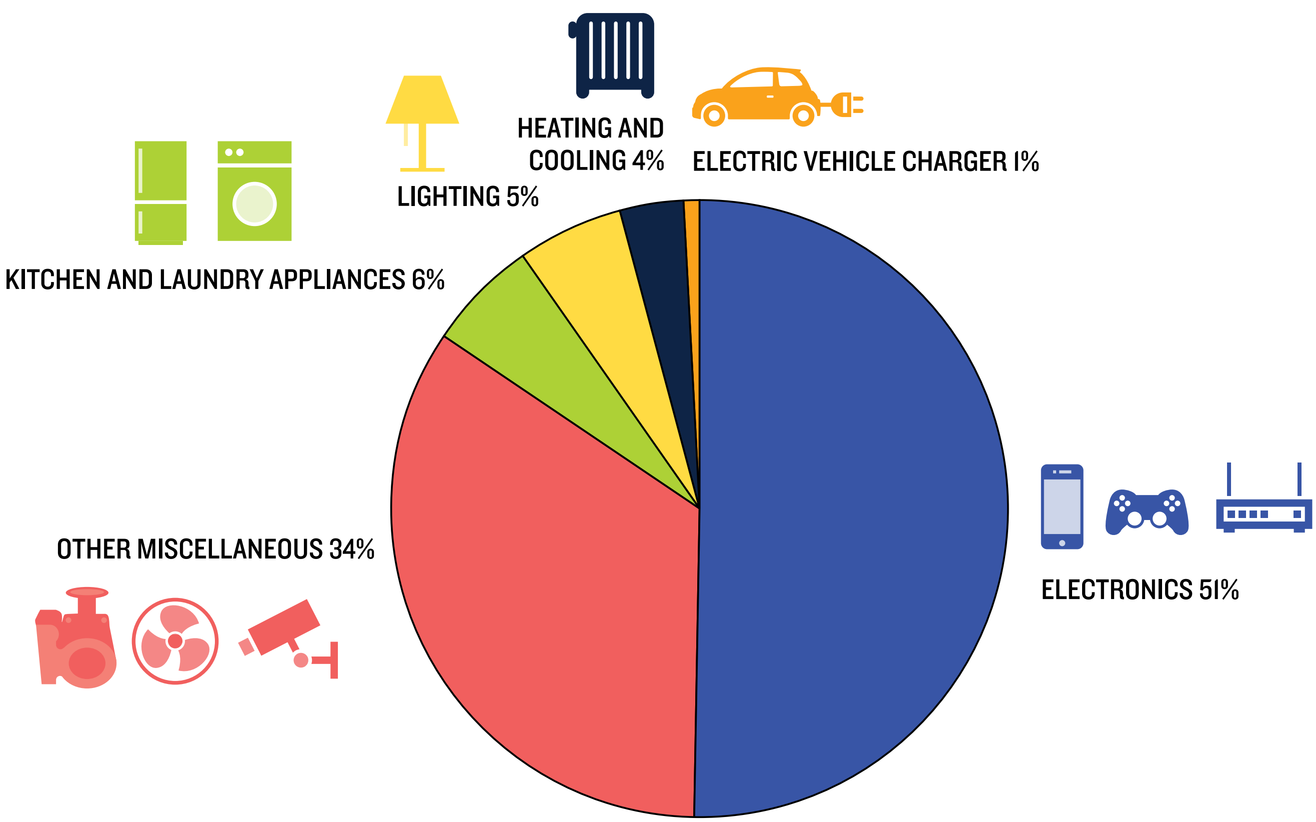


power individually when idle, but contribute to 23 percent of residential electricity consumption in California.

The 428 devices drawing 1 watt or more include many of the same type in each home, such as ground fault circuit interrupter (GFCI) or arc fault circuit interrupter (AFCI) outlets, external power supplies, etc. When grouping them by type, we ended up with 97 types of devices contributing to home idle load, which suggests that a "top offender" approach to efficiency programs and standards would not be effective at controlling idle load.

As shown in Figure 10, electronic devices, such as TVs, computers, and the gear connected to them, were responsible for half of the idle load on average. Large energy uses such as heating and cooling; lighting; kitchen and laundry appliances; and electric vehicle charging accounted for just 16 percent; and the remaining 34 percent of idle load was due to miscellaneous electrical loads such as recirculation pumps, towel heaters, and GFCI outlets.

Figure 10: Idle (Always-On) Loads by Major Product Category in 10 Homes Audited



THE IDLE ENERGY HOGS

Just 10 device types were responsible for half the identified idle load across the 10 homes we audited. These energy hogs fall into two categories:

1. Those with a high standby load, such as many audio/video devices.
2. Continuously active devices, like fishpond equipment, recirculation pumps, fan and light fixtures, and computers left on 24/7. These can add up to a large share of home idle.

Table 3: Top 10 Idle Loads by Household Across 10-Home Sample

1. Fishpond equipment

1 fishpond measured in **1** home
220 watts of 24/7 power
$220 in annual bills

2. Hot water recirculation pump

Measured in **3** homes
1 pump per home
28–92 watts of 24/7 power
$28-$93 in annual bills

3. Set-top box

Measured in **6** homes
1 to 3 set-top boxes per home
16–57 watts of 24/7 power
$16-$57 in annual bills

4. Audio/video gear

Measured in **8** homes
1 to 3 A/V devices per home
7–40 watts of 24/7 power
$7-$40 in annual bills

5. Fan

1 fan measured in **1** home
110 watts of 24/7 power
$111 in annual bills

6. 24/7 lights

Measured in **2** homes
1 to 2 24/7 lights per home
4–104 watts of 24/7 power
$4–$104 in annual bills

7. Television

Measured in **6** homes
1 to 2 TVs per home
2–54 watts of 24/7 power
$2–$54 in annual bills

8. Aquarium

Measured in **3** homes
1 aquarium per home
9–67 watts of 24/7 power
$9-$67 in annual bills

9. Desktop computer

Measured in **7** homes
1 computer per home
1–49 watts of 24/7 power
$1–$49 in annual bills

10. Modem

Measured in **5** homes
1 to 2 modems per home
5–17 watts of 24/7 power
$5–$17 in annual bills

Notes on Table 3:

Existing devices: The devices measured include older equipment which may not be representative of the latest models on the market. Newer devices may have lower idle—or they may have higher idle, as in the case of electronic devices with "instant on" or "quick start" modes such as the Microsoft Xbox One game console, and many "smart" TVs.

Number of homes: Some devices, such as set-top boxes and TVs, were present in more homes than indicated here, but we were not able to measure their idle power due to residents' requests not to unplug them.

24/7 power: The range represents the homes where these devices used the lowest and the highest idle power. For example, one home had two set-top boxes drawing 16 watts together, another had three set-top boxes drawing a total of 57 watts in idle.

Annual bills: This is calculated using the U.S. average electricity rate of $0.125 per kilowatt-hour and an average of 22 hours of inactive use per day. The annual cost could be two to three times that amount for residents in the highest tier of a tiered utility rate.

THE PHANTOM ARMY OF MISCELLANEOUS ELECTRICAL LOADS (MELS)

The remaining 87 device types were responsible for the other half of total idle load. Many of these devices have low idle load per unit and may go unnoticed by a home's occupants, but because there are many of them, they represent a significant total idle load as a group. For example, 60 GFCI outlets using on average 1 watt each were found in the 10 homes (an average of 6 per home), making these outlets the 11th-largest idle energy consumer across our sample.

Miscellaneous idle loads can range from high-occurrence but low-idle devices (such as a GFCI outlet or cordless phone, found in almost every home, and sometimes in large quantities, although each has a low idle load) to low-occurrence but high-idle devices (such as fishpond equipment and recirculation pumps, found in few homes, although each may have a high idle load and may, in fact, be among the top idle energy users in the household), as shown in Figure 11. The total energy consumption might be comparable at both ends of the spectrum.

Miscellaneous Electrical Load (MEL)

Energy efficiency initiatives have traditionally focused on the top offenders—the few devices that use the most energy overall, such as refrigerators, clothes dryers, and TVs. Charts representing energy use in homes typically label these top offenders individually, and everything else falls under "Miscellaneous," a catch-all category. However, in the 10 homes audited for this study, such miscellaneous electrical loads (MELs) accounted for 85 percent of idle energy.

