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Space Heaters, Computers, Cell Phone Chargers: How Plugged In Are Commercial Buildings?

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DISCLAIMER

ABSTRACT

Evidence of electric plug loads in commercial buildings is visible everyday: space heaters, portable fans, and the IT technician's two monitors connected to one PC. The Energy Information Administration estimates that office and miscellaneous equipment together will consume 2.18 quads in 2006, nearly 50% of U.S. commercial electricity use. Although the importance of commercial plug loads is documented, its very nature (diverse product types, products not installed when building initially constructed, and products often hidden in closets) makes it difficult to accurately count and categorize the end use.

We audited sixteen buildings in three cities (San Francisco, Atlanta, Pittsburgh) including office, medical and education building types[1]. We inventoried the number and types of office and miscellaneous electric equipment as well as estimated total energy consumption due to these product types. In total, we audited approximately 4,000 units of office equipment and 6,000 units of miscellaneous equipment and covered a diverse range of products ranging from electric pencil sharpeners with a unit energy consumption (UEC) of 1 kWh/yr to a kiln with a UEC of 7,000 kWh/yr. Our paper presents a summary of the density and type of plug load equipment found as well as the estimated total energy consumption of the equipment. Additionally, we present equipment trends observed and provide insights to how policy makers can target energy efficiency for this growing end use.

Introduction

Each year, the Energy Information Administration (EIA) publishes the Annual Energy Outlook (AEO). In the AEO 2006 commercial building summary, a couple of key figures stand out. In 2006, "other uses" of electricity consume over 1.6 Quads and office equipment consumption climbed to over 0.5 Quads. Combined, these two end-uses consume nearly half of the total electricity for commercial buildings.

While overall consumption and historic growth make these two end uses prime research targets, their very characteristics complicate robust data collection efforts. There is a large amount of variation in miscellaneous equipment across any sample of commercial buildings because it depends not just on building function but also on the types of products that employees choose to bring to work, which can be determined by work policy and/or personal preference. Miscellaneous equipment is often "out-of-sight" meaning that it is frequently located in utility or equipment closets, which allows it to be overlooked during energy audits and it is frequently unreported by building owners and energy managers either because it is dismissed as being unessential to building energy operations or because it remains an unknown factor to these key personnel. Similar to office equipment, miscellaneous equipment consumption varies heavily with individual user behavior.

The result of these factors is that even though the miscellaneous end use is the largest individual commercial electricity end use, we actually know surprisingly little about the end use itself. Our study objective was to build the foundation of a commercial plug-load equipment

[1] Later we refer to just twelve buildings as we aggregated the five small office buildings into just "one" small office.

database that inventoried the stock of both office equipment (OE) and miscellaneous equipment (ME) types that are found in commercial buildings. In order to better estimate consumption of commercial office equipment, this database also includes turn-off and power management rates for office equipment. Ultimately, this data can be used to estimate consumption and identify/determine ways to increase control of, and ultimately lower building electrical use. It was never our study goal to survey enough buildings to allow us to state with statistical certainty the profile of miscellaneous electricity across commercial buildings. It is our goal to generally characterize the ME and OE end use within certain building types by determining the number and types of units present. To meet our objective, we conducted a series of after-hours surveys in a total of sixteen buildings in three cities (San Francisco, Pittsburgh and Atlanta).

Methodology

To gather data on miscellaneous equipment, we conducted a series of after-hours surveys in commercial buildings located in San Francisco, Pittsburgh and Atlanta (for a complete description, refer to Roberson 2004). We recorded the number and types of ME and OE. We also recorded the power status of ME as well as the turn-off rates and power management success rates of OE[2].

Definition

ME refers to plug-load devices whose energy use is not usually accounted for by building energy managers because they are portable, often occupant-provided units whose number, power consumption and usage patterns are largely unknown. All ME in this report, including lighting, is plug-load, as opposed to hard-wired. Our definition of ME excludes "traditional" end uses such as primary space heating/cooling, ventilation, water heating, and any hard-wired lighting or refrigeration equipment. Office equipment includes the following equipment categories and types:

- computers: desktop, laptop (notebook or mobile), server, and integrated computer system (ICS);
- monitors: cathode ray tube (CRT), and liquid crystal display (LCD);
- printers: impact, inkjet, laser, thermal, solid ink, and wide format;
- fax machines: inkjet, laser, and thermal;
- copiers;
- scanners: document, flatbed, slide, and wide format; and
- multi-function devices: inkjet and laser.

