

Electronics Come of Age: A Taxonomy for Miscellaneous and Low Power Products

Bruce Nordman and Marla Sanchez, Lawrence Berkeley National Laboratory

ABSTRACT

Most energy end uses such as space conditioning or water heating are apparently well-defined in what is included, and have terminology that derives from the professionals who work in the relevant field. The topic of “miscellaneous” consumption lacks such clarity for historical and practical reasons. As this end use grows in size and interest for the energy community, the confusion and ambiguity around the topic is an increasing barrier to progress. This paper provides definitions for key terms and concepts with the intent that that future work can be more correctly and consistently reported and interpreted. In addition, it provides a taxonomy of product types and categories, which covers both residential and commercial miscellaneous consumption. A key element is identification of “electronics” as a distinct energy end use. Finally, products are identified as to whether they commonly have a low-power mode, and product types that have such modes within the traditional end uses are also listed.

Introduction

Background

When building energy efficiency science emerged in the 1970s, attention was naturally drawn to the end uses that were the largest, most closely related to building services, potentially interactive with the building shell, and most easily characterized in traditional physics efficiency terms. These were climate control (HVAC), lighting, water heating, and major appliances (esp. refrigerators); we call these the “traditional” end uses. Other consumption was typically relegated to “Miscellaneous” or “Other”. In monitoring projects, it was common to meter the whole building and the traditional end uses, then calculate the residual for the miscellaneous loads.

Over the last 30 years, the traditional end uses have become more efficient (at least per unit floor area and service delivered) and the absolute amount of miscellaneous electricity consumption has risen. The number and types of miscellaneous products found in buildings has also increased. The result is a significant increase in the percent of electricity use in the “other” category. For highly efficient new houses, it can exceed 50%. There is increasing interest in this topic area, but no consistent set of terminology on which to base policy and analysis. Since so many product types are covered, definitions are sorely needed to avoid confusion.

Scope

This taxonomy covers only electricity used by mains-voltage (115 and 230 V for the U.S.) AC products. It does not include any gas consumption (standby or otherwise), but does include the electricity consumption of primarily gas products. It addresses primarily residential

and commercial buildings¹, but not exclusively. It does not cover low-voltage DC-powered products (e.g. USB or Power Over Ethernet), though the consumption of the latter are included in the products that provide the low-voltage DC such as computers and powered USB hubs.

Approach

In this project we surveyed current taxonomies of miscellaneous or low power products to draw inspiration for the approach and specific naming and categorization. We had previously reviewed issues related to power modes (Nordman 2004a) and brought the results of that analysis to the taxonomy. We combined the past approaches with knowledge of how this taxonomy could be used in the future to craft a system with the primary goals of consistency and clarity².

Key Terms

Definitions

Following are proposed definitions (“low power”, “product”, and “product type” taken or adapted from that specified in (Nordman 2004a)).

Low Power Mode³. Any mode in which a product is not performing any of its principal functions. Some products have more than one principal function. When feasible, low-power modes shall be categorized into on, sleep, and off modes. Disconnected is not a low power mode.

Standby. The minimum power mode of a product, or more formally, “the lowest power consumption mode which cannot be switched off (influenced) by the user and that may persist for an indefinite time when an appliance is connected to the main electricity supply and used in accordance with the manufacturer’s instructions.” (IEC 2005).

Product. A piece of equipment that can be powered directly from mains power. This covers a specific instance or model number.

Product Type⁴. A general category of product within which there is a sufficient amount of common functionality, modes, and behavior.

¹ One of the principal sources for miscellaneous products, Roberson 2004, included educational buildings in addition to strictly commercial ones. Most of the sources used are residential, so that our coverage of commercial miscellaneous products is considerably less comprehensive.

² The full version of the paper includes an appendix with additional information including a description of each of the source taxonomies. A spreadsheet of all of the raw data is also available.