Figure 11: Top 20 Idle Loads—Across 10 Homes

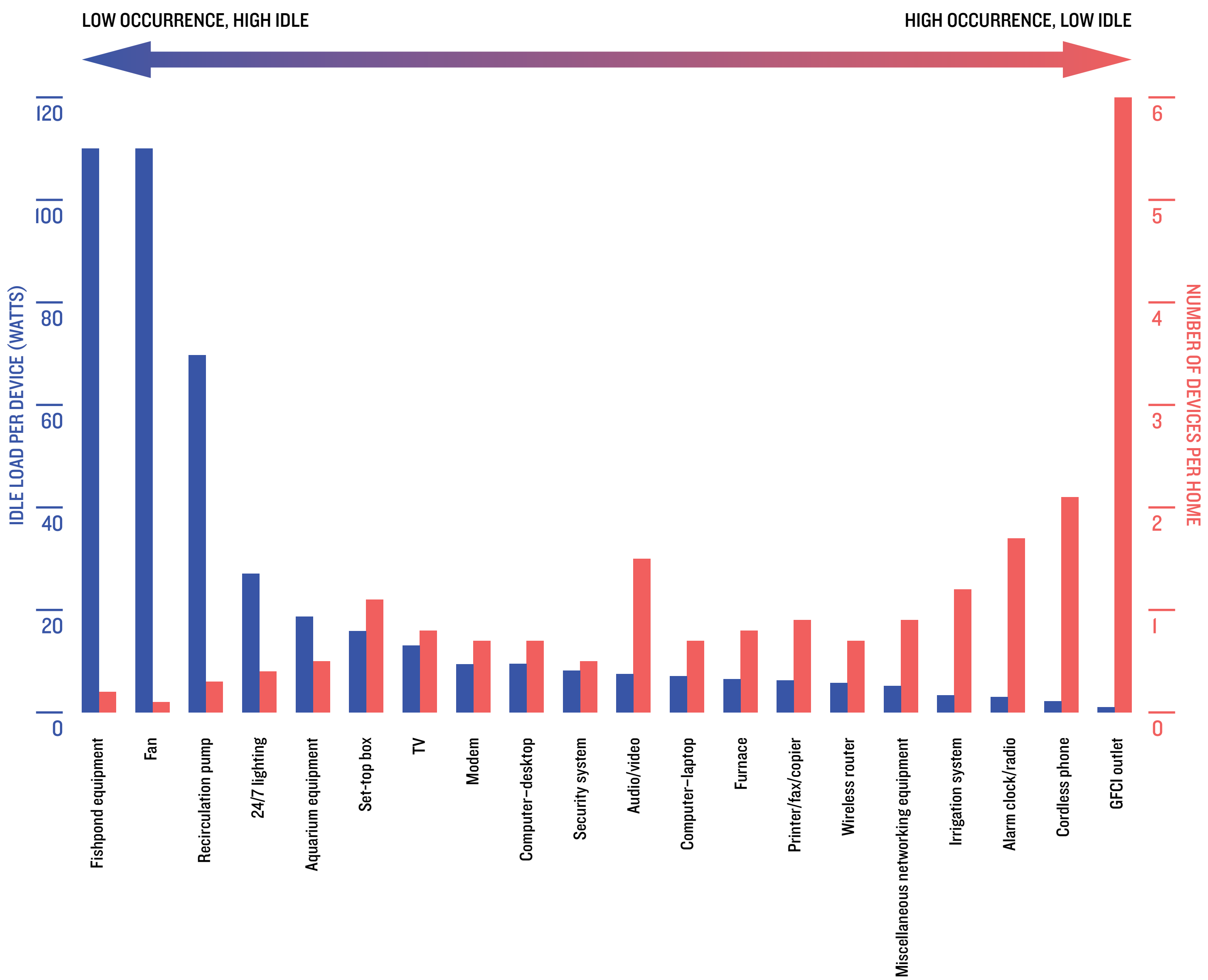


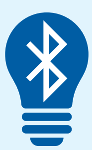
Table 3: Top 20 Idle Loads (Average Idle Load per Device Across 10-Home Sample)			
Devices	**Idle (watts)**	**Devices**	**Idle (watts)**
1. Fishpond equipment	**110**	11. Audio/video devices	**7.5**
2. Fans	**110**	12. Computers–Laptop	**7.1**
3. Recirculation pump	**70**	13. Furnace	**6.7**
4. 24/7 lighting	**27**	14. Printer/fax/copiers	**6.3**
5. Aquarium equipment	**19**	15. Wireless routers	**5.5**
6. Set-top boxes	**16**	16. Miscellaneous networking equipment	**5.2**
7. TVs	**13**	17. Irrigation system	**3.5**
8. Modems	**11**	18. Alarm clocks/radios	**2.9**
9. Computers–Desktop	**9.5**	19. Cordless phones	**2.2**
10. Security systems	**8.2**	20. GFCI outlets	**1.0**

OTHER EMERGING LOADS: MANY DEVICES ARE BECOMING DIGITAL

An increasing number of previously purely mechanical devices have gone digital as electronics become ubiquitous in homes and offices. This trend brings advanced new features such as information displays and has the potential for energy savings through smart controls. Unfortunately, it can also result in high idle load if devices are not designed with energy efficiency in mind.

The following are examples of emerging digital devices with idle loads found in homes beyond the 10 audited for this study.

Bluetooth-enabled LED lightbulb

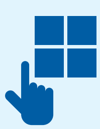


1.5 watts of 24/7 power per bulb (15 watts for 10 bulbs)

$1.50 to $4.00 per bulb in annual electricity bills (using national average and highest local utility's tier price)

Internet-connected LED light bulbs are very efficient when lit, but high standby power can offset these savings if poorly implemented. We found an instance of an LED light bulb with continuous Bluetooth connectivity drawing 1.5 watts in standby. Over the course of a year, this light bulb uses more energy off than on! (This assumes the bulb uses 10 watts for 1,000 hours per year).

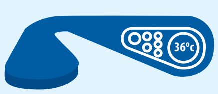
Digital light switch



Multi-touch-sensitive switch with sensors, LED backlight, and advanced logic to control lighting, heating, and cooling.

Unknown idle load. A home would presumably have at least a dozen.

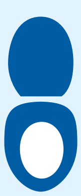
Digital faucet



Digital faucet with temperature display. Users can set water temperature and flow.

Unknown idle load.

Heated night-light toilet seat



This toilet seat features an LED night-light that is presumably very efficient, but if the heating element is left on continuously, it wastes a lot of power on an annual basis.

Rated power: **55 watts**

Between **$55** (national average) and **$145** (highest local utility tier) in annual electricity bills.

Connected devices: an idle load blessing or curse?

An increasing number of devices can now be connected to a home network, such as smart thermostats, appliances, plugs, and even light bulbs. This allows for smarter home energy management and has the potential to save energy, such as switching off devices automatically when no one is home. However, energy savings can be offset by high idle load if devices are poorly designed. Technology exists for connected devices to use very low power when in standby mode and connected, but they must be designed that way.

NOTABLE IDLE ENERGY HOGS

The following are examples of idle energy hogs found in Bay Area homes other than the 10 homes audited for this study. Note: These are extreme but real examples. Their inclusion in this report does not mean all whole-house audio and security systems have such high idle power (many do not), but without standards guaranteeing a minimum level of energy efficiency, some poorly designed systems can waste a lot of energy and cost consumers dearly.

Heated towel rack

140 watts of 24/7 power

$140 to $375 in annual electricity bills

This particular unit has a plug, but no "off" switch or timer.

Whole-house audio system

350 watts of 24/7 power

$350 to $900 in annual electricity bills

These systems, which can broadcast music throughout a home, are sometimes installed during construction. They are often unused but remain connected to a power source and consume a large amount of energy 24/7 for years.

Not all such systems are energy hogs, but they need to be designed for low idle power. A system drawing 350 watts may not be representative of the average audio system, but it shows the need for more efficient designs.

Security/surveillance system

500 watts of 24/7 power

$500 to $1,300 in annual electricity bills

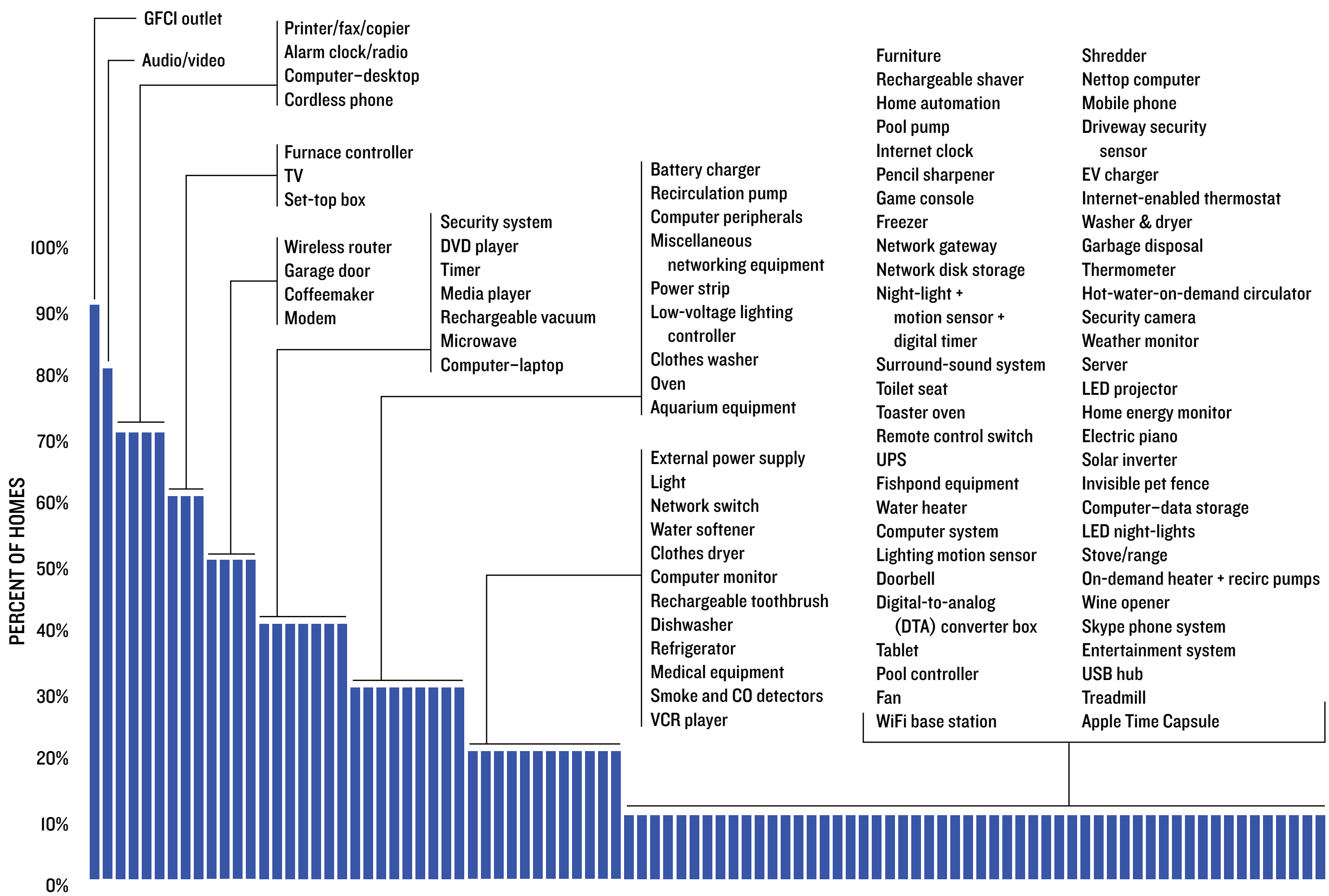
Similar to whole-house audio systems, security systems remain connected to a power source 24/7 and need to be designed for low-power idle. A system drawing 500 watts may not be representative of the average security system, but it shows the need for more efficient designs.

VARIETY OF DEVICES

Some devices are common across many homes, particularly electronic equipment. However, many of the high-idle devices are found in only one or a few homes. In fact, as shown in Figure 12, **more than half of the devices with 1 watt idle load were found in only one of the 10 homes we audited, and 87 percent were found in less than half of the homes**.

This diversity of devices makes both educational programs and standard-setting challenging for miscellaneous electrical loads. Focusing on the handful of highest-consuming devices—the traditional approach used by efficiency programs and standards—would not be very effective in the case of home idle. Instead, what is needed are different approaches, such as using smart meter data to target customers with the highest idle loads, and setting cross-cutting standby standards and labeling requirements that apply to many different types of devices.

Figure 12: Percent of Homes in 10-Home Sample Where Each Device With At Least 1 Watt Idle Load Was Found



NOTE: Although the chart shows some devices like set-top boxes with a count lower than 10, this does not mean these devices were not present in other homes; the chart only shows devices that we were able to measure and that used at least 1 watt in the home idle state.

IDLE ENERGY–SAVING APPROACHES FOR HOME OCCUPANTS

The good news about home idle is that there are many no-cost or low-cost actions that consumers can take to reduce their home idle load. They range from very simple and easy to implement to more time-consuming actions. We recommend three approaches for hunting down these idle loads, from the simplest to the most comprehensive.

DO-IT-YOURSELF GUIDE TO REDUCE YOUR HOME IDLE LOAD

OPTION 1 Quick and Easy: Find and Unplug the Top Offenders

WHICH DEVICES TO LOOK FOR:

- Audio devices such as an amplifier, stereo, boom box, Internet radio
- TVs, cable and satellite set-top boxes, computers, game consoles, printers
- Power adapters (with or without a device attached) that are plugged in all the time and feel warm to the touch
- Recirculation pumps and any other equipment on 24/7 that could be powered down at times when no one uses them, such as in the middle of the night
- Older devices such as old fridges and freezers, which often (but not always) use more energy than newer ones.

