

Low Power Mode Energy Use in California Homes – Results from a 2008 Study

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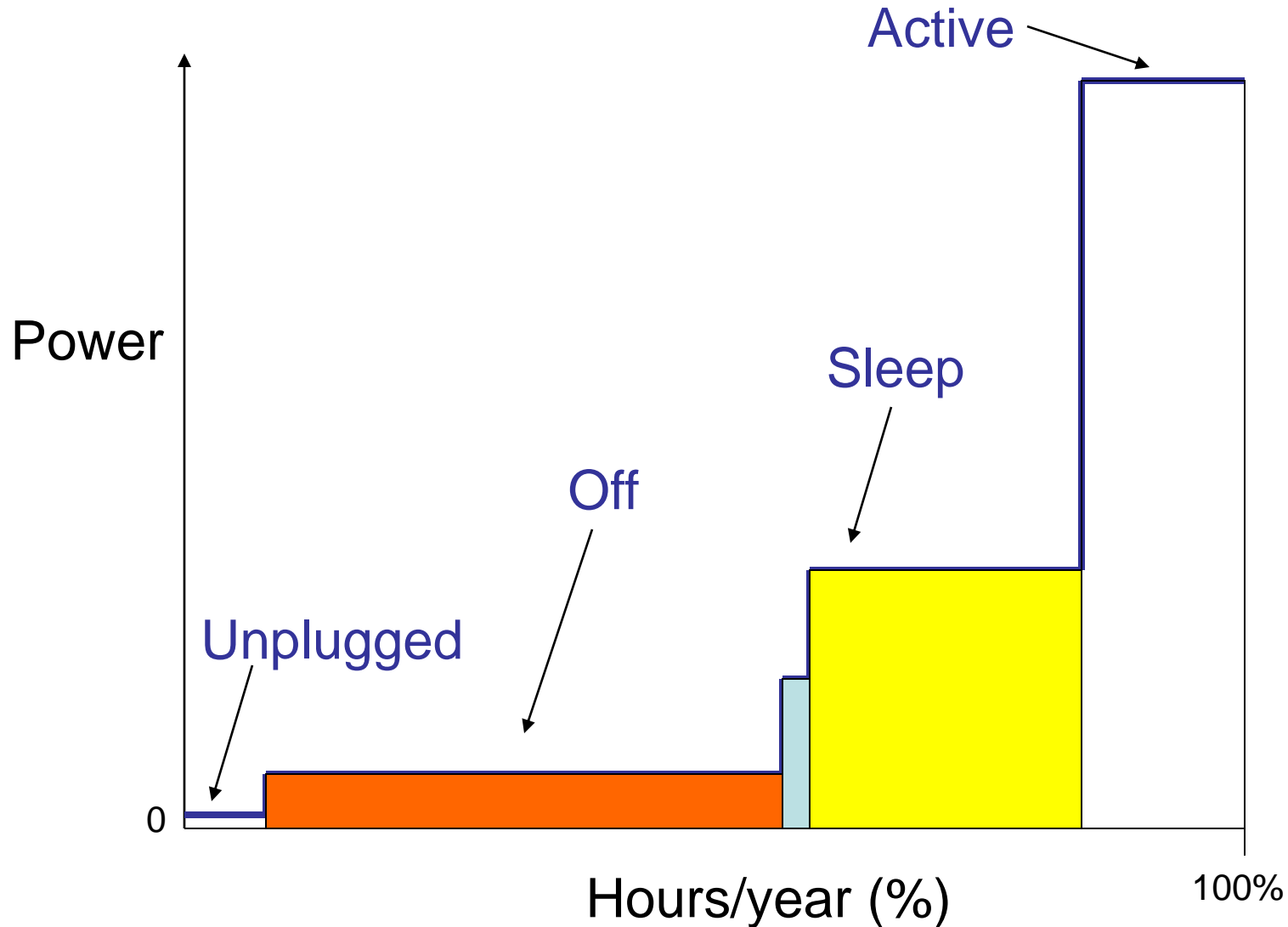
Project Goal: How Much Low-Power Mode Electricity is Consumed in California Homes?

- In what products?
- What factors affect low power mode energy use?
- Future energy use?
- Methodology for estimation?