³ This definition is expansive as it includes “ready” modes that are forms of “on”. It also is intended to include the powered mode of single-mode products.

⁴ This is the core term of interest to energy professionals, e.g. “dishwasher” or “TV, CRT”. Product types are differentiated “by capacity or other performance-related features that provide utility to the consumer and affect efficiency.” (U.S. Department of Energy (DOE). 1991. Energy Conservation Program for Consumer Products: Final Rule Regarding Energy Conservation Standards for Three Types of Consumer Products. Code of Federal Regulations, Title 10 Part 430, Vol. 56, No. 93, May 14, 1991. Docket No. CE-RM-88-101).

Electronics. Devices whose primary function is Information (obtaining, storing, managing, or presenting).

Traditional End Uses. HVAC, Lighting, Water Heating, and Major Appliances.

Major End Use. The Traditional end uses plus Electronics.

Miscellaneous. Any product type not included in any of the major end uses. “Other” should be taken as a synonym for Miscellaneous.

Overlooked Products. Devices that perform the function of a traditional end use but are not usually included in that end use’s total. We have these included in the Miscellaneous end use.

Plug Loads⁵. A product powered by means of an ordinary AC plug (e.g. 100, 115, or 230 V).

Hard-Wired Loads. A product with a direct-wired connection to an AC source. These can have switches or timers between the product and the AC source.

Category. A group of product types within a single end use that share common functionality or are otherwise logically related.

Key Topics

Electronics. In future building science policy and analysis, there should always be a separate end use of “Electronics” (Nordman 2004c) — covering products “... whose primary function is Information”. Most products in this end use were previously categorized as consumer electronics or office equipment. The electronics end use does not include electronic components of principally non-electronic devices (e.g. dishwasher controls) unless it is a separately powered device (powered from mains AC or from DC other than from the non-electronic device⁶). Electronic products can have significant non-electronic components. For example, a laser printer contains large heating loads but retains information presentation as the principal function. Electronics were formally part of miscellaneous but the magnitude of electronics consumption in both the residential and commercial sectors and consistency of function (information) across electronics makes it logical to recognize it as a distinct major end use⁷.

There are some products that can be reasonably argued to be within or outside of the electronics category, e.g. smoke and CO detectors (which provide information about potential fire status), and exit signs (which provide directional information rather than illumination in the usual sense). In both of these cases we did not include the product type in the electronics end use as their status in the infrastructure and lighting categories (respectively) seemed clearly established. In addition, at least at present, they do not usually connect to other electronic devices. By contrast, we have included the entire security category in electronics as the amount

⁵ This is often understood to exclude product types included in major end uses.

⁶ For example, a 24 VAC thermostat powered from a furnace is not considered electronics, but an electronic HVAC control powered by mains AC or by USB would be considered to be electronics.

⁷ “Office equipment” is now better characterized as IT as those products can and often are used for non-office purposes, particularly as used in the home.

of information is larger and increasing and the security devices are also increasingly linked to clearly electronic devices.

Miscellaneous. Miscellaneous is taken to be all building energy consumption (on the load side of the utility meter) that is not covered by any of the major end uses. This includes “overlooked” products — those that serve the broad functions of the major end uses but are not usually included in estimates (e.g. ceiling fans, humidifiers, space heaters). Per above, electronic products as a whole comprise a distinct end use and can no longer be mixed in with miscellaneous products.

Miscellaneous products span the range from the very small to the very large, both in electricity consumption and physical size. Examples range from staplers to pool pumps.

Low Power Modes. Low power mode consumption was reviewed in great detail in (Nordman 2004a). That paper took an expansive view of the concept, including “ready” modes and consumption of single-mode products. It is useful to look at these modes collectively across many product types. The purpose and potential efficiency, of low power mode consumption is often similar across products whose active functions are quite different. Note that per IEC 62301, “standby” is defined with respect to its power level and in practice can occur in any operating mode (On, Sleep, or Off).