WHAT ACTIONS TO TAKE:

- **Unplug** devices that are no longer used or are used very rarely, such as:
  - The TV and DVR set-top box in the guest bedroom
  - A second fridge when you don't need it. Plug it in only when you need it, or consider getting rid of it altogether as the old fridges found in garages and basements are typically energy hogs and can cost residents more than $100 per year in electricity bills.
  - The furnace in the summer (switch it off if hardwired)
- Plug devices into a **power strip**, or consider installing a whole-house switch that remotely turns off controlled outlets with the single flip of a switch. Use a power strip for:
  - TV, speaker bar, and other TV accessories. You can switch them all on and off with a standard power strip. Better yet, use an advanced power strip that automatically turns off the TV, sound bar, and other devices when no one is using them.
  - Computer, monitor, printer, computer speakers, and other computer accessories
  - Internet radio if it uses more than a couple of watts in standby with Internet connection

- Plug them into a **timer** (also called a scheduler). A digital timer is better than a mechanical one because digital timers typically have a lower standby load. Use a timer for:

  - Hot water recirculation pump; program the timer to switch the pump off at times when typically no one is using hot water.
  - Instant coffee machine
  - Towel heater
  - Heated bathroom floor
- Adjust **power settings** on devices such as these:
  - TV: The "quick start" setting can use as much as 37 watts 24/7 in some models. Disable this setting if it uses more than a couple of watts.
  - Computer: Set your computer to go to sleep after 30 minutes or less of inactivity. Turn it off when you've finished using it.
  - Game console: Disable the "instant on" mode if you don't need it.
- Purchase **ENERGY STAR™**-labeled equipment wherever possible:
  - ENERGY STAR includes requirements to minimize idle load (low standby power, auto power down), in addition to using lower power in active mode.

Many utilities offer financial incentives for some of these actions, such as recycling an old fridge, buying smart power strips, or purchasing an energy efficient major appliance. Consumers can search for these incentives online or call their utility for information.

The quick-and-easy actions should yield significant reductions in your idle load and utility bill. To get even better results, consider these additional steps that can help identify and reduce additional idle loads.

OPTION 2 Moderate: Measure Your Devices to Better Estimate Idle Load

- Estimate your total home idle load, either by going to HEA's "Unplug Stuff" website (www.UnplugStuff.com), viewing or downloading your home's usage data from your utility's website (may be labeled Green Button), or by reading the electricity meter while your home is in idle mode.
- Buy a simple power meter, such as the Kill-a-Watt (approx. $25 online), or check with your local library, which may have one you can borrow. Use the meter to measure the devices listed above, as well as any others you find.

OPTION 3 Ultimate: Take a Detailed Inventory of Devices

(See our online Self-Diagnosis and Action Guide)

- Inventory by electrical circuit all the plug-in and hardwired electrical devices in your home.
- Measure each circuit's idle load by switching each one off in turn and calculating the difference between "before" and "after" readings on your utility meter.
- Use a power meter or a home energy monitor, and your detailed inventory of devices as a guide, to measure each device by circuit.

HOME AND OFFICE ENERGY MANAGEMENT SOLUTIONS

Using new smart meter data analytics solutions, some energy management companies offer residential and commercial utility customers a detailed breakdown of their bills by some of the major electricity uses, and over time. Sometimes, control solutions are also available to automatically switch off devices when unused. Companies providing such services include Bidgely, EcoFactor, Embertec, Home Energy Analytics, Nest, OhmConnect, Opower, PlotWatt, Tendril, ThinkEco, TrickleStar, and many others. These solutions offer great promise for both active and idle load reduction, as long as any on-premises components of the solution (e.g., gateway devices collecting measurements) are designed for low-idle power so their own power consumption does not significantly offset savings. These management solutions are good candidates to be deployed at scale as part of behavior efficiency programs where smart meter data are available.

POLICY OPPORTUNITIES

Although there are many options to reduce home idle load, few consumers are likely to take the necessary action without solutions that make it easy and worthwhile. Most consumers are unaware of the contribution of idle loads to their electricity bills. They also do not know which devices contribute the most or what to do about them, and they may not be willing to spend time to adjust power settings, or money to buy timers and power strips.

Technology exists to design electronics and equipment with very low idle loads, and it is already used in some products today. The problem is that too many devices fail to adopt this technology; designing for a low idle load is a lower priority than getting the product to market as quickly and as cheaply as possible. Even when a low-power mode is in the design, business decisions may override energy efficiency considerations. For example, Microsoft ships its Xbox One game console with the “instant on” mode disabled in Europe because of the European Union’s standby energy standards. But the company ships the same product with the “instant on” mode enabled by default in the United States because our nation lacks standby power energy efficiency standards. Consumers may keep this mode enabled without realizing that it adds 12 watts (as of April 2015) to their always-on load, the equivalent of an extra non-DVR cable set-top box.

Policy measures are key to overcoming these market barriers and encouraging more consumers to take action. The results will cut energy waste, reduce the need to generate electricity from dirty fossil fuels that harm our health and the environment, and avoid the necessity of adding costly energy infrastructure. There are two types of policies the can be effective with idle loads:

1. **Efficiency programs.** Outreach and incentive efficiency programs will raise customer awareness of the issue of home idle load and introduce recommended solutions. For example, merely listing a customer’s idle load consumption relative to peers on the customer’s electric bill may have a significant effect.
2. **Efficiency standards.** With mandatory efficiency standards requiring that all devices be designed to minimize idle load, energy consumption from home idle will drop over time as consumers buy new devices with lower idle loads and retire old ones.

BEHAVIOR AND INCENTIVE EFFICIENCY PROGRAMS—ENCOURAGING AND HELPING MORE CONSUMERS TO TAKE ACTION

Education and incentive efficiency programs have the potential to reduce electricity waste and utility customer bills very cost-effectively by leveraging the many zero- and low-cost opportunities to reduce idle loads in customer homes. Electric utilities can take the following measures, among others, to encourage and help customers to reduce their idle load:

1. Use the monthly utility bill to inform customers of their home idle load consumption (as measured from smart meter readings), the annual cost impact, and ways to reduce it.
2. Identify customers whose homes have much higher idle load than comparable homes and alert them to how they compare with their peer group.
3. Analyze smart meter data to detect large changes in customer idle loads (such as might be caused by a fan being plugged in and left on 24/7), and alert residents to the impacts of these idle loads.
4. Reach out to customers with higher-than-average idle loads and offer them assistance, such as a free power meter, home energy monitor, online diagnostic tool, phone call with an expert, or even an in-home visit. Continue to engage these customers over time and provide feedback on the evolution of their home idle load and the comparison with their peer group.
5. Provide customers with financial incentives for reducing their measured idle load, similar to PG&E’s winter gas savings programs.[29]
6. Offer rebates on timers and power strips to customers with high idle loads.

EFFICIENCY STANDARDS—ENSURING THAT ALL DEVICES ARE DESIGNED FOR LOW IDLE

While efficiency programs can be very cost-effective to reduce idle loads, by themselves they can achieve only a limited share of available efficiency savings. If, for example, one-fifth of customers take action and reduce their energy consumption by 20 percent, this yields only 4 percent average savings. To achieve a large share of available savings, all new devices must be designed for low idle power. When old, inefficient devices are replaced at the end of their useful life by new, more efficient ones, home idle energy consumption will decrease over time.

Energy efficiency standards can be voluntary or mandatory:

- **Voluntary standards**, like the ENERGY STAR™ label program administered by the U.S. Environmental Protection Agency, encourage the adoption of the most efficient products on the market. ENERGY STAR already includes some requirements on idle (also known as standby loads) and needs to continue to evolve to address the increasing energy consumption of devices when they are not in active use. However, ENERGY STAR does not affect the least efficient products on the market, and so far it has focused mostly on the top-end energy-using devices. It does not cover many of the smaller devices in home idle's "long tail" of miscellaneous electrical loads.
- **Mandatory standards** address all products on the market within a regulated category. They can be specific to one product type (for example, TVs) or cover many different types of devices sharing a common function. Examples of such cross-cutting standards include minimum efficiency requirements for external power supplies (brick power adapters for a variety of electronic products) in the United States, the European Union, and several other countries; products with rechargeable batteries in California; and standby and off mode in the European Union. The U.S. Department of Energy also includes standby and off mode energy use in federal appliance efficiency standards, but this applies only to covered products such as kitchen and laundry appliances, not to the large number of small electricity uses that are responsible for the vast majority of home idle, as identified in this study. Cross-cutting mandatory standards applying across the board would be the most effective way to ensure that all devices on the market are designed to minimize their idle load.

Lessons from the European Union

The European standby and off-mode efficiency standard addresses a large portion of the idle load issue highlighted in this study because it requires products to go into a low-power mode after a certain period of user inactivity, and sets power limits for these low-power modes. The power management requirement offers flexibility for products where user inactivity would be an inappropriate criterion, such as televisions, which are often in use for an extended period of time even without user input. The power limits for low-power modes depend on which functions are still available in that mode, such as readiness for reactivation from a remote control or through a network connection, and how quickly devices must be able to respond to user input.

Complementary measures may be necessary for products where power management and low-power mode requirements are inappropriate for their intended use, such as furnaces or televisions that remain on for long periods of time without consumer input. For example:

1. **Product-specific standards** can set requirements for power management in operation as well as in standby mode.
2. **Building codes** could minimize the idle load of new construction or retrofitted homes by requiring of builders and contractors that furnaces, doorbells, garage doors, and other hard-wired systems not exceed reasonable standby levels and are configured to automatically power down to low-power modes when unused.
3. **Labeling** could inform consumers of the idle load of products and homes, along with the associated utility costs. (For example: "10 watts idle; $50 to $130 over five years, depending on your electric rates.") Like MPG ratings for cars and nutrition labels on food, idle load labeling of devices would allow customers to make informed choices.