Building Sample

[2] We recorded the power status of ME in order to later be able to better estimate unit energy consumption for product types with multiple modes. The office equipment portion of this analysis was initiated by the US Environmental Protection Agency's Energy Star Program and a portion of this project was aimed at estimating the success rate of power management enabling, office equipment turn-off rates and then using these inputs to estimate current consumption of commercial office equipment as well as calculate savings attained by the Energy Star office equipment program.

Our building types were selected based on the office equipment portion of the building audits. According to CEBCS 2002, 74% of the U.S. population of computers was found among office, education, and health care buildings; therefore, our building recruitment effort focused on these three types of buildings. This is only a subset of the total population of building types. A differently structured sample would have likely resulted in a different distribution of the number and types of ME.

In our analysis, a small office has <50 employees, a medium office has 50-500 employees, and a large office has >500 employees on site. In characterizing the size of an office, we do not consider employees working at other site locations. We also do not consider the number of employees that work outside of the audit space location. Our 'small office' is actually aggregated results for five small businesses in three different buildings: (1) a graphics and printing business, (2) an environmental consulting firm, (3) a commodity brokerage firm, (4) a software development firm, and (5) an engineering firm. Their number of employees ranged from 4 to 25, with a collective total of 77 employees[3].

Data Collection

We conducted each survey on a weekday evening or weekend. A team of four people participated in each survey and each survey took up to four hours to complete. Using a floor plan, clipboard, flashlight and tape measure, we systematically recorded each plug-load device. Our data collection was as unobtrusive as possible, if a workspace was occupied or obviously in use, we skipped it and returned later, if possible.

In each building, we surveyed as much area as possible in four hours or until we covered the area accessible to us, whichever came first. For each unit of ME, we recorded any information that could be used to estimate unit energy consumption. For lighting, we recorded lamp type, wattage, and fixture type. For battery chargers, we noted the portable component and whether the charger was empty or full. For vending machines, we recorded temperature, type of product vended and any product lighting information. We recorded power status of ME where applicable. For unknown equipment we noted make and model for later determination of identity and power specifications. We also noted if there was a plug-in power supply or an in-line power supply.

For each unit of OE, we recorded the make (brand) and model as it appears on the front or top of the unit. We recorded the diagonal measurement, to the nearest inch, of monitor screens, except those of laptops. In order to subsequently calculate equipment turnoff rates and power management success rates, the power state of each unit was recorded as on, low, off, or unplugged (exception: we did not record units that were unplugged if it appeared they were never used). We did not record load data. A detailed summary of our procedure for determining OE power states is found in Roberson 2004.

[3] The aggregation of the small offices results in the 12 survey buildings as cited in tables (as opposed to 16 actual surveyed).

Results

Overall Equipment Density

Table 1 shows a summary of the buildings in the survey as well as the number and density of OE and ME found in each building. Our survey captured data on over 10,000 units of equipment, including almost 4,000 units of office equipment and over 6,000 units of miscellaneous equipment (note that the one small office building listed is actually an aggregate of five small office buildings surveyed).

Figure 1 shows that education buildings in our sample had the lowest equipment densities overall. Among our sample of 12 buildings, the building types with the highest densities are small and large offices. We suggest that small offices may have high equipment density because every office needs certain devices (e.g., copier, fax machine, microwave oven, refrigerator), regardless of how many or few people share it. Medium offices exhibited the largest range of density, but on average their total equipment density is similar to that of health care facilities.

Closer examination of the results for each building reveals some underlying trends. For example, the large variation in OE density between the two large office buildings is largely due to the fact that site M employees rely on laptop computers (most of which were absent during our visit; company policy requires employees to take their laptops home or lock them up when not at work). As a result, the computer density at that site was only 1.8 computers/1000 ft^2. Similarly, site E (medium office building) also relied largely on laptop computers, which resulted in a computer density of only 1.7/1000 ft^2 and explains the very low OE density for that site.