The Answer: 112 watts/home

- 13% of California residential electricity use
- 980 kWh/year
- “Electronics” responsible for about half
- 44 products/home
- Lowest mode responsible for ~ 54 W
- Network mode present in relatively few products

Low Power Mode Energy Use



We Coined a Word: “lopomo”

- LOw POwer Mode
 - All functional modes where the product is not actively providing its intended primary service
 - Examples:
 - Microwave oven: not cooking
 - Set-top box not playing video to TV
 - TV not displaying image
 - Battery charger w/o batteries
- “One lopomo, two lopomos... lopomo energy use”
- **Network mode is a lopomo**

Methodology to Estimate Total Lopomo Energy in California Homes

1. Define products & modes
2. Perform exploratory studies
3. Collect data for each product
 - Saturations
 - Modes and power consumption in each
 - Usage
4. Aggregate

Data Collection

For each product type:

lopomo energy use =

$$(\text{no. of CA homes}) \times \text{saturation} \times \sum_{\text{all modes, } i} \text{power}_i \times \text{hours}_i$$

- For each product type, we need to know
 - Saturation
 - Power & operating hours for mode 1
 - Power & operating hours for mode 2
 - Power & operating hours for mode 3
 - Power & operating hours for mode 4

Diverse Data Sources

Power	Usage	Saturation
Spot measurements in 75 homes with analyses from RLW and Ecos	RLW telephone survey of 306 homes	RLW telephone survey of 306 homes
LBNL preliminary measurements of lopomo energy use in eight houses (from an earlier part of this project)	Ecos and RLW analyses of time series measurements in 50 homes	RLW/Ecos in-home survey of 75 homes
LBNL measurements of builder-installed miscellaneous energy	Surveys (e.g., Nielsen)	California Residential Appliance Saturation Survey (RASS)
Other LBNL measurements	Earlier phases of this project	California Lighting and Appliance Saturation (CLASS)
Australia (<i>in situ</i> and in-store measurements)	Magazine articles	Trade journals
Product technical specifications	Australian case studies	Trade associations
Measurements from other countries (principally Denmark, UK, Germany, New Zealand)	Journal articles, typically dealing with specific product types	Australian case studies
Journal articles	Other technical reports	U.S. DOE Residential Energy Consumption Survey (RECS)
Personal communications		Earlier phases of this project

Green boxes denote primary data collected for this project

Saturations

telephone survey of 306 homes
in-home audit of 75 homes
other sources

sample from data tables ---->

Appliance	Saturation
Air cleaner, portable	22.7%
Air conditioning, evaporative cooler	4.0%
Air freshener	13.3%
Aquarium	14.7%
Auto engine heater	0.0%
Automatic griddles	0.0%
Bicycle light	5.3%
Blanket	16.0%
Blender	76.0%
Breaker, AFI	5.3%
Breaker, GFCI	12.0%
Broiler	10.7%
Charger, hedge trimmer	4.0%
Charger, weed trimmer	8.0%
Coffee grinder	40.0%
Computer display, plasma screen	20.0%
Detector, carbon monoxide	9.3%
Detector, smoke	50.7%
External drive	8.0%
External power supply	0.0%
Fan, portable	141.3%
Fountain, indoor	6.7%
Furnace fans	5.3%
GFCI outlet	112.0%
Humidifier	9.3%
Infant monitor, receiver	8.0%
Karaoke machine	4.0%
Kettle	9.3%
Kiln	1.3%
Toaster oven	41.3%

Power Measurements

72 homes
62 product types
1,925 products
2 - 5 modes/product

sample from data tables ---->

Product/Mode	Mean (W)	Min (W)	Max (W)	Count
Charger, mobile phone				
On, charged	2.24	0.75	4.11	4
On, charging	3.68	0.27	7.5	23
Power supply only	0.26	0.02	1	32
Charger not connected to phone	0.14	0.14	0.14	1
Computer Display, CRT				
Off	0.8	0	2.99	21
On	65.1	34.54	124.78	21
Sleep	12.14	1.6	74.5	14
Computer Display, LCD				
Off	1.13	0.31	3.5	32
On	27.61	1.9	55.48	31
Sleep	1.38	0.37	7.8	30
Computer, desktop				
On, idle	73.97	27.5	180.83	63
Off	2.84	0	9.21	64
Sleep	21.13	1.1	83.3	52
Computer, notebook				
Fully on, charged	29.48	14.95	73.1	13
Fully on, charging	44.28	27.38	66.9	8
Off	8.9	0.47	50	19
Power supply only	4.42	0.15	26.4	19
Sleep	15.77	0.82	54.8	16
Heating, furnace central				
Off	4.21	0	9.8	16
On	339.71	70.5	796	14