The Taxonomy

Naming and Categorization

Traditional energy analysis deals with a small number of end uses with a modest number of product types within each end use. Allocation of product types to end uses is almost always obvious. Naming and categories are by no means trivial but are clearly driven by functional and capacity factors. By contrast, miscellaneous products lack clarity in categories, product types, and naming.

The number of different miscellaneous product types is large. For example, an assessment of just eight California houses, (Nordman 2004a) found 108 different product types among only products with low power modes (that is, not including miscellaneous products without low power modes). An audit of 16 commercial buildings (Roberson 2004) found 321 different product types without even assessing closets, plenums, basements, or attics.

Many past studies have listed and categorized product types, but the naming and grouping has generally been *ad hoc*. We reviewed the listing and naming of products in 28 different studies (listed in the References), each of which offered a system of product grouping that was typically secondary to the study scope.

Structure

This *taxonomy* covers two distinct but significantly overlapping topics: *miscellaneous* and *low-power mode* product types. Miscellaneous is the electricity end use which includes all products not included in other end uses (including arcane uses such as utility meter and wire

resistance losses⁸). The other end uses are the *traditional* ones — HVAC, lighting, water heating, major appliances — plus the new end use of *electronics*.

For each of the traditional end uses, there are products that are usually not counted as part of them but are performing the end use’s function. Examples are portable fans, task lights, point of use water heaters, and wine refrigerators (for HVAC, lighting, water heating, and major appliances respectively).

The overall structure is shown in Table 1. The taxonomy is divided into two major end uses plus the traditional end uses. Each end use is divided into a number of *categories*. There is one category for each traditional end use to accommodate low power mode consumption of these products — products without low power mode consumption in the traditional end uses are not included. There is also a category within miscellaneous corresponding to each traditional end use for the overlooked products. Most electronics are in categories that were formerly consumer electronics or information technology. Everything else is truly miscellaneous.

Table 1. Overall structure of the taxonomy

End Use	Categories
Electronics	Audio, <i>Cash exchange</i> , Computer, Display, Imaging, Networking, Peripherals, Security, Set-top, Telephony, Video
Miscellaneous	Business equipment, <u>HVAC</u> , <i>Commercial kitchen equipment</i> , Electric housewares, Hobby/leisure, Infrastructure, <u>Lighting</u> , <u>Major Appliances</u> , <i>Medical (lab, exam, and specialty)</i> , Other, Outdoor Appliances, Personal Care, Power, Transportation, Utility, <u>Water heating</u>
Traditional	HVAC, Lighting, Major Appliance, Water heating

Note. Italicized categories occur rarely if ever in residential buildings. Overlooked categories are underlined.

The degree to which product types are comprehensive or split into many pieces is a combination of a number of factors, including the similarity of the ultimate function provided, the key technology employed (e.g. inkjet vs. laser printers), capacity/size, power levels, usage patterns, stock-wide consumption, and ease of disaggregation. Some studies will find it useful or necessary to split some product types or to combine several. Over time, this taxonomy will change, as technologies and the stock of products evolve. The taxonomy reflects products in use rather than for sale.

In our review of relevant literature, we encountered numerous taxonomies of product categories. Table 2 provides an overview of some categorizations we found during our review. The order of the categories has been changed to provide some correspondence across these examples.

The variety and scope of the categories included varied widely. For example, office and consumer electronics were treated in many different ways, with office equipment variously characterized as IT, treated as a separate equipment category, or wrapped into the consumer electronics category as a whole. Different studies included or dropped entire categories, and the naming showed wide variation. The current version of the taxonomy is presented in Table 3.

⁸ The loss from electrical resistance of wiring within buildings is not due to the use of a “product” *per se*, but accounting for it as such is the best way to include it in total building consumption.

