Commercial and Residential Sector Miscellaneous Electricity Consumption: Y2005 and Projections to 2030

Final Report to the U.S. Department of Energy's Energy Information Administration (EIA) and Decision Analysis Corporation (DAC)

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TIAX LLC
15 Acorn Park
Cambridge, MA
02140-2390

www.TIAXLLC.com

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Table of Contents for Products Analyzed

Glossary

AEC – Annual Electricity Consumption

AEO – Annual Energy Outlook (EIA reference)

CCTV – Closed-Circuit Television

CMOS – Complementary Metal Oxide Semiconductor: A type of semiconductors currently used in many integrated circuits, notably microprocessors

CRA – Colorado River Aqueduct: A major water project that transports water from the Colorado River to Southern California

CT – Computed Tomography

DOE/BT – U.S. Department of Energy, Building Technology Program

EPA - Environmental Protection Agency

EPAct – Energy Policy Act

EPRI – Electric Power Research Institute

kVA – kilovolt-amps

LBNL – Lawrence Berkeley National Laboratory

MRI – Magnetic Resonance Imaging

NEMA – National Electrical Manufacturers Association

PoE – Power over Ethernet: A way to provide up to 15W of electric power to device via the ethernet cable used to provide data to that device

PWS – Public water system

SIC – Standard Industrial Classification: System used to classify economic activity by type of work performed

SWP – California State Water Project: A system to transfer water between Northern and Southern California

Tesla – Unit for magnetic flux density (i.e., magnetic flux per unit area)

TWh – Terawatt-hours of electricity (tera=10^{12})

UEC – Unit Annual Electricity Consumption

This study developed estimates for the current and future electricity consumption of a total of twenty one (21) commercial and residential miscellaneous electric loads.

- **"Current"** values are for 2005
- **Future projections** are for 2010, 2015, 2020, and 2030
- **Total miscellaneous electricity consumption has grown significantly**
  - Ranks as one of the largest "end uses" in both sectors, projected to become an even larger percentage in the future
- **Residential sector growth appears to be driven by consumer electronics**
  - Growth likely to continue and could accelerate (e.g., due to networking of home appliances) in the future
- **Commercial Sector has not grown as quickly**
  - Even more varied loads than residential sector
  - Many miscellaneous electricity uses not well quantified, includes several unconventional loads (i.e., not appliances or equipment)

These values will enable EIA to disaggregate several components of the "other" energy consumption category and, thus, refine future electricity consumption projections for both the residential and commercial sectors.

We selected ten commercial sector miscellaneous electric loads for analysis. Over the course of our analysis, we added another end use.

- First, we developed a long list of potential loads to analyze
  - More than 100 loads identified
  - Many are residential products used in commercial settings, also a wide variety of medical equipment
  - Need to focus efforts on key loads
- Ten miscellaneous electric loads were selected for further study based on:
  - Preliminary annual electricity consumption (AEC) estimates
  - Relative importance to EIA, interest by EIA
    - EIA considers distribution transformers and water purification, supply, and treatment as a miscellaneous commercial sector electric loads – *EIA prioritized the analysis of these end uses*
    - EIA considers office equipment / information technology (IT) equipment as a distinct end use in the commercial sector – *EIA excluded these products from this study*
  - Assessment of the value of further study (i.e., will further study within the level of effort of this project appreciably improve AEC estimates?)
    - TIAX has carried out a detailed study of office equipment / IT equipment in the commercial sector in 2002 – *EIA excluded these products from this study*

We used a bottom-up approach to analyze commercial sector energy consumption.

- **Appliances**
  - Identify key modes
  - Quantify power draw and usage by mode, estimate installed base
- **Leverage existing studies as possible, focus efforts on unknown data**
  - Perform additional literature searches as needed
- **Provide qualitative assessment of data quality**
- **For Projections, we considered several factors:**
  - Leveraging AEO projections for U.S.:
    - Commercial building floorspace
    - Population
    - Gross domestic product
  - Technology trends
  - Cultural & Societal trends
  - Policy trends (notably energy efficiency)

We selected ten residential sector miscellaneous electric loads for analysis. This effort highly leveraged a concurrent TIAX study of miscellaneous electric loads carried out for DOE/BT.