RANGE OF IDLE LOADS & SOLUTIONS FOR 10 COMMON HOUSEHOLD DEVICES FOUND IN NRDC'S ONSITE AUDIT*

1. HOT WATER RECIRCULATION PUMP

WATTS (low to high): 28–92
COST (low to high): $28–93

LOCATION: Garage or HVAC closet

TYPICAL # DEVICES PER HOME: 1

SOLUTIONS NOW: Timer, Settings

SOLUTIONS NEEDED: Manufacturer improvements, Standards, Utility EE incentive programs

2. SET-TOP BOX

WATTS (low to high): 4–30
COST (low to high): $4–30

LOCATION: Living room, bedroom, family room

TYPICAL # DEVICES PER HOME: 2

SOLUTIONS NOW: Unplug seldom-used

SOLUTIONS NEEDED: Manufacturer improvements, Standards, Utility EE incentive programs

3. TELEVISION

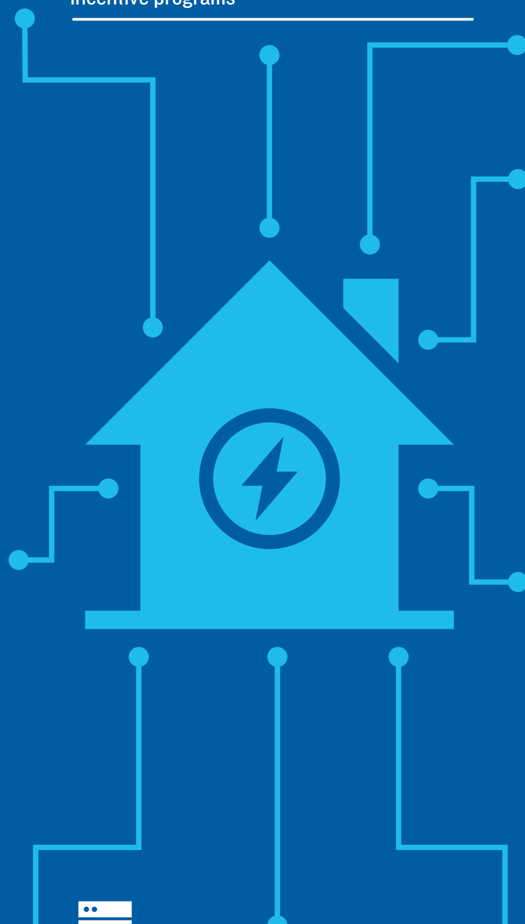
WATTS (low to high): <1–38
COST (low to high): <$1–38

LOCATION: Living room, bedroom, family room

TYPICAL # DEVICES PER HOME: 3

SOLUTIONS NOW: Settings, Smart strip/smart outlets, Unplug extras

SOLUTIONS NEEDED: Manufacturer improvements, Stronger standards, Utility EE incentive programs



4. DESKTOP COMPUTER

WATTS (low to high): <1–49
COST (low to high): <$1–49

LOCATION: Home office, family room

TYPICAL # DEVICES PER HOME: 1

SOLUTIONS NOW: Settings

SOLUTIONS NEEDED: Manufacturer improvements, Standards, Utility EE incentive programs

5. AUDIO RECEIVER/ STEREO

WATTS (low to high): <1–22
COST (low to high): <$1–22

LOCATION: Living room, family room

TYPICAL # DEVICES PER HOME: 2

SOLUTIONS NOW: Adjust Settings, Smart strip/smart outlets, Unplug

SOLUTIONS NEEDED: Manufacturer improvements, Stronger standards, Utility EE incentive programs

6. PRINTER

WATTS (low to high): <1–11
COST (low to high): <$1–11

LOCATION: Home office, family room

TYPICAL # DEVICES PER HOME: 2

SOLUTIONS NOW: Settings, Smart strip/smart outlets, Unplug

SOLUTIONS NEEDED: Manufacturer improvements, Standards, Utility EE incentive programs

7. FURNACE

WATTS (low to high): 3–8
COST (low to high): $3–8

LOCATION: Garage or HVAC closet

TYPICAL # DEVICES PER HOME: 1

SOLUTIONS NOW: Programmable & smart thermostats, Switch off in summer

SOLUTIONS NEEDED: Manufacturer change, Utility EE incentive programs

8. COFFEE MAKER

WATTS (low to high): <1–6
COST (low to high): <$1–6

LOCATION: Kitchen

TYPICAL # DEVICES PER HOME: 1

SOLUTIONS NOW: Timer, Settings

SOLUTIONS NEEDED: Standards

9. DRYER

WATTS (low to high): <1–4
COST (low to high): <$1–4

LOCATION: Garage or laundry room

TYPICAL # DEVICES PER HOME: 1

SOLUTIONS NEEDED: Manufacturer improvements, Standards, Utility EE programs

10. GFCI OUTLETS

WATTS (low to high): 1–1
COST (low to high): $1–1

LOCATION: Bathroom (2), kitchen (2), garage (1), outdoor (1)

TYPICAL # DEVICES PER HOME: 6

SOLUTIONS NEEDED: Manufacturer change, Standards, Building codes

Note: EE = Energy Efficiency
*For details of 10-home onsite audit, see http://www.nrdc.org/energy/home-idle-load.asp

ACTION GUIDE FOR ALL ACTORS TO HELP REDUCE IDLE LOAD

Consumers	■ **Unplug** unused or rarely used devices. ■ Put known idle energy hogs that don't need to stay on 24/7 on a **power strip**, and switch them off when unneeded. Better, use a smart strip for entertainment and computer systems. ■ Plug devices that you use on a regular schedule into a **timer** (scheduler), and program the timer to come on only when needed. ■ Adjust the **power settings** on your computer, game console, and TV. ■ **Track** your idle load using the methods described on page 22, and keep looking for ways to reduce the idle load of these always-on devices, to save money and cut power plant pollution.
Device manufacturers	■ Design devices to use less than **0.5 watt in low-power mode.** ■ Design devices to **automatically switch to low-power mode** after extended periods of user inactivity, when appropriate for intended use.
Energy management companies	■ Implement **energy data analytics** solutions to make consumers aware of their idle load and help them manage it.
Utilities and third-party efficiency program implementers	■ Implement **efficiency programs** that inform customers of their home idle load (as measured from smart meter readings), its annual cost, and ways to reduce it—all via their monthly bill. ■ **Monitor** customer idle loads, detect large changes (such as might be caused by a fan being plugged in and left on 24/7) and alert customers to the impacts of these idle loads. ■ Offer **home energy efficiency kits** to targeted customers with the highest idle loads. ■ Offer customers **financial incentives** for reducing their measured idle load, similar to PG&E's Winter Gas Savings program.[30]
Government agencies	■ **Incentivize utilities** to implement efficiency programs to reduce idle load. ■ Implement **cross-cutting minimum efficiency standards** to ensure all devices are designed for low-power idle load, and to automatically switch to low-power mode after extended periods of user inactivity, when appropriate for intended use.

APPENDICES

APPENDIX A—DETERMINING HOME IDLE AND ALWAYS-ON LOADS

The Monthly Minimum Hourly Power metric used by this study to measure home idle load includes continuous or "always on" loads, as well as some non-continuous or intermittent loads that are active often enough that they are recorded on all minimum hourly intervals.

Refrigeration: Due to the way refrigerators and freezers work, the Minimum Power metric may include some refrigeration for certain homes, but not all homes. Fridges and freezers run a compressor at intervals varying from every few minutes to once per several hours, depending on the model and operating conditions. Fridges that cycle their compressor more often than once an hour, day and night, over an entire month will have some of their active power included in the Minimum Power metric. Fridges that cycle less than once an hour will have little or no active power included in the Minimum Power metric. Fridge standby power, such as from its electronic components, is fully included.

Heating, Ventilation, and Air Conditioning (HVAC): There is little or no active HVAC power included in the Minimum Power metric in mild climates because to be counted, HVAC loads would have to run during every hourly interval, such as throughout the night and throughout periods of time when occupants are away from home. This is very unlikely in most homes in this study and in mild climates in general. Even room air conditioners would not typically run every hour of every day and night over an entire month, except if vastly undersized. In cold and hot climates, idle load may include a higher share of HVAC. Most of the HVAC power included in idle load in this study is that of controllers and transformers that draw power 24/7, even when the HVAC equipment is inactive. However, some newer building technologies like heat recovery ventilators (HRVs) are designed to run continuously and would therefore be included.

Refrigerators and HVAC are probably the largest intermittent loads to be partially captured in idle load. Other examples include aquarium heaters, poorly insulated hot water dispensers, wine coolers, heat pump water heaters, HEPA filters, dehumidifiers, humidifiers, air fresheners, sump pumps, attic fans, and dog bed heaters.

Given that intermittent loads can be responsible for a significant share of total energy use in homes, it was important to understand how much of average idle load they represent. This appendix provides a rough estimate of the average intermittent share of idle. The estimate is for the average across many homes; the exact intermittent share of idle for a particular home will vary widely, depending on the number and load pattern of intermittent loads.

Data necessary to precisely determine the share of refrigeration and other intermittent loads captured by the Minimum Power metric were unavailable for this study. However, we were able to derive partial estimates from two data sets: a 388-home sample with 15-minute data from Home Energy Analytics (HEA), and an eight-home sample with 1-minute data from PlotWatt.[31] Fewer intermittent loads are included in the 15-minute data than in the 60-minute data, and very few or none are included in the 1-minute data. By comparing 60-minute, 15-minute, and 1-minute data for the same homes, we were able to derive rough estimates of intermittent loads' share of idle.

Table A1: Determination of Home Idle and Always-On Loads

	Home sample size	Difference between 60- and 15-min. sampling	Difference between 60- and 1-min. sampling	Difference between 15- and 1-min. sampling
HEA	388	18%		
PlotWatt	8	13%	29%	16%

The PlotWatt sample size is too small to be statistically significant, and the HEA 15-minute data may still include some intermittent loads. Therefore, these comparisons are indicative only and merit further research. Nonetheless, the limited data suggest that the intermittent share of idle, including refrigeration and other intermittent loads, may be in the range of 20 to 30 percent. We therefore discounted Minimum Power by 25 percent to estimate a home's always-on load.

There are two other major uses/sources of electricity to consider relative to the Minimum Power metric:

Home electric vehicle (EV) charging stations: Only a small fraction of homes currently have an EV charger, yet EV chargers are much talked about these days as rapidly emerging loads in California and some other regions of the United States. Home EV chargers are expected to be active mostly overnight, and could in some cases increase overnight minimums. However, most EV chargers are active for only a couple hours per night, unless a low-power charger is charging a large-capacity vehicle. We expect that EV charging would have no impact on the Minimum Power metric in most cases, other than for the charger's own standby power.

Solar: Homes with rooftop photovoltaic panels present another challenge for the Minimum Power metric because they typically cause the net consumption of the home to go negative during the day, which would lead to a Minimum Power metric that is zero or negative. To avoid this, we used only nighttime hourly intervals for homes with solar, which is when the PV panels are not generating power. But this approach can result in artificially higher values for those homes that use nighttime-only devices such as fans, baby monitors, night-lights, landscape lighting, electric blankets, EV chargers, etc.

APPENDIX B—ENERGY SAVINGS METHODOLOGY

Idle energy cost estimates in this report are calculated using both the national average rate of $0.125 per kilowatt-hour, and PG&E's E-1 tiered rate schedule, where the price of electricity increases as consumption increases, just as income tax rates increase with revenue.

Table B1—PG&E E-1 Rate Schedule, January 1, 2015, Total Energy Rates ($ per kWh)[32]

Tier 1	Baseline Usage	$0.162
Tier 2	101%–130% of Baseline	$0.185
Tier 3	131%–200% of Baseline	$0.273
Tier 4	201%–300% of Baseline	$0.333
Tier 5	Over 300% of Baseline	$0.333

The baseline threshold varies depending on the climate zone where each home is located. Tiered rates provide a strong incentive for conservation and efficiency because energy savings reduce electricity bills at the rate of the highest tier the consumer pays each month (and perhaps the tier below that if reductions cause usage to drop to a lower tier). Tiered rates are the norm in many states, particularly in the western United States.[33]

In this report we provided estimates of electricity costs and potential savings using a range from U.S. average rate to PG&E Tier 4. Using only the U.S. average rate would not be representative of the costs of idle load for customers who are on tiered rates and whose marginal price of electricity is significantly higher than the U.S. average. For example, reducing idle load would save customers who use more electricity than the PG&E Tier 4 threshold nearly three times as much as the U.S. national average rate.