Table 2. Product categories used in five sample studies

Australia	Lebot	Sanchez	Rosen	Ross
IT	IT	Electronics	Office	Computer
Entertainment	Video		Video	Entertainment
	Hi-Fi		Set-top	
			Audio	
	Telephone Systems		Telephony	Communication
Major Appliances	Cooking	Motor		Miscellaneous
Small Appliances	Miscellaneous	Heating		
		Lighting		

Australia: Ministerial Council on Energy Forming Part of the National Greenhouse Strategy. Money Isn't All You're Saving. Australia's Standby Power Strategy 2002-2012. **Lebot:** Lebot, Benoit et al. Global Implications of Standby Energy Use. **Sanchez:** Sanchez, M. et al. Miscellaneous Electricity Use in the U.S. Residential Sector. **Rosen** Rosen, K. et al. National Energy Use of Consumer Electronics in at the end of the Twentieth Century. **Ross:** Ross, JP and A. Meier. Whole House Measurements of Standby Consumption.

Table 3. The Miscellaneous and Low Power Taxonomy: May 10, 2006 version (Residential)

Electronics

Audio	Dock, notebook	Scanner, flatbed
Amplifier	Display	Networking
Audio minisystem	Computer display, CRT	Hub, ethernet
Cassette deck	Computer display, LCD	Hub, USB
CD player	Computer display, plasma screen	Modem, cable
CD player, portable	Game console, portable	Modem, DSL
Charger, digital music player	Projector, slide	Modem, POTS
Equalizer (audio)	Projector, video	Router, ethernet
Home theatre system	Television, large CRT	Wireless access point
Karaoke machine	Television, LCD	
Musical keyboard	Television, plasma	Peripherals
Radio, table	Television, rear projection	CD recorder
Receiver (audio)	Television, standard CRT	Dock, PDA
Speakers, powered	Television/VCR	External drive
Speakers, wireless (base station)		Speakers, computer
Speakers, wireless (speakers)	Imaging	
Stereo, portable	Copier	Security
Subwoofer	Fax, inkjet	
Tuner	Fax, laser	Security system
Turntable (audio)	Fax, thermal	
Computer	Multi-function device, inkjet	Set-top
Computer, desktop	Multi-function device, laser	
Computer, integrated-CRT	Printer, inkjet	Set-top box, analog cable
Computer, integrated-LCD	Printer, laser	Set-top box, digital cable
Computer, notebook	Printer, photo	

Set-top box, digital cable with PVR
 Set-top box, game console
 Set-top box, game console with internet connectivity
 Set-top box, internet
 Set-top box, PVR
 Set-top box, satellite
 Set-top box, satellite with PVR

Answering machine
 Caller ID unit
 Charger, mobile phone
 Phone
 Phone, conference
 Phone, corded
 Phone, cordless
 Phone, cordless with answering machine

Video

Charger, still camera
 Charger, video camera
 DVD player
 DVD recorder
 VCR
 VCR/DVD
 Videocassette rewinder

Telephony

Miscellaneous

Business equipment

Adding machine
 Pencil sharpener
 Shredder
 Stapler
 Typewriter

Toaster
 Toaster oven
 Vacuum, central
 Vacuum, rechargeable
 Vacuum, standard
 Waffle iron

Garage door opener
 GFCI outlet
 Infant monitor, receiver
 Infant monitor, transmitter
 Utility meter
 Wire losses

Electric housewares

Automatic griddles
 Blanket
 Blender
 Bread maker
 Broiler
 Clock
 Clock, radio
 Coffee grinder
 Coffee maker, residential
 Corn popper, air
 Corn popper, hot oil
 Deep fryer, residential
 Espresso maker, residential
 Food processor
 Food slicer
 Frying pan
 Hand mixer
 Heating pad
 Hot plate (kitchen)
 Iron
 Juicer
 Kettle
 Knife
 Mug warmer
 Oven, microwave
 Pasta maker
 Rice maker
 Sewing machine
 Slow cooker
 Stand mixer