Figure 1. Office and Miscellaneous Equipment Density by Building Type

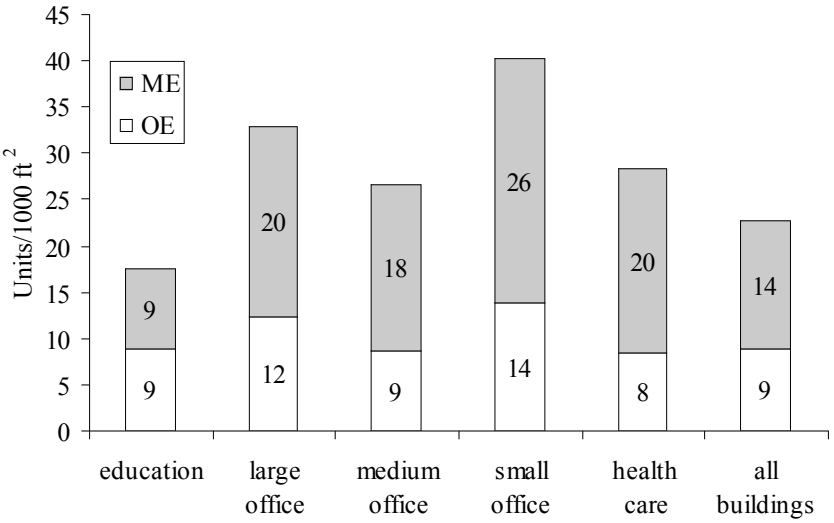


Table 1. Office and Miscellaneous Equipment: Number of Units and Density sorted by total units (units/1000 ft^2)

				Number of Units				Equipment Density (units/1000 ft^2)		
bldg type	**site**	**Location**	**Bldg. Description**	**OE**	**ME**	**Total**	**Ft^2 Surveyed**	**OE**	**ME**	**Total**
large office	**C**	GA	corporate headquarters	536	616	1,152	28,000	19	22	41
medium office	**H**	GA	information services dept	340	630	970	24,000	14	26	40
small office	**K**	PA	5 small businesses combined	275	528	803	20,000	14	26	40
health care	**G**	CA	outpatient clinic	460	1,002	1,462	45,000	10	22	32
medium office	**E**	GA	business consulting firm	97	444	541	22,000	4	20	25
large office	**M**	PA	corporate headquarters	227	753	980	40,000	6	19	25
health care	**J**	PA	private physicians' offices	171	458	629	26,000	7	18	24
education	**A**	GA	university classroom bldg	377	259	636	28,000	13	9	23
education	**P**	GA	university classroom bldg	204	234	438	20,000	10	12	22
medium office	**B**	PA	non-profit headquarters	410	422	832	55,000	7	8	15
education	**D**	CA	high school	258	291	549	40,000	6	7	14
education	**F**	PA	high school	573	597	1,170	100,000	6	6	12
all buildings				**3,928**	**6,234**	**10,162**	**448,000**	**9**	**14**	**23**

Office Equipment Turn-Off Rates

Of the office equipment found in our survey, we want to determine the extent to which users in commercial building turn-off their equipment at night, as well power management success rates. Our sample includes data on the power state of 1,464 desktop computers, 1,630 monitors, 363 printers, 90 servers, 65 multi-function devices, 59 fax machines, 46 integrated computer systems, 38 scanners, and 40 copiers. 'Turn-off rate' is the percent of each equipment type that is turned off, while 'PM rate' is the percent of those *not off* that are in low power. **Table 2** shows the numbers of each type of office equipment, and their after-hours power state[4].

[4] We note that "after-hours" may not be a direct simulation of during-hours conditions, but this was typically the only time that we had access to the building, employee workstations and equipment. Note that PM rate only applies to those units that were not turned off during audit (meaning that if a facility had a high turn-off rate, it could theoretically still have a low PM rate under certain conditions). In this study, we do not address the achieved power level of the sleep state.