Readers can look at their bill to determine their average effective rate for a particular month.

Time-of-use rates: Customers with time-of-use rates (rates that vary depending on the time of day and day of week of usage) can calculate their idle load costs by multiplying their idle energy consumption in kilowatt-hours by the weekly average of their time-of-use rates.

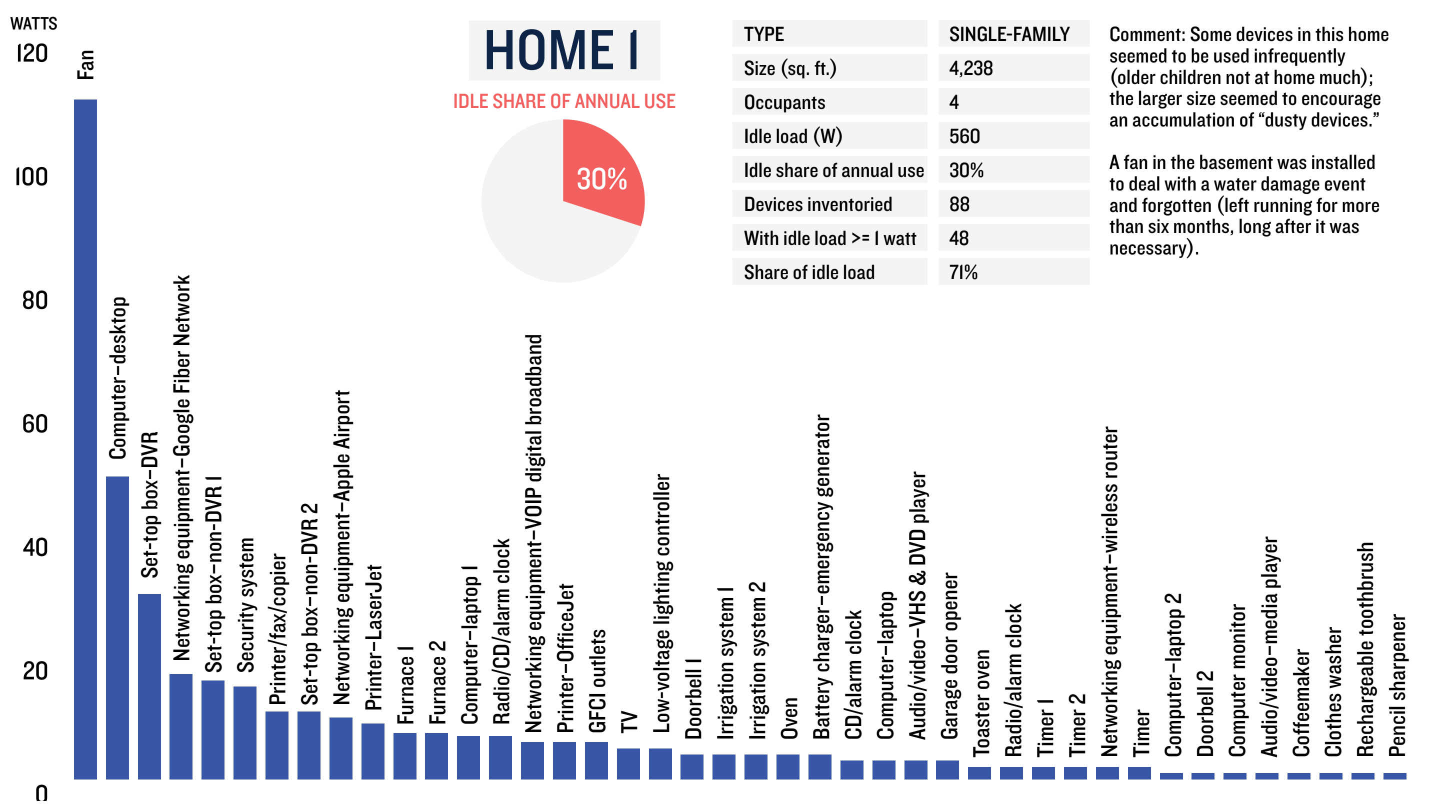
Flat rates: Customers with flat rates can simply multiply their idle energy consumption in kilowatt-hours by their flat rate.

APPENDIX C—HOME AUDIT DETAILS

Overview

Home	Size (sq. ft.)	Year built/ fully remodeled	Number of occupants	Type	Idle load (W)	Idle load/ 1,000 sq. ft.	Idle v. Total kWh	Number of devices inventoried	Contribution to % of idle load	Measured devices with at least 1 watt idle load
Home 1	4,238	1987	4	Single-family	560	132	30%	88	71%	48
Home 2	1,488	1981	1	Town house	395	265	40%	63	89%	35
Home 3	3,050	1999	3	Single-family	294	96	31%	65	52%	28
Home 4	1,320	1959	3	Single-family	300	227	30%	51	48%	26
Home 5	2,346	1955	3	Single-family	488	208	53%	46	38%	29
Home 6	1,517	1995	2	Single-family	1255	827	74%	120	34%	81
Home 7	1,200	1925	2	Multi-family	92	77	29%	26	97%	13
Home 8	1,300	1940	4	Single-family	102	78	30%	57	98%	45
Home 9	2,400	1970	2	Single-family	237	99	21%	39	69%	36
Home 10	4,000	1995	3	Single-family	367	92	33%	93	100%	87
Average							37%	65	70%	43

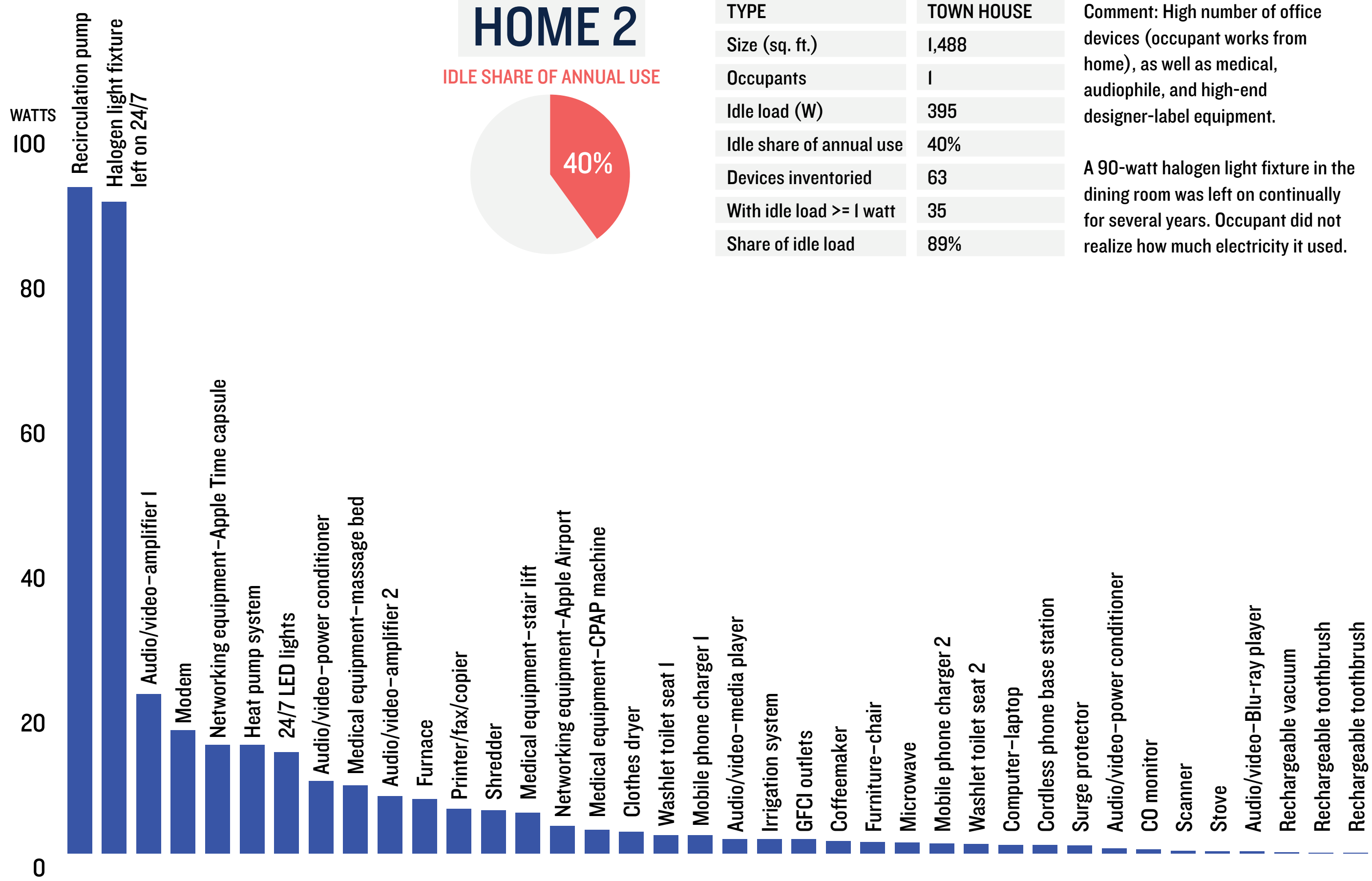
Note: The first six homes were chosen to represent a range of idle load intensities out of a sample of 2,750 Bay Area homes and are reasonably typical of average Bay Area residences. The last four are those of NRDC staff members, family, or other energy efficiency experts, so they may not be typical of average Bay Area homes in terms of energy consumption and idle load.



TYPE	SINGLE-FAMILY
Size (sq. ft.)	4,238
Occupants	4
Idle load (W)	560
Idle share of annual use	30%
Devices inventoried	88
With idle load >= 1 watt	48
Share of idle load	71%

Comment: Some devices in this home seemed to be used infrequently (older children not at home much); the larger size seemed to encourage an accumulation of "dusty devices."

A fan in the basement was installed to deal with a water damage event and forgotten (left running for more than six months, long after it was necessary).