Hobby/leisure

Aquarium
 Kiln
 Pool
 Sauna, electric
 Spa/hot tub

HVAC

Air cleaner, mounted
 Air cleaner, portable
 Air conditioning, evaporative cooler
 Ceiling fan
 Dehumidifier
 Exhaust fan
 Fan, portable
 Fan, rangehood
 Fan, whole house
 Fan, window
 Furnace fans
 Heating, fireplace electric
 Humidifier
 Space heater, portable (electric)
 Space heater, portable (non-electric)

Infrastructure

Breaker, AFI
 Breaker, GFCI
 Detector, carbon monoxide
 Detector, smoke
 Doorbell

Lighting

Dimming switch
 Emergency light, interior (commercial)
 Grow lamps
 Lamp, decorative
 Lights, holiday
 Low voltage landscape
 Motion sensor, exterior
 Motion sensor, interior
 Night light, interior
 Photosensors, exterior
 Timer, exterior
 Timer, interior

Major Appliance

Garbage disposal
 Refrigerator, wine cooler
 Trash compactor
 Water dispenser, bottled

Other

Fountain, indoor
 Waterbed

Outdoor Appliances

Charger, hedge trimmer
 Charger, weed trimmer
 Coil, snow melting

Grill, outdoor	Power	Bicycle light
Lawn mower		Charger, battery
Timer, irrigation	External power supply	Floor polisher
Personal Care	Power strip	Pet fence
	Power supply	Power tool
Air freshener	Surge protector	Power tool, cordless
Curling iron	Timer	Pump, sump
Hair dryer	Uninterruptible power supply	Pump, well
Heat lamp	Transportation	Water heating
Home medical equipment		
Massager	Auto engine heater	Water heating, instantaneous
Shaver	Car, wheelchair or golf cart	single point of use
Toothbrush		Water heating, point of use tank
Water softener	Utility	

Traditional End Uses

HVAC	Lighting, residential	Dishwasher
Air conditioning, central		Freezer
Air conditioning, heat pump	Major Appliance	Oven, electric
Air conditioning, room/wall		Oven, gas
Heating, boiler	Clothes dryer, electric	Refrigerator
Heating, furnace baseboard, floor or wall unit	Clothes dryer, gas	Water heating
Heating, furnace central	Clothes washer, horizontal axis	Water heating, electric
Heating, heat pump	Clothes washer, standard	Water heating, gas
Lighting	Cooktop, electric	Water heating, heat pump
	Cooktop, gas	Water heating, other

Product Type Naming

We brought a variety of principles to the process of selecting names for product types.

- Strive for brevity, e.g. dropping “electric” from “electric knife” since non-powered knives would obviously not have energy consumption. Also use common acronyms like “TV”, “CD”.
- Give preference to names used in ordinary language. Avoid brand names.
- Use commas to distinguish related types of products, e.g. “TV, CRT” and “TV, LCD” or “Clothes dryer, electric” and “Clothes dryer, gas”. Related types need not be in the same category.
- Use “/” within lists rather than commas. Use only one comma; if more needed use parentheses and “(’s)”.
 • Use parentheses to denote product types that share a common name, e.g. “Amplifier (network)” and “Amplifier (audio)”.
- Distinguish between products that can be run off of integral rechargeable batteries (“rechargeable products”) from those that cannot (“non-rechargeable products”). Non-rechargeable products includes both those that can be run from AC or generic batteries and those that can only be powered by AC (e.g. some audio minisystems); this distinction is not considered

significant for the purposes of the taxonomy. It is not considered significant whether a battery powerable product can be used while being AC powered (e.g. many shavers, mobile phones) from those that can't (e.g. power tools, some vacuums).

- “Portable” as a suffix is to indicate if something can be easily moved, not whether it can be powered by batteries.