Table 2. Office Equipment: After-Hours Power States

		Number					Percent				
		low	off	on	unplugged	total	low	off	on	unplugged	PM rate
computers	desktop	60	524	869	11	1464	4%	36%	59%	1%	6%
	server	0	2	87	1	90	0%	2%	97%	1%	-
	ICS	11	27	7	1	46	24%	59%	15%	2%	61%
monitors	CRT	648	422	259	12	1341	48%	31%	19%	1%	71%
	LCD	164	49	56	17	286	57%	17%	20%	6%	75%
	plasma	0	2	1	0	3	0%	67%	33%	0%	-
printers	laser	81	24	53	0	158	51%	15%	34%	0%	60%
	inkjet	0	37	86	8	131	0%	28%	66%	6%	-
	impact	0	6	16	0	22	0%	27%	73%	0%	-
	thermal	0	7	31	2	40	0%	18%	78%	5%	-
	wide format	0	6	2	0	8	0%	75%	25%	0%	-
	solid ink	3	0	1	0	4	75%	0%	25%	0%	75%
MFDs	all	18	15	31	1	65	28%	23%	48%	2%	37%
copiers	all	5	18	14	3	40	13%	45%	35%	8%	26%
fax machines	all	3	0	56	0	59	5%	0%	95%	0%	5%
scanners	all	12	14	8	3	37	32%	38%	22%	8%	60%

1. Table only includes units for which we recorded power status.
2. "PM rate" or *power management success rate* is the percent of units not off that were in low power.

Not surprisingly, turn-off rates were lowest among fax machines and server computers. Turn-off rates were highest for integrated computer systems (59%), copiers (45%), and scanners (41%)[5]. PM rates were highest among LCD monitors (75%), CRT monitors (71%), ICSs (61%), scanners (60%), and laser printers (60%).

Because copiers and MFDs often have long (2-4 hour) PM delay settings that may not have elapsed at the time of our visit, PM rates in Table 2 for this equipment should be considered a minimum or lower bound. The lowest power management rates were among desktop computers and fax machines (6% and 5% respectively).

Although the power management success rate among desktop computers is low, it is similar to the 5% rate found in a previous study (Webber et al. 2001) and is likely indicative of actual user behavior and the complexity of the office equipment environment. For example, at Site M, the building manager informed us that company policy (a consequence of a previous fire due to a piece of malfunctioning electronic equipment that had been left on all night) dictated that all office equipment was to be turned off each night and that no *personal* electric devices or electronics were allowed to be brought into the workplace. Since security patrolled each night enforcing the policy, we were assured that we would find little ME and no units of OE left on during the audit. What we actually found was plenty of personal fans and space heaters as well as equipment turn-off rates that weren't any different than the average for the buildings in our survey.

Miscellaneous Equipment

[5] Turn-off rates were also high for plasma monitors and wide format printers, but we did not have a large sample size of units.

To begin our analysis, we created a taxonomy for the commercial miscellaneous electricity end use (included as an appendix). Specifically, we named each individual equipment type and then more broadly assigned each equipment type to an end use category. Our taxonomy includes the following end use categories:

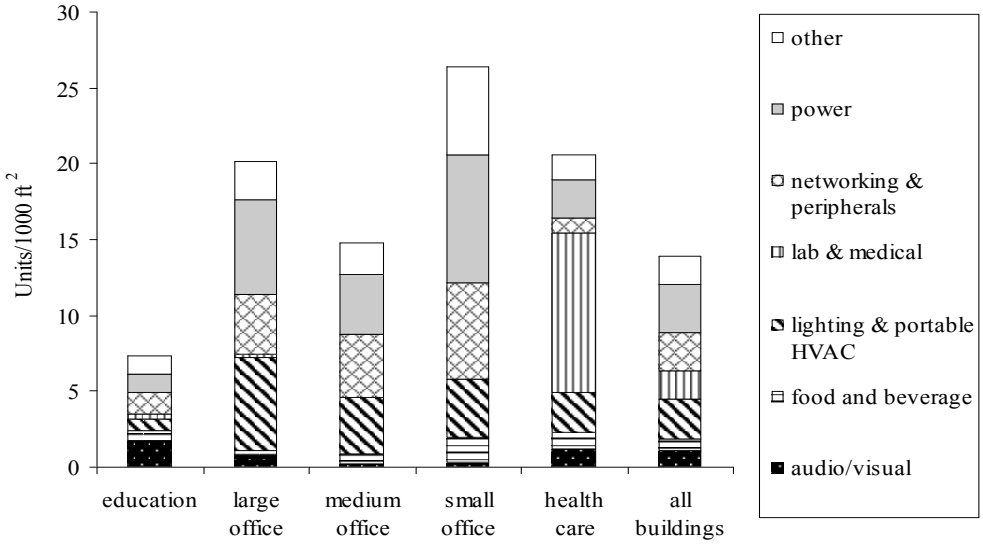
- audio/visual, lighting and portable HVAC, lab and medical (*includes laboratory, medical and medical specialty*), networking and peripherals, power, other (*includes money exchange, office miscellaneous, security, specialty, telephony, utility/maintenance*)