HOME 2

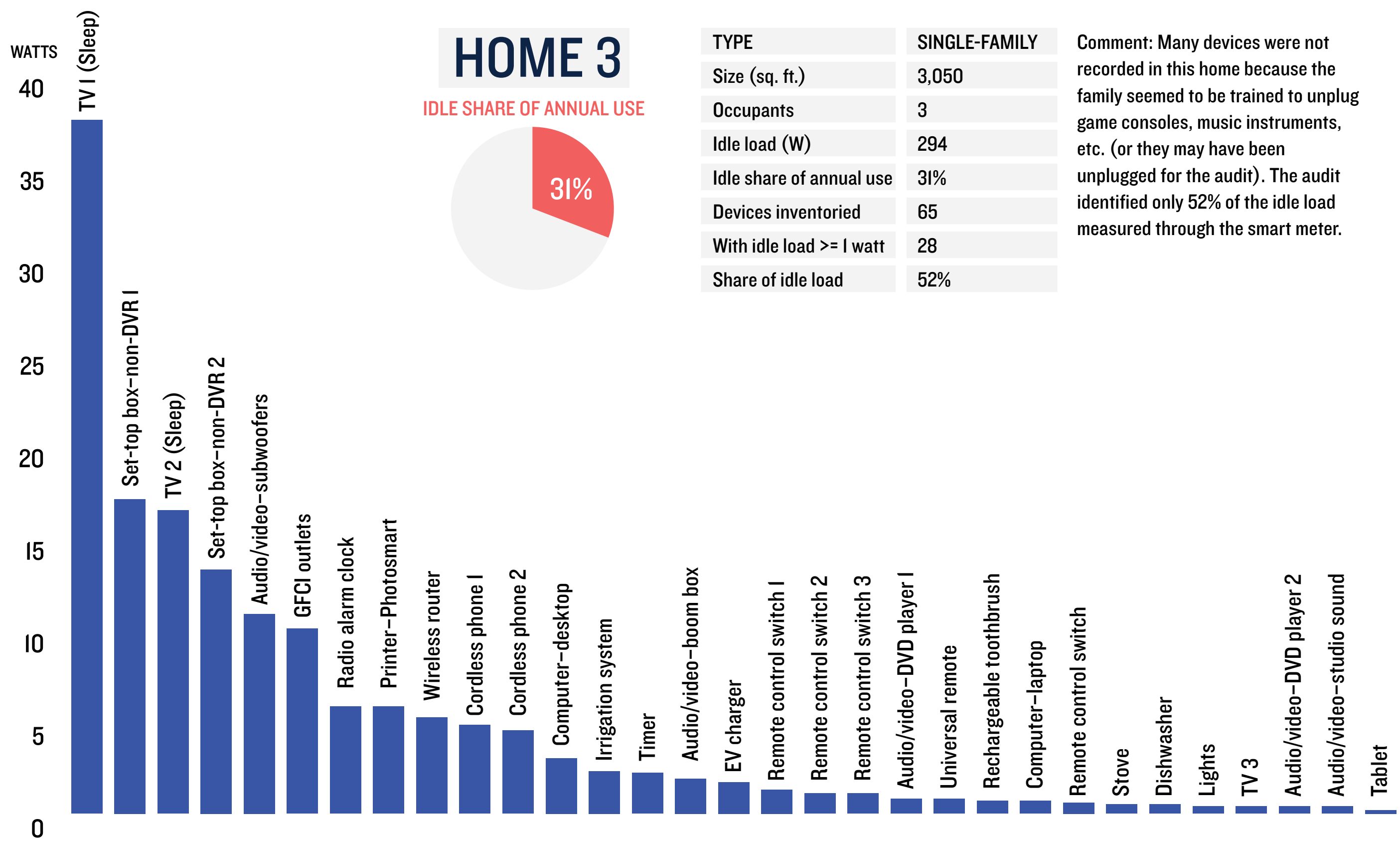
IDLE SHARE OF ANNUAL USE

40%

TYPE	TOWN HOUSE
Size (sq. ft.)	1,488
Occupants	1
Idle load (W)	395
Idle share of annual use	40%
Devices inventoried	63
With idle load >= 1 watt	35
Share of idle load	89%

Comment: High number of office devices (occupant works from home), as well as medical, audiophile, and high-end designer-label equipment.

A 90-watt halogen light fixture in the dining room was left on continually for several years. Occupant did not realize how much electricity it used.



HOME 3

IDLE SHARE OF ANNUAL USE

31%

TYPE	SINGLE-FAMILY
Size (sq. ft.)	3,050
Occupants	3
Idle load (W)	294
Idle share of annual use	31%
Devices inventoried	65
With idle load >= 1 watt	28
Share of idle load	52%

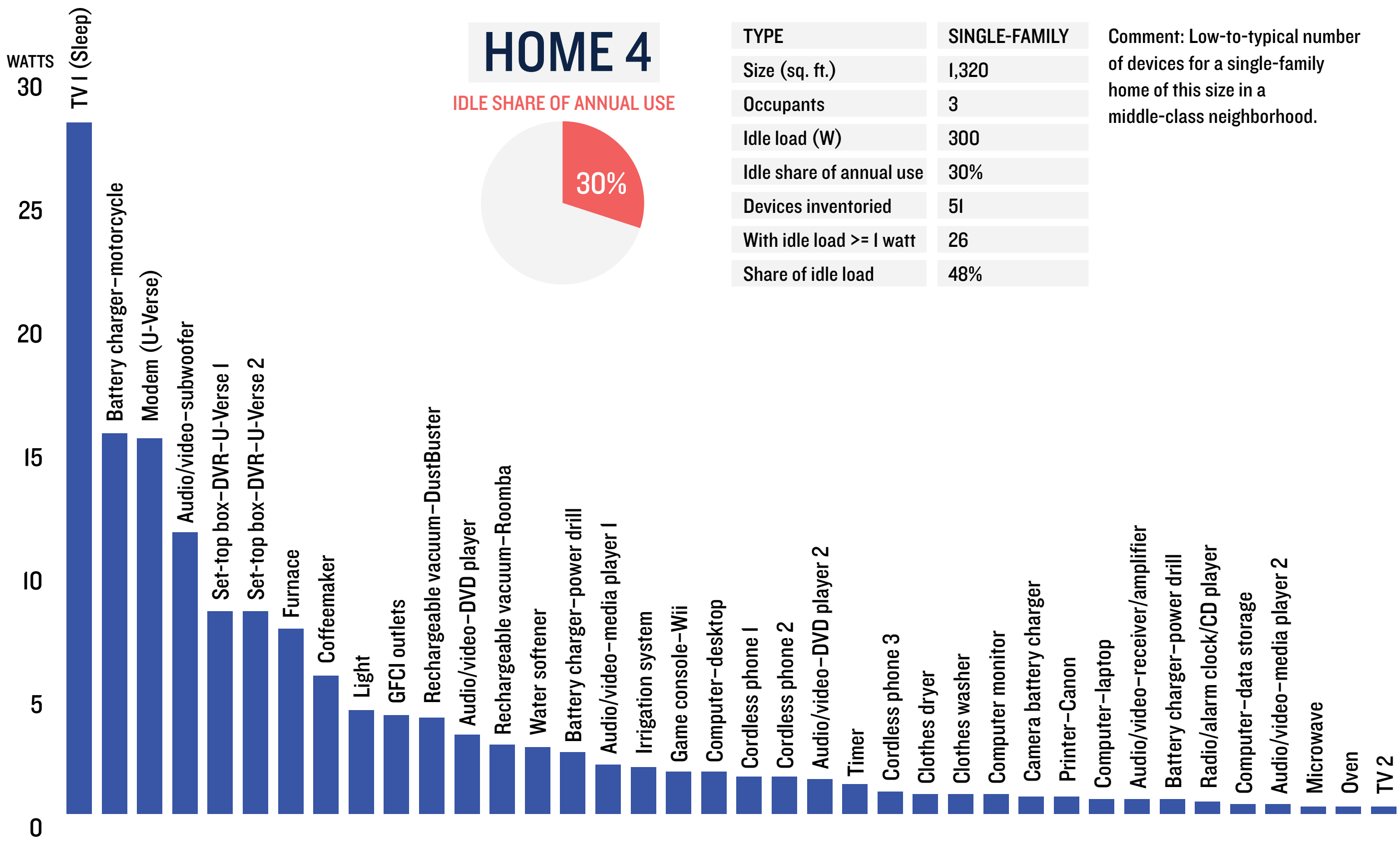
Comment: Many devices were not recorded in this home because the family seemed to be trained to unplug game consoles, music instruments, etc. (or they may have been unplugged for the audit). The audit identified only 52% of the idle load measured through the smart meter.

HOME 4

IDLE SHARE OF ANNUAL USE

TYPE	SINGLE-FAMILY
Size (sq. ft.)	1,320
Occupants	3
Idle load (W)	300
Idle share of annual use	30%
Devices inventoried	51
With idle load >= 1 watt	26
Share of idle load	48%

Comment: Low-to-typical number of devices for a single-family home of this size in a middle-class neighborhood.

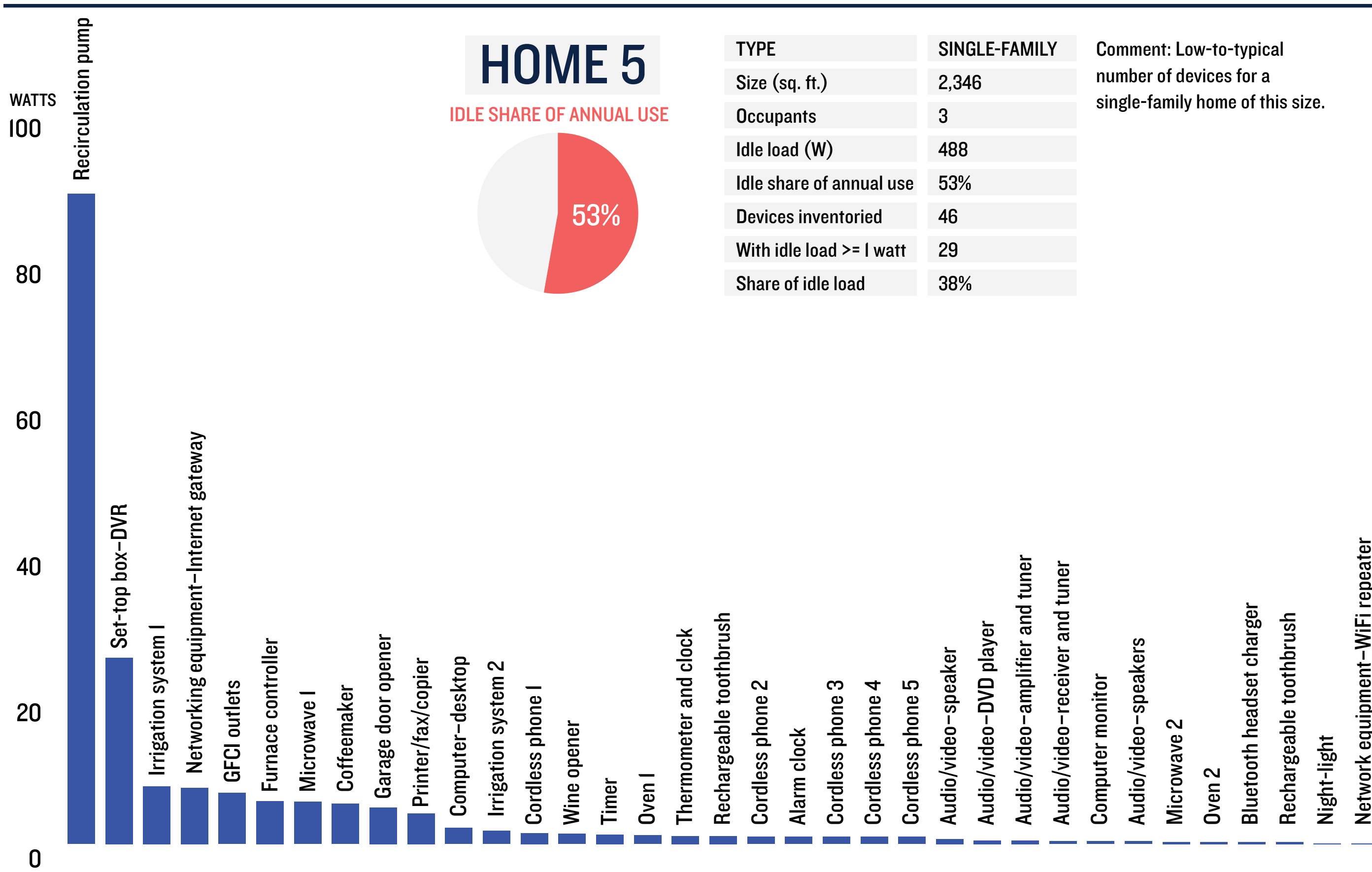


HOME 5

IDLE SHARE OF ANNUAL USE

TYPE	SINGLE-FAMILY
Size (sq. ft.)	2,346
Occupants	3
Idle load (W)	488
Idle share of annual use	53%
Devices inventoried	46
With idle load >= 1 watt	29
Share of idle load	38%

Comment: Low-to-typical number of devices for a single-family home of this size.