Network mode present in some products

Operating Hours in Each Mode

Taken from:

- long-term monitoring of products in 50 homes
- Telephone survey
- Other reports and surveys
- Our guesses

Results:

California Lopomo Energy Use

	Per Home		California	
	Power	Energy/year	Power	Energy/year
Lopomo energy	112 W	982 kWh	1.29 GW	11,300 GWh
“Mode 1” energy (“standby” IEC 62301)	54 W	470 kWh	0.617 GW	5,410 GWh
Total residential electricity use	840 W	7,350 kWh	9.6 GW	84,500 GWh
Number of lopomo products	44		506 million	

Results probably apply to rest of USA

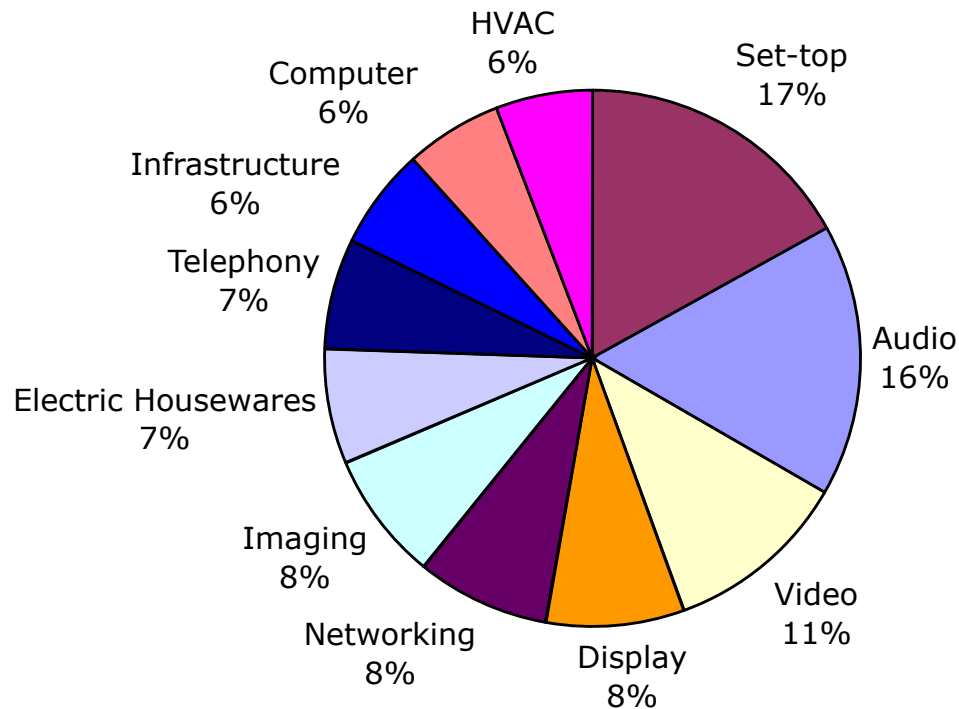
N.B. Study didn't capture “active” energy use of these products

Top Ten

Product Type	Average Lopomo Electricity Use Per Home		Fraction of Total Lopomo Energy Use
	(kWh/year)	(W)	
Set-top box, satellite	58	7	6%
Set-top box, digital cable	50	6	5%
Television, CRT	47	5	5%
Video, DVR	38	4	4%
Audio minisystem	38	4	4%
Computer, desktop	37	4	4%
Receiver (audio)	33	4	3%
Phone, cordless	33	4	3%
Air conditioning, central	27	3	3%
Oven, microwave	26	3	3%
Total of top 10	387	44	40 %

Lopomo is Highly Dispersed

but electronics are responsible for 80%



Future Lopomo Use

- 10 - 15 years out
- 11 assumptions regarding future technologies and saturations

Rise of network mode not explicitly considered

The fraction of products with low-power modes will increase for many product types

VCRs (and rewinders) and audio cassette decks will disappear

New & existing buildings will include more GFCI outlets and arc-fault interrupt breakers

Battery-powered smoke detectors will be gradually replaced by hard-wired detectors.