- First, we developed a “long list of potential loads to analyze
  - More than 100 loads identified
  - Many estimated to be quite small (LBNL 1998)
  - Top 20 accounted for ~73% of total circa 1995 (LBNL 1998)
  - Focused efforts on key loads
- Ten miscellaneous electric loads were selected for further study based on:
  - Loads analyzed for the DOE/BT study – greatest leverage
  - Loads with the highest estimated AEC – most energy (based on preliminary AEC estimates)
  - Loads where current study adds most value – some loads may require more detailed evaluation than possible under this project’s scope
    - TIAX carried out a detailed study of residential office equipment / IT equipment consumption in 2006 – *EIA excluded these products from this study*

TIAX is also conducting an independent analysis of energy consumed by residential consumer electronics (CE). Survey research for that study will yield improved estimates for CE usage and unit energy consumption (UEC).

We also used a bottom-up approach to analyze residential sector energy consumption.

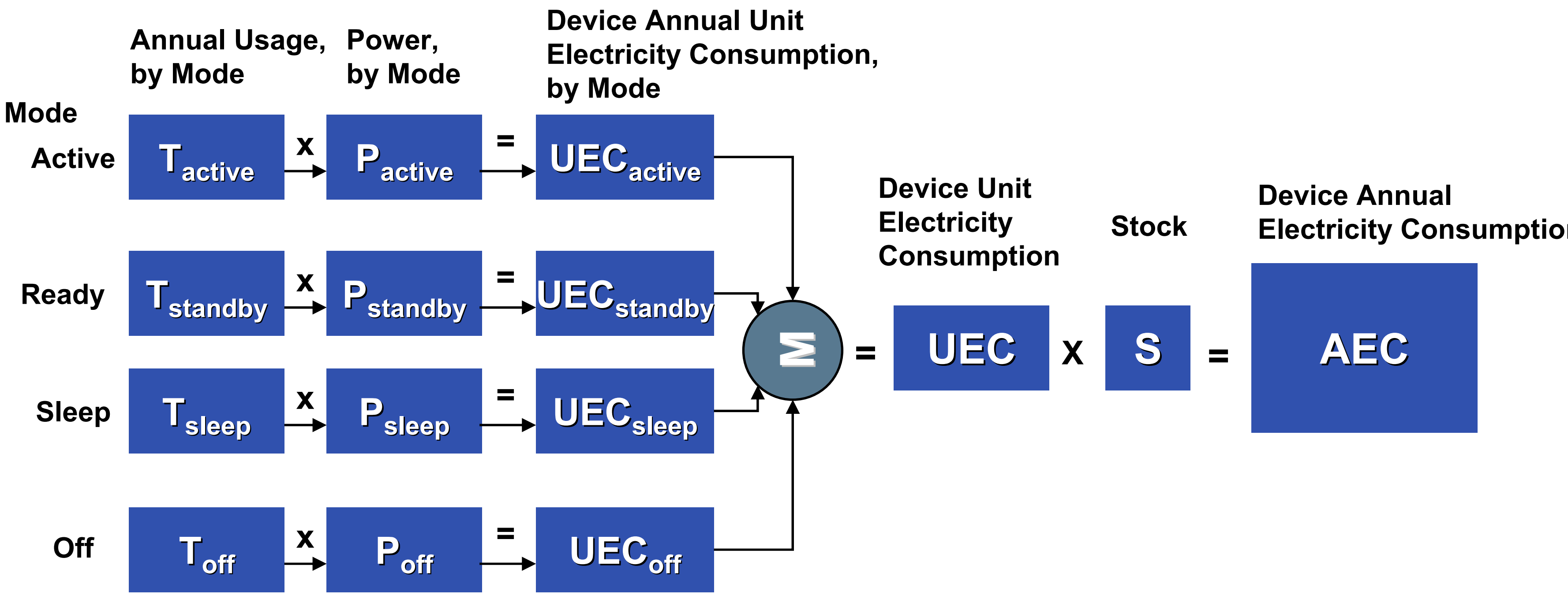
- **Appliances – similar approach to commercial**
  - Identify key modes
  - Quantify power draw and usage by mode, estimate installed base
- **Leverage existing studies as possible, focus efforts on unknown data**
  - Perform additional literature searches as needed
- **Provide qualitative assessments of data quality**
- **For Projections, we considered several factors:**
  - Leveraging AEO projections:
    - Residential floor space, Number of residences, Population, Gross Domestic Product
  - Technology trends
  - Cultural & Societal trends
  - Policy trends (notably energy efficiency)
  - Very challenging to develop projections to 2020 or 2030 for consumer electronics due to rapid pace of change