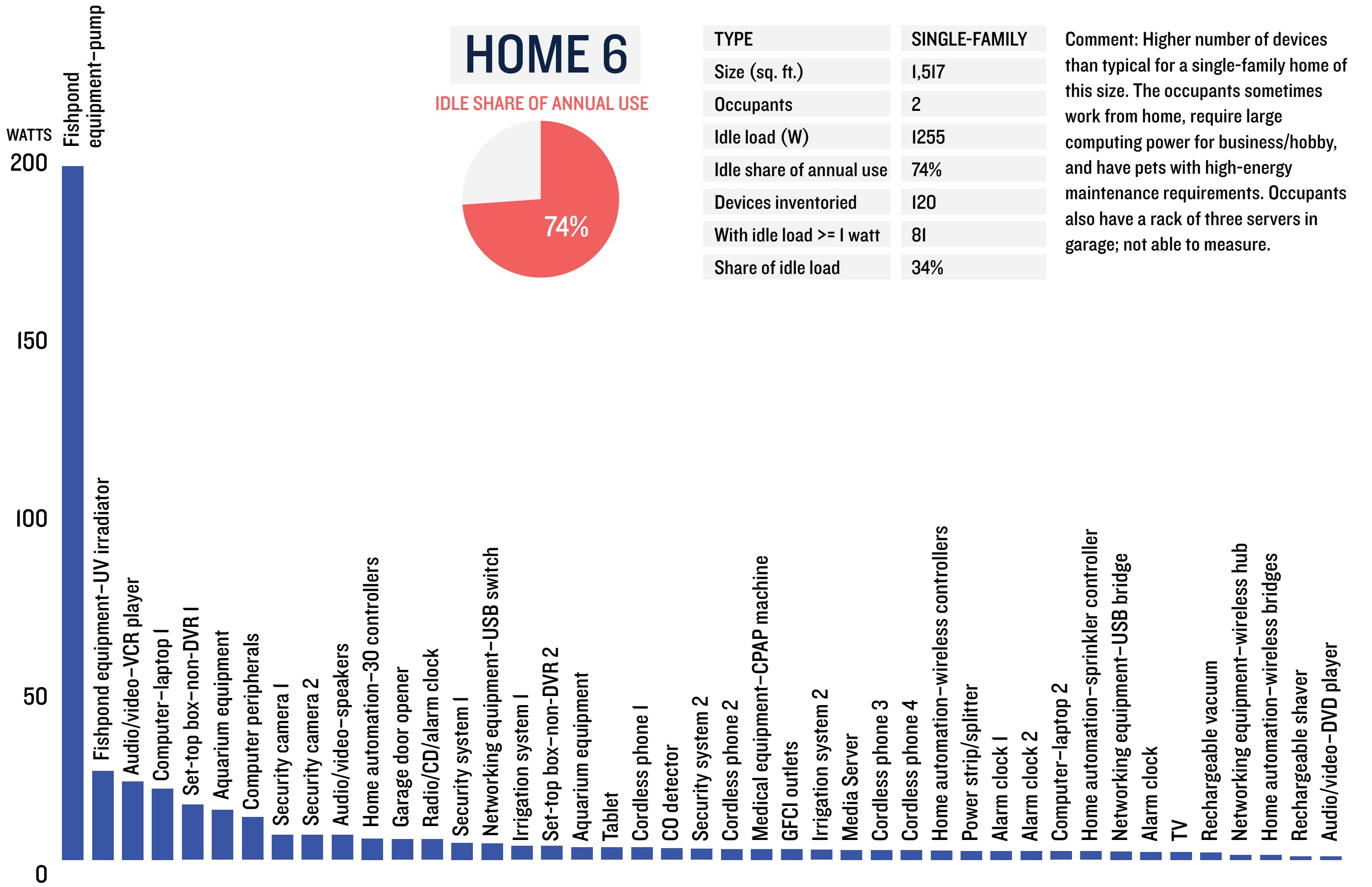
HOME 6

IDLE SHARE OF ANNUAL USE

74%

TYPE	SINGLE-FAMILY
Size (sq. ft.)	1,517
Occupants	2
Idle load (W)	1255
Idle share of annual use	74%
Devices inventoried	120
With idle load >= 1 watt	81
Share of idle load	34%

Comment: Higher number of devices than typical for a single-family home of this size. The occupants sometimes work from home, require large computing power for business/hobby, and have pets with high-energy maintenance requirements. Occupants also have a rack of three servers in garage; not able to measure.



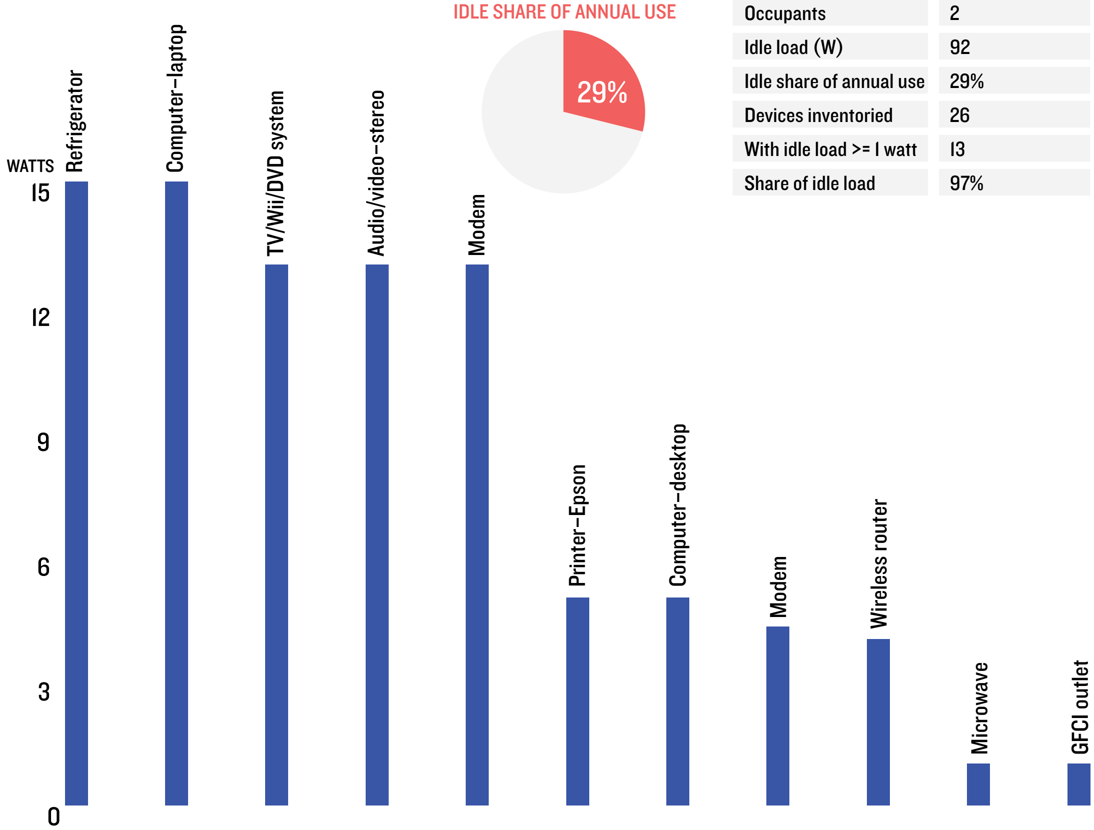
HOME 7

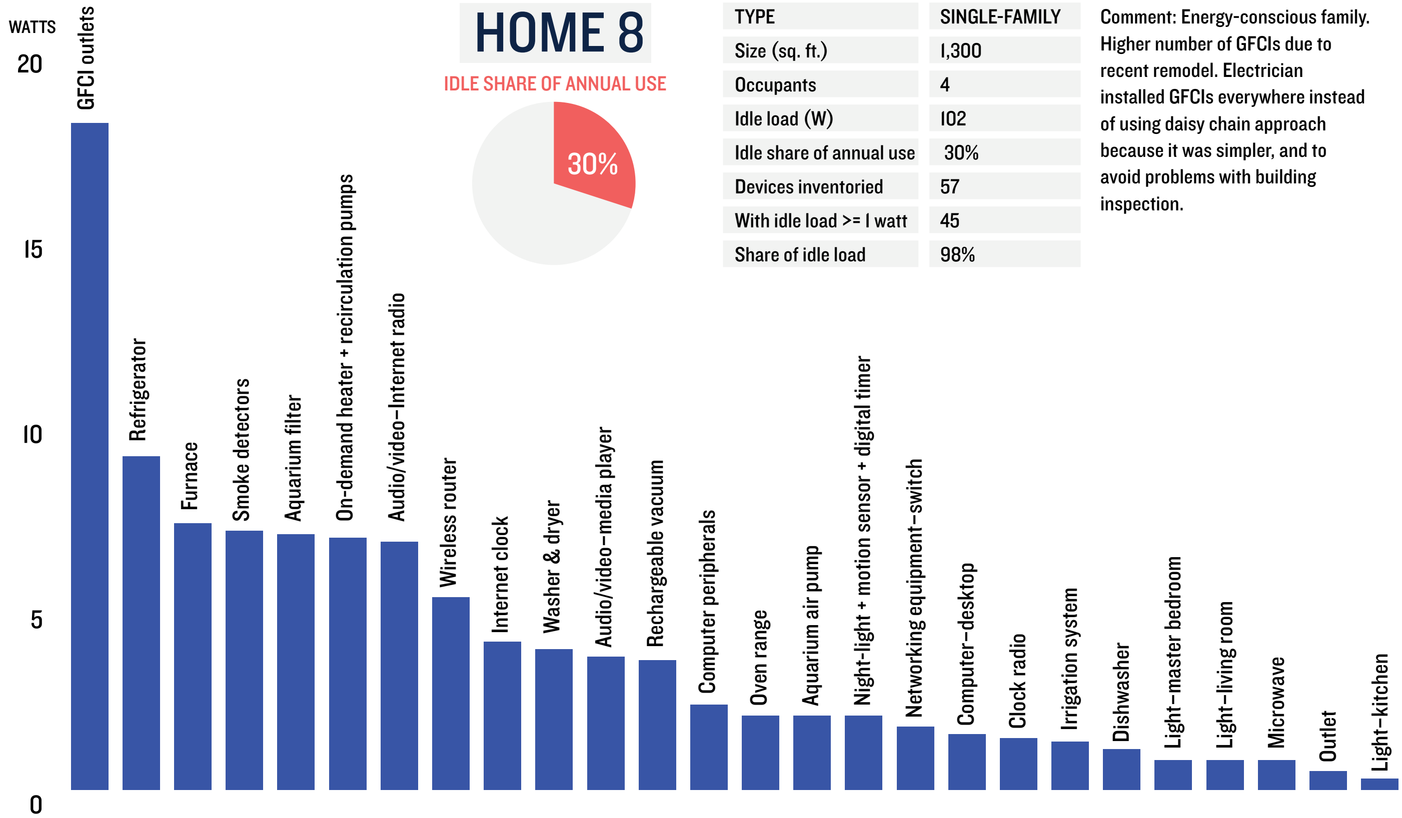
IDLE SHARE OF ANNUAL USE

29%

TYPE	MULTIFAMILY
Size (sq. ft.)	1,200
Occupants	2
Idle load (W)	92
Idle share of annual use	29%
Devices inventoried	26
With idle load >= 1 watt	13
Share of idle load	97%

Comment: Very energy-conscious couple, not typical.