ME Results

We encountered a wide range of types of ME during our audit. We documented numerous equipment types that we expected to see such as powered phones, computer speakers and cell phone chargers. We also documented several truly miscellaneous products such as walkie-talkie chargers, electric air fresheners, decorative water fountains, and even a levitating globe. In total, ME outnumbered OE at all sites except one (a university, site A). On average, the ratio of ME to OE was 1.5:1 and in one instance (a medium office, site E), the ratio of ME to OE was 4.6:1.

Figure 2 shows the distribution of miscellaneous equipment by building type. Audio/visual was the single largest category in education buildings while lab and medical was the single largest category in health care buildings. In office buildings, the lighting/portable HVAC, networking/peripherals, and power categories dominated. Education buildings had the lowest overall ME density and small office buildings had the highest ME density. It is not surprising that small offices had the highest equipment density. Our audit of 5 small offices (consisting of just 77 total employees) revealed 17 boom boxes, 15 clock radios, 4 compact audio systems, and 6 refrigerators. For *all buildings*, "power" had the highest equipment density (includes power strips, surge suppressors), followed by "lighting/HVAC" (particularly under-cabinet and compact fluorescent lamps), and then "networking/peripherals".

Figure 2. Miscellaneous Equipment Density by Building Type



In addition to estimating equipment density, we calculated the total energy consumption of ME in the surveyed buildings to accomplish the following: generate order-of-magnitude consumption estimates of ME for surveyed building types, estimate the percentage load due to ME for surveyed building types, and compare our estimates to AEO.

To calculate total energy consumption of the ME, we estimated typical unit energy consumption (UECs) for over 70% (230 of 321 types) of ME found among buildings in this survey. We used data from previous metering projects and other available sources to estimate power and operation hours. In some cases we found UEC estimates in the literature. To estimate power consumed in each power state, we relied primarily on metering data by Lawrence Berkeley National Laboratory and others, online and published sources, and comparison to similar devices for which we have data (AD Little 1996, Cadmus 2000, USDOE 1995, Wenzel 1997). Our UEC estimates ranged from 1 kWh/yr for pencil sharpeners to 7,008 kWh/yr for kilns; total energy consumption (TEC) estimates ranged from 1 kWh/yr (e.g., for one shaver) to almost 80,000 kWh/yr for 24 refrigerated vending machines.

Because of the high UECs associated with many food and beverage equipment types, the energy intensity of this category is considerably higher than its relative equipment densities would predict. Even though educational buildings had the lowest equipment densities, these buildings had relatively high-energy intensities because of the food and beverage equipment found in the survey (**Figure 3**).