We used the following values from the EIA's 2006 Annual Energy Outlook (AEO) and a preliminary version of AEO 2007 in several of the projections. In some instances, we also used building-type specific projections for the number and ft^2 of commercial buildings and region-specific values for residential buildings.

	2005	2010	2015	2020	2030
U.S. Population [millions]	297	310	324	337	365
Number of Households [millions]	113	121	128	135	148
Household Size [ft^2]	1,766	1,823	1,872	1,915	1,987
Commercial Building Floorspace [billion ft^2]	76.2	82.3	88.9	96.0	112
U.S. Gross Domestic Product [billion $US]	$11,147	$13,043	$15,082	$17,541	$23,112

Note: The spreadsheet used for population, GDP, and commercial floorspace values indicates that it comes from AEO 2006. The spreadsheet used for the number of households and ft^2 per household come from "Preliminary AEO 2007."

Where it makes sense, we will use a bottom-up methodology to estimate the AEC of the loads studied.

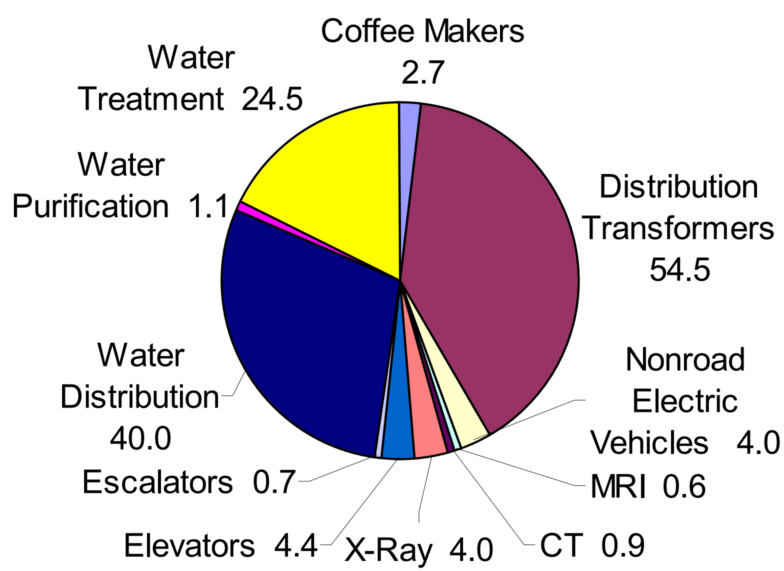


Note: Modes Illustrative, actual modes will vary by device

Commercial Miscellaneous Electric Loads

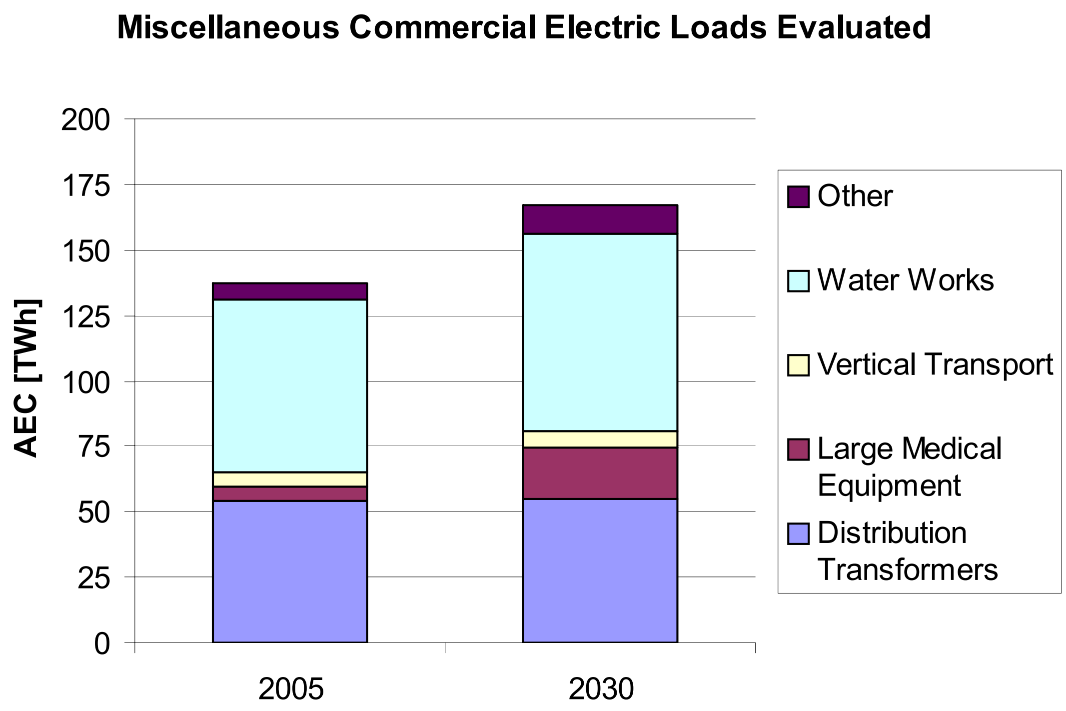
Distribution transformers and water works account for the bulk of commercial sector miscellaneous electric loads evaluated in this study.

Misc. Elec. Loads Evaluated, Commercial Sector
2005 Total = 137TWh



Overall, this electricity accounts for about 30% of EIA's commercial sector miscellaneous electricity.

In 2030, distribution transformers and water works will likely continue to account for the bulk of the energy consumed by the commercial sector miscellaneous electric loads evaluated in this study.



Overall, this electricity accounts for about 15% of EIA's projected commercial sector miscellaneous electricity.

Commercial-style coffee brewers consume a substantial quantity of electricity keeping coffee warm.

		2005	2010	2015	2020	2030