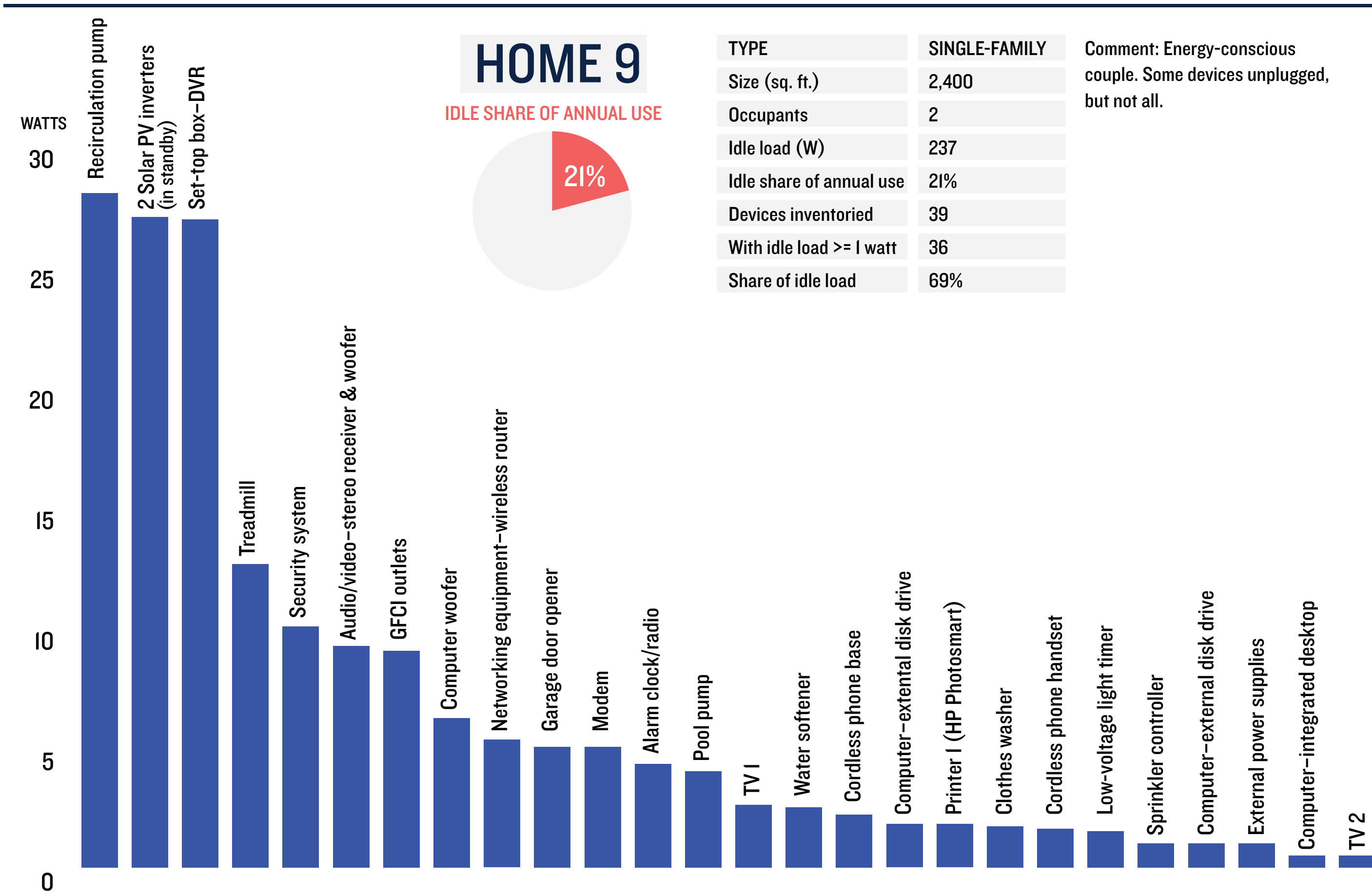
HOME 8

IDLE SHARE OF ANNUAL USE

30%

TYPE	SINGLE-FAMILY
Size (sq. ft.)	1,300
Occupants	4
Idle load (W)	102
Idle share of annual use	30%
Devices inventoried	57
With idle load >= 1 watt	45
Share of idle load	98%

Comment: Energy-conscious family. Higher number of GFCIs due to recent remodel. Electrician installed GFCIs everywhere instead of using daisy chain approach because it was simpler, and to avoid problems with building inspection.



HOME 9

IDLE SHARE OF ANNUAL USE

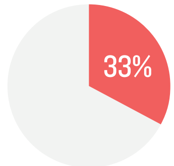
21%

TYPE	SINGLE-FAMILY
Size (sq. ft.)	2,400
Occupants	2
Idle load (W)	237
Idle share of annual use	21%
Devices inventoried	39
With idle load >= 1 watt	36
Share of idle load	69%

Comment: Energy-conscious couple. Some devices unplugged, but not all.

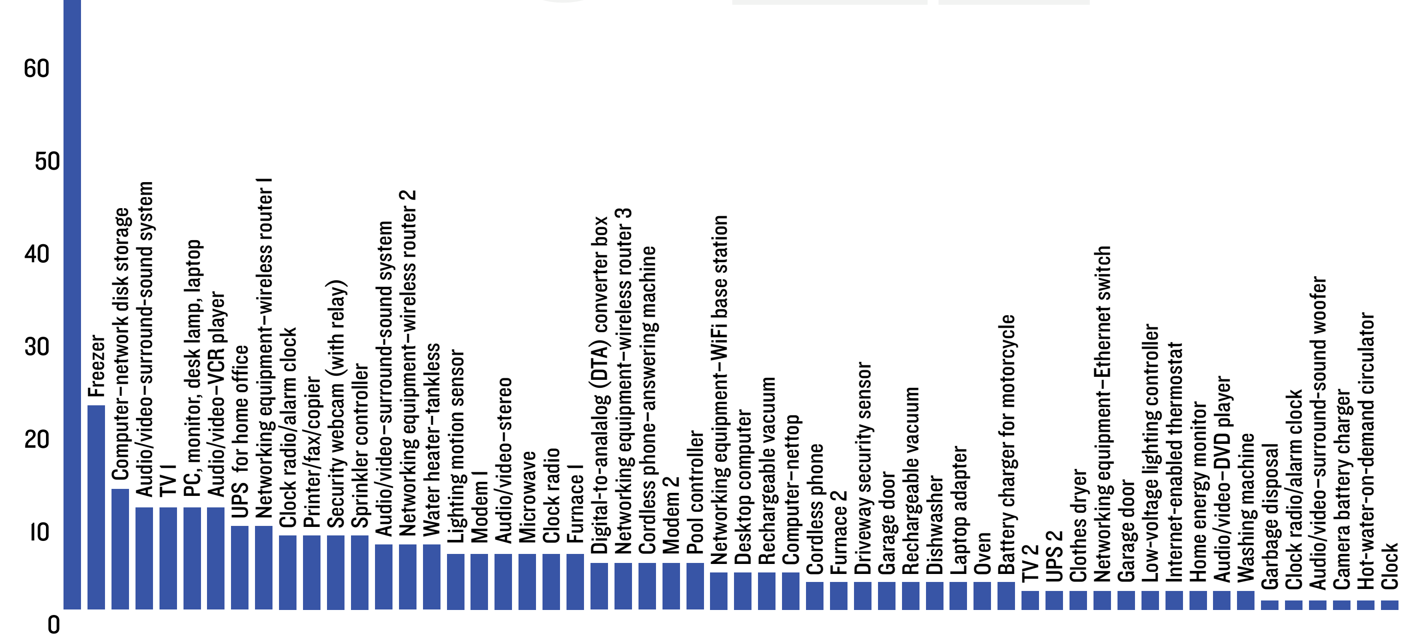
HOME 10

IDLE SHARE OF ANNUAL USE



TYPE	SINGLE-FAMILY
Size (sq. ft.)	4,000
Occupants	3
Idle load (W)	367
Idle share of annual use	33%
Devices inventoried	93
With idle load >= 1 watt	87
Share of idle load	100%

Comment: Energy-conscious family.



ENDNOTES

1 Savings calculated using the national average electricity rate of $0.125, per EIA "Electric Power Monthly," January 2015, Table 5.6.B - Average Retail Price of Electricity to Ultimate Customers by End-Use Sector, by State, Year-to-Date Through November 2014 (accessed January 28, 2015).

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11 Cost comes to $165 using the national average rate of $0.125 per U.S. Energy Information Administration (hereinafter EIA) "Electric Power Monthly," January 2015, and $440 using PG&E top-tier E-1 rate bracket of $0.333, as explained in Appendix B.

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14 A 150 ml cup of water heated from ambient temperature (20°C/68°F) to boiling point (100°C/212°F) at 90 percent efficiency requires 15.4 Wh. 1,313 kWh represents 85,000 cups of water annually, or 234 cups daily.

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26 We used the CORREL function in Microsoft Excel to determine the relationship between idle load and various properties—i.e.., home age, home size (floor area in square feet), and number of occupants—by estimating their correlation coefficient values. The data on home age and size comes from online sources (aggregated by Home Energy Analytics); the number of occupants was self-reported by subscribers to the service.

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30 Ibid.

31 Data set provided by PlotWatt to the study team in January 2015; not publicly available.

32 Pacific Gas and Electric Company, "Electric Schedule E-1, Residential Services," December 2014, www.pge.com/tariffs/tm2/pdf/ELEC_SCHEDS_E-1.pdf (accessed January 23, 2015).

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