Product Types in the Traditional End Uses

We relied primarily on RECS category definitions to determine which products were grouped into the traditional end uses, though we have modified these, and will be seeking clarification on how the RECS definitions are applied. Our lists are shown in Table 4.

For HVAC and Water heating, we used the RECS definitions directly. RECS includes many products in “appliances” that seem to not merit the “major” name and are not likely included in most energy analysis estimates of appliances. Examples include: evaporative coolers, spas, and waterbed heaters. For lighting, RECS includes “Energy used to supply electricity to light bulbs inside and outside of the housing unit. All types of light bulbs are included: incandescent, fluorescent, compact fluorescent, halogen, and high-intensity-discharge (HID),” and includes lighting in the general “appliance” category. We use a narrower definition. “permanently installed” includes products that are hardwired as well as those that have plugs but are screwed down or otherwise firmly attached.

Table 4. Products Types included in the Traditional End Uses

End Use	Included
HVAC	Boiler, heat pump, central furnace, heater (baseboard, floor, or wall unit — any fuel type), central air conditioning, heat pump and air conditioner (room or wall unit)
Water heating	Tank units (electric, gas, heat pump, and other fuel types, such as LPG)
Major appliances	Clothes dryer, clothes washer, dishwasher, refrigerator, freezer, oven, and cooktops
Lighting	Permanently installed fixtures (interior), permanently installed fixtures (exterior), floor lamps, table lamps

Product Type Attributes

In (Nordman, 2004a), products types were categorized as one of four types for the likelihood of having low-power modes as defined in Table 5 (from (Nordman, 2004a)). Estimates of energy consumption need to take into account the fraction of the time that examples of each product type actually have a low power mode at all. This affects understandings of power levels and usage patterns. The taxonomy spreadsheet indicates which product types sometimes or always have low power modes.

Table 5. Attributes of Product Types

Product Type Classification	Characteristic	Examples
Always	Always (or nearly always) have low-power modes.	Cordless telephone

Sometimes	Some examples have low-power modes; others do not.	Ceiling fan, radio, toaster
Never	Never [or rarely] have low-power modes	Corded power tools
Excluded	Not included in this measurement procedure, regardless of whether or not they have low-power mode consumption.	Refrigerator

Note: The concept of an excluded product type does not apply to the taxonomy.

Details

In some cases the principal function is not absolutely clear. For example, is a clock radio mainly a clock or mainly a radio? While the energy use, cost, and physical size may be driven more by the radio feature, we judged that these are foremost used as clocks and only secondarily as radios. This does not preclude an audio system from having a clock on its display; these will be judged to be principally audio devices with the clock only incidental.

For audio equipment, an “Audio minisystem” (or compact audio system) is one in which the speakers sold with the product can be physically detached from the main electronics. This is in contrast to a “Stereo, portable” which has integral non-detachable speakers. In the comments, a “Rack” system is a set of separately-powered components that are often sold as a unit that match and readily stack. This provides the equivalent of separately purchased independent components.

Future Development

We have included commercial products found in studies we reviewed, though few of the studies had the commercial sector as a focus. At present, only the Roberson report and Energy Star commercial kitchen products are included. A key missing area is much of commercial building infrastructure.

As the taxonomy evolves over time, it should be republished with dated versions and clear differences identified from previous ones (this version is dated May 10, 2006).

Conclusions

A major result of this taxonomy is that electronics should be considered a major end use on its own, distinct from miscellaneous products. While products in the traditional end uses are not a particular focus of this project, it is necessary to know what precisely is in them to know what is or is not in the miscellaneous category. Products can be named in a reasonably consistent manner and put into categories that well serve many purposes — no taxonomy is ideal for all purposes (for example, hardwired products are not a distinct category as the fact of being hardwired is not related to the function which is our criteria for assigning to categories). This taxonomy is not the ultimate — and it will always evolve over time — but this should get the energy efficiency community most of the way towards a consistent framework for naming and categorizing these products.

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