Figure 3. Energy Intensity of Miscellaneous Equipment by Building Type

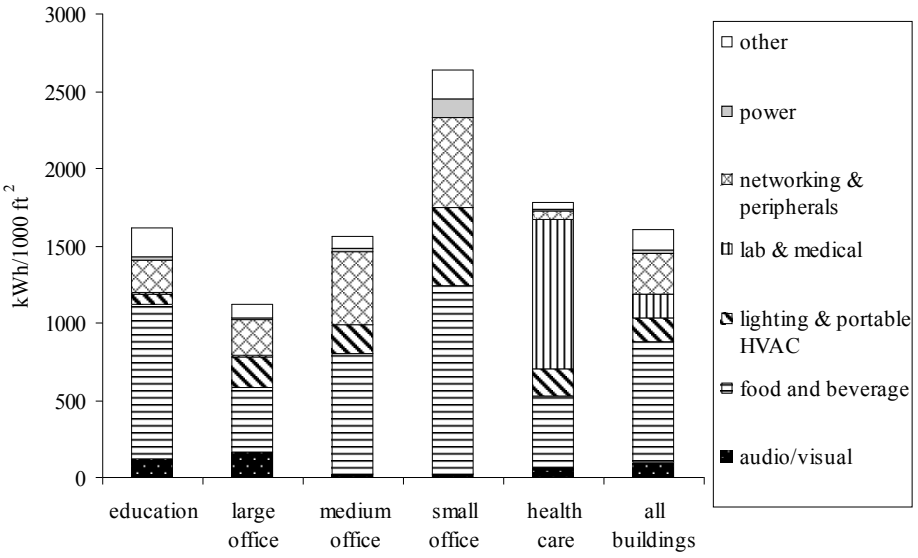


Table 3 shows the energy dominance of the food and beverage category. In terms of total energy consumption, the top 25 equipment types consumed nearly 75% of all commercial electricity accounted for in the buildings surveyed (they account for 32% of the total number of units found in the buildings). Eleven of the 25 top end uses were from the food and beverage category (representing over 40% of the miscellaneous electricity surveyed).

Table 3. Top 50 Miscellaneous Equipment Types Ranked by TEC

Ranking	Code	Equipment Type	UEC (kWh/yr)	Total Units	Sum Total Units	Annual Consumption (kWh/yr)	% Total Miscellaneous	Sum Miscellaneous Electricity
1	F/B	vending machine, cold beverage	3,318	26	0%	86,268	12%	12%
2	F/B	refrigerator, commercial	4,300	20	1%	86,000	12%	24%
3	PERI	speakers	74	501	9%	36,866	5%	29%
4	NETW	switch, ethernet	17	78	10%	34,353	5%	34%
5	F/B	freezer, commercial	5,200	5	10%	26,000	4%	38%
6	F/B	microwave oven	447	53	11%	23,675	3%	41%
7	LIGHT	fluorescent undercabinet lamp, ave 24"	33	632	21%	21,033	3%	44%
8	OTHER	kiln	7,008	3	21%	21,024	3%	47%
9	LAB	autoclave	3,942	5	21%	19,710	3%	49%
10	F/B	hot cabinet	4,700	4	21%	18,800	3%	52%
11	F/B	coffe maker, commercial or specialty	1,349	13	21%	17,542	2%	55%
12	F/B	coffee maker	450	39	22%	17,542	2%	57%
13	F/B	refrigerator, S	277	50	23%	13,860	2%	59%
14	F/B	visi-cooler	3,900	3	23%	11,700	2%	61%
15	HVAC	heater	329	33	24%	10,841	2%	62%
16	F/B	ice maker	2,167	4	24%	8,668	1%	63%
17	F/B	refrigerator, M	567	15	24%	8,507	1%	64%
18	HVAC	air cleaner	761	11	24%	8,371	1%	66%
19	LIGHT	incandescent desk/table lamp, 75 W ave	78	104	26%	8,112	1%	67%
20	NETW	router	350	23	26%	8,059	1%	68%
21	PERI	external drive, tape	701	11	26%	7,709	1%	69%
22	A/V	VCR	64	120	28%	7,661	1%	70%
23	A/V	LED display sign	1,183	6	28%	7,096	1%	71%
24	MED/S	charger, defibrillator	335	21	29%	7,036	1%	72%
25	A/V	TV	53	131	31%	6,994	1%	73%
26	A/V	projector, overhead	96	68	32%	6,524	1%	74%
27	PERI	projector, computer	204	32	32%	6,523	1%	75%
28	F/B	fryer	5,884	1	32%	5,884	1%	76%
29	LAB	refrigerator, small	526	11	32%	5,782	1%	76%
30	POWR	uninterruptible power supply	36	137	35%	4,983	1%	77%
31	MED	exam table, heated drawer	130	38	35%	4,940	1%	78%
32	*NETW*	*hub, ethernet*	*11*	437	42%	4,785	1%	78%
33	OMISC	adding machine	58	81	44%	4,730	1%	79%
34	F/B	vending machine, room T snack	657	7	44%	4,599	1%	80%
35	MED	charger, oto-opthalmoscope	39	116	46%	4,573	1%	80%
36	OTHER	phone, powered	42	98	47%	4,116	1%	81%
37	PERI	external drive, hard disk	292	13	47%	3,796	1%	82%
38	OMISC	typewriter	116	32	48%	3,700	1%	82%
39	MED/S	vital signs monitor	153	24	48%	3,679	1%	83%
40	OTHER	bookshelves, mobile	613	6	48%	3,679	1%	83%
41	HVAC	fan, medium (8-16" diam)	62	56	49%	3,495	0%	84%
42	A/V	system control, rack-mount	692	5	49%	3,460	0%	84%
43	F/B	bottled water tap, hot & cold	799	4	49%	3,196	0%	84%
44	F/B	water cooler, hot & cold	799	4	49%	3,196	0%	85%
45	F/B	refrigerator, L	701	4	49%	2,803	0%	85%
46	POWR	power strip	3	1076	67%	2,771	0%	86%
47	MED/S	sterilizer, hot bead	394	7	67%	2,759	0%	86%
48	MED	exam light	31	87	68%	2,714	0%	86%
49	LAB	drying oven or steam incubator	1,314	2	68%	2,628	0%	87%
50	NETW	video processor, rack-mount	263	10	68%	2,628	0%	87%
TOTAL				**6,234**	**68%**	**717,215**	**87%**	**87%**