Most homes will have a central set-top box and two remote boxes to serve other televisions

CRT televisions and CRT displays will have been totally replaced by flat screens

Digital Television Adaptor came and disappeared

Wireless access devices will be present in all homes

The saturation of computers will continue to rise

Game console use will rise

New devices will appear that will have significant lopomo energy use

Future Lopomo Use

Total 132 W

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Product Type	Contribution to Average Lopomo Energy (kWh/year)	Power (W)
Future set-box	117	13.4
Computer, desktop	59	6.7
Wireless access point	41	4.7
GFCI outlet	39	4.5
DVD player	38	4.4
Video, DVR	38	4.3
Audio minisystem	38	4.3
Computer, notebook	35	4.0
Receiver (audio)	33	3.7
Phone, cordless	33	3.7
Air conditioning, central	27	3.1
Television, LCD	27	3.1
Oven, microwave	26	3.0
Multi-function device, inkjet	24	2.8
CD player	22	2.5
Clock, radio	22	2.5
Printer, inkjet	20	2.3
Garage door opener	19	2.1
Modem, cable	18	2.1
Heating, furnace central	18	2.0
Subwoofer	17	1.9
Game console	16	1.9
Future medical product	16	1.8
Future media product	16	1.8
Future display product	16	1.8
Total for top 25	775	88.4
Total for all product types	1162	112

Sensitivity & Uncertainty

- >2000 values estimated in this project
- Composition of uncertainty is complex
- We explored impact of certain kinds of errors:
 - ‡ a product type was overlooked (how large would it have to be to cause a 1% error?)
 - ‡ saturations were consistently underestimated
 - ‡ power consumptions were consistently underestimated
 - ‡ periods of time spent in low-power modes were incorrectly underestimated

Impact on Lopomo Energy Use from Different Kinds of Potential Errors

Type of Error	Impact
Overlooked product type	Missing product type's lopomo energy use must exceed 5.6 W with a saturation of 20% in order to change overall value 1%
Underestimated saturations	A 20% increase in saturations leads to 20% increase in lopomo energy use
Underestimated power values (by a percentage)	A 20% increase in all power modes leads to 20% increase in lopomo energy use
Underestimated power values (by 1 W in every mode)	A 32% increase in lopomo energy use
Incorrect estimates of the amounts of time that products remain in different modes	If products reside in lowest mode all the time, then lopomo energy use falls to about 100 W
	If products reside in highest mode all the time, then lopomo energy use rises to about 300 W

It is possible to devise scenarios where lopomo energy use is much higher than our estimate but our explorations demonstrate that such scenarios are highly unlikely for a variety of reasons. These explorations suggest that our estimate is robust.

Conclusions

Meier, A., B. Nordman, et al. (2008). “Low-Power Mode Energy Consumption in California Homes”. Sacramento, California Energy Commission.

- Low power modes are responsible for an average of 112 W/home
 - 13% of residential electricity use
 - 980 kWh/year
 - Lowest mode responsible for ~ 54 W
- “Electronics” responsible for about half
- 44 lopomo products/home
- Future: ~130 W/home
- “Standby” not going away but it is changing in character

Comparison With Other Studies

Location, Year, & Number of Homes*	What was Reported?	Results (per home)*
This report, California, 2007, all California homes	Combination of spot and long-term measurements, and estimates	44 lopomo products; 112 W lopomo; 54 W mode 1 power
Australia, 2005, 120 homes	Spot measurements of appliances in mode found by auditors	27 lopomo products; 83 W
New Zealand, 2006, 400 homes	Energy use of appliances for several weeks	50 W (after subtracting refrigerator)
Denmark, 2005	Spot measurements of mostly electronic products in various low-power modes	67 W lopomo
Portugal, Greece, Italy, Denmark, 2002, 297 homes	Spot and long-term measurements	46 – 60 W lopomo (but appears to include ~16 W for refrigerators and excluded very small products)
California, 2006, 14 homes	Spot measurements of builder-installed products in new, unoccupied homes	112 W lopomo (after subtracting refrigerator)
California, 2002, 10 California homes	Spot measurements of all accessible devices in various power modes	19 lopomo products; 67 W
Japan, 2005, unknown number of homes	Spot measurements and survey data	35 W
TIAX, 2007, all United States homes (assumed 120 million)	Measurements and estimates for electronics only, all modes, excludes digital TVs	45 W for sleep and off modes (based on their conclusion that 32% of 147 TWh of total is consumed while in off and sleep modes)

* We adjusted reported results to make them as comparable as possible including conversion of energy to average power and regional consumption to per home.