1. Annual Consumption estimates Ethernet switches and hubs are based on total number of ports, which is a function of the number of units found in this study.

To estimate the percentage of load due to miscellaneous equipment, we collected one-year utility bill data from three of our surveyed buildings. Since we only surveyed a portion of total audited floor space, we extrapolated the equipment count from the audited floor space to account for total in-use building space using floor plans provided to us. Based on bill data, total equipment stock and estimated UEC data, we calculated the percentage of total building consumption due to OE and ME in these three buildings as shown in **Table 4**. Only 7% of the total electricity use in the large office building was due to office equipment, which seemed somewhat low given the fact that site M's office equipment density was very similar to Site F

and Site J's. We did contact the maintenance supervisor at the large office building to see if our extrapolated office equipment counts matched those in their records and they seemed to be in agreement, which would tend to support the estimate in Table 4. Site M's total electricity usage is twice that of Site J's and 50% higher than Site F's so it's likely that the majority of their consumption is due to other loads in the building. Only 4% of the large office total electricity use was due to miscellaneous electricity, which may be due to the low energy intensity of miscellaneous electricity in large office buildings as shown in Figure 3.

AEO 2006 shows 0.56 Quads of PC and non-PC office equipment or 12.7% of commercial electricity use (our buildings office equipment estimates range from 7-10% of total building electricity consumption). On the other hand, AEO shows 1.62 Quads of "other" electricity, 37% of total commercial electricity. Our results show a range of 4-9% of total electricity consumption due to miscellaneous (this difference is also supported by differences in energy intensities, AEO 2006 has an "other" energy intensity of ~6,100 kWh/1000 ft^2 whereas our total building energy intensity is less than 2,000 kWh/ft^2). There are several possible reasons for this discrepancy:

- there are real differences between the AEO (more a top-down modeling approach) and our (bottom-up) approach to stock-accounting
- we weren't able to account for all miscellaneous loads in the building and we only estimated 70% of all UECs
- all building and product types (like ATMs and service stations) covered in AEO are not covered here
- it is also possible that AEO's "other" end use consumption and projection is inflated beyond what is realistically consumed by many commercial buildings.

Table 4. Comparison of ME and OE Consumption in Three Surveyed Buildings

	Site F (Eduction) kWh/yr	Site M (Large Office) kWh/yr	Site J (Medical) kWh/yr	Site F (Eduction) % total kWh	Site M (Large Office) % total kWh	Site J (Medical) % total kWh
Office Equipment	288,404	333,927	242,822	9%	7%	10%
Miscellaneous	305,322	185,797	225,307	9%	4%	9%
Other	2,660,123	4,473,776	2,052,521	82%	90%	81%
Total	**3,253,849**	**4,993,500**	**2,520,650**	**100%**	**100%**	**100%**

Conclusions

We audited sixteen buildings in three cities (San Francisco, Atlanta, Pittsburgh) including office, medical and education building types. We inventoried the number and types of OE and ME equipment, recorded power status of equipment, and estimated total energy consumption due to these product types. In total, we audited approximately 4,000 units of OE and 6,000 units of ME. The database that resulted from this work will assist in better estimating consumption of the OE/ME end use, estimating savings from energy efficiency programs such as Energy Star, and examining strategies for reducing consumption in these key end uses. Our results show the following:

- for all buildings combined, the OE plug-load equipment density was about 9 units per 1000 gross ft^2
- OE turn-off rates varied by equipment type (0% as expected for fax machines, 67% for plasma monitors) as did estimated power management success rates (only 6% for

desktop computers). These results suggest improving turn-off rates among low turn-off products and increasing equipment enabling can realize additional savings

- for all buildings combined, the ME plug-load equipment density was about 14 units per 1000 gross ft^2
- it is hard to generalize miscellaneous electricity across all commercial buildings, as density, energy intensity, and especially "product composition" varies across the individual building types
- within the commercial miscellaneous electricity end use, there are a couple of "big ticket items" in terms of energy consumption. The top five are: cold beverage vending machines, commercial refrigerators, computer speakers, Ethernet switches, and commercial freezers
- for three of our audited buildings, OE is estimated to account for 7-10% of annual electricity consumption and ME is estimated to account for 4-9% of annual electricity consumption. Our ME estimate is substantially less than that in AEO 2006 (37%), which suggests the need to look in more detail at modeling this end use

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Appendix: Miscellaneous Equipment Taxonomy

Category	Equipment Type (not an exhaustive list)
audio/visual	television, video cassette player/recorder, overhead projector, audio amplifier, compact disk audio device, digital video disk device, slide projector, video monitor, audio mixer, audio tape device, LED display sign, receiver, speaker, tuner, digital video camera, video conferencing device, microfilm viewer, scan converter, public address system, set-top box
food & beverage	microwave oven, refrigerator (all sizes), coffee maker, toaster/toaster oven, vending machine, hot/cold bottled water tap, hot pot/kettle, water cooler, freezer, hot beverage dispenser, hot food cabinet, ice maker, coffee grinder, drinking fountain, fryer/griddle, steam trays, visi-cooler, meat slicer, mixer, soda fountain pump, blender, refrigerated case
hvac, portable	fan, heater, air cleaner, room air conditioner
laboratory	scale, spectrophotometer, tabletop centrifuge, temperature monitor, lab refrigerator, microscope, autoclave, shaker/stirrer, lab freezer, hot plate/warmer, drying oven, timer
lighting	fluorescent undercabinet lamp (by size), desk/table/floor lamp (by lamp type and power use), incandescent spotlight or studio lamp, decorative lamp, strand or cable lights, fluorescent light box, incandescent or halogen track light or recessed lamp, exterior fluorescent sign
medical	oto-opthalmoscope charger, exam light or headlamp, x-ray light box, exam chair or table, body scale, hospital bed, utensil sterilizer, blood pressure monitor, IV cart
medical specialty	vital signs monitor, respirator, defibrillator charger, EKG machine & accessories, pulse oxymeter, eye chart projector, lensmeter, glucometer charger, hot bead sterilizer, suction pump charger, hearing test device, retinal scanner, fundus camera, hyfrecator, sonoscope
money exchange	credit card reader, cash register, bar code scanner, change or stamp vending machine
networking	modem, router, hub, printer hub, switch, print controller/server, video processor, wireless access point, audio/video modulator, tape drive, broadband distribution amplifier, driver
office miscellany	clock and/or radio, boombox or compact audio system, pencil sharpener, adding machine, shredder, typewriter, stapler, postage meter or scale, hole punch, laminator, time stamper, binding machine, microfiche reader
peripheral	computer speakers (pair), laptop docking station, personal digital assistant dock, computer projector, keyboard/video/mouse switch, external drive (CD, zip, hard disk, tape backup), pen tablet, digital whiteboard,
power	power strip, surge protector, PIPS, ILPS, uninterruptible power supply, charger (for laptop computer, cell or cordless phone, power tool), power conditioner, battery backup system
security	badge reader, book demagnetizer, shoplifting sensor, article surveillance system
specialty	pottery wheel, mobile bookshelves, oscilloscope, shrinkwrapper, bench wheel, soldering iron
telephony	conference or speaker phone, answering machine, intercom, phone switch, phone jack or box, dictation machine, PBX phone line converter, voice control box, switchboard phone, integrated voice server
utility/maintenance	vacuum cleaner, floor polisher, dishwasher, ultrasonic cleaner, water purifier, clothes washer or dryer