Recommendations

- Research
- Market Surveillance
- Regulations

Research Recommendations

- ***Develop networks, protocols, and network interface devices that minimize lopomo energy use.*** Networked products will be responsible for an increasing fraction of lopomo energy use. If networks are poorly designed, then the products will spend more time in unnecessarily high power modes.
- ***Develop technologies to reduce lopomo energy use in set-top boxes, tankless water heaters, and HVAC controls.***
- ***Develop technologies to reduce lopomo energy use in smoke detectors, ground fault interrupt circuits and other “hard-wired” applications.***
- ***Investigate the potential lopomo impacts of electric vehicles,*** including golf carts, Segways, wheelchairs, and electric bicycles. Minimum standards may be appropriate.
- ***Investigate the ways in which behavior can affect lopomo energy use.*** Results from this research could influence the design of network interfaces to encourage energy-saving behavior.
- ***Establish a research center to investigate technologies to reduce energy use in electronics.*** Energy conservation in electronics requires careful management of information flows, both within a single product and in networks of products, as well as improved components. Today, innovations from one product (such as mobile phones) often fail to get transferred to other products (such as set-top boxes). A dedicated research center could identify these innovations and accelerate the adoption of energy-saving technologies.

Market & Technology Surveillance Recommendations

- ***Undertake regular surveillance of new products and meter their power use in all modes.***
- ***Periodically measure lopomo (and active mode) electricity use in a sample group of California homes.*** Ten homes will still yield useful information.
- ***Revise residential appliance surveys (RASSes) to capture more information about presence of products with lopomo energy use.***
- ***Maintain the taxonomy of products in the “electronics” end use.*** An association of manufacturers or an independent non-profit organization might take responsibility for maintaining and updating this list.
- ***Establish a web site to display measurements from this study and future measurements.*** Public access to these measurements will allow better understanding of current energy use patterns and potentials for energy savings. The web site will also fulfill a useful consumer service.

Regulations Recommendations

- **Test procedures for white goods should be modified to capture loop energy use.**
- **Consider requiring auto power-down for equipment beyond set-top boxes.**
- **Consider regulating the efficiency of electricity consuming devices that are required by building codes in new homes.**

DVD Power Measurements

Table 8. Spot measurements of DVD Player power consumption in different modes

DVD mode	Power measurements (W)
Off	0 0 0 0 0 0
Average: 1.55 W	0.02 0.07 0.17 0.17 0.2 0.27 0.4 0.49 0.5 0.5 <u>0.58</u> 0.6 0.64 0.76 0.9
Count: 33	1.43 1.66 1.79 2.24 2.47 2.65 2.95 3.14 3.38 4.4 8.1 10.58
Ready	0.24 1.6 3.99 4.1 4.21 4.27 4.5 4.81 5.2 5.2 5.2 5.6 5.7
Average: 7.54 W	7.15 7.81 7.99 <u>8.09</u> 8.2 8.6 9.26 9.5 9.67 9.7 9.83 9.86 9.9
Count: 33	10.3 10.4 10.67 10.88 11.2 12.56 12.7
Active	5.28 5.85 5.95 6.1 6.15 6.28 6.5 6.5 6.5 6.74 7.6 8.52 8.72
Average: 9.91 W	9.1 9.4 9.5 <u>9.75</u> 10.22 10.3 10.4 10.84 11.07 11.1 11.24 11.75
Count: 33	12 12.59 12.86 13.7 15.4 15.52 16.5 17.17

Note: The median value for each mode is underlined in bold face.

Some observations about the DVD Player data:

- One product used more when off than most did when they were on (Ready or Active), even while playing.
- A fourth of the products used 0.1 W or less while off, with almost a fifth using no power (these of course can't then be switched on with a remote control).
- The range of power when Ready (which corresponds to on but not playing) was enormous—a factor of more than fifty different.
- The range of power when Active (on, playing) was about as large in absolute terms as with Ready (about 12 W), though just over a factor of 3 in relative terms.