Installed Base [thousands]		3,000	3,170	3,350	3,530	3,950
Power Draw [W]	**Active**	2,100	2,100	2,100	2,100	2,100
	Ready	165	165	165	165	165
	Off	2	2	2	2	2
Annual Usage [hours]	**Active**	150	150	150	145	140
	Ready	3,500	3,500	3,500	3,505	3,510
	Off	5,110	5,110	5,110	5,110	5,110
UEC [kWh/year]		905	905	900	895	885
AEC [TWh/year]		2.7	2.9	3.0	3.2	3.5

Commercial-Style Coffee Brewers

- **Three primary styles of commercial-style coffee brewers exist**
  - Approximate Shares of Installed Base: Decanter: 45%, Thermal: 30%, Satellite: 25%
- **Usage estimates reflect several assumptions:**
  - *Active:* Daily cups of coffee consumed outside the home, combined with brewer performance data and coffee wastage estimates based on an industry source; significant uncertainty exists in the estimated 9oz. typical cup size
  - *Ready*: TIAX estimate of 10 hours/day combined spent in warming and brewing modes, reviewed by an industry source
- **The projections for total number of cups per day grows with population**
  - In practice, gustatory/cultural trends will have a major impact – these are very challenging to forecast
- **The projections for the number of brewers scales with the percentage increase in food service (50% weight) and office buildings (50%)**
  - Reflects two major markets – Food service and office coffee service
- **Coffee brewer power draw is not expected to change appreciably because power draw for the two major modes influencing power draw, "active" and "heating," depend upon energy consumed to heat a volume of water and that used to maintain coffee temperature in standard design footprints.**
  - Heating mode accounts for most energy consumption

Distribution transformers in commercial buildings represent a substantial commercial sector end use.

		2005	2010	2015	2020	2030
Installed Base (billion KVA)	**Dry**	510	546	570	608	706
	Liquid	232	246	260	276	323
Average Total Losses [W/kVA]	**Dry**	10.3	9.7	8.9	8.2	6.9
	Liquid	4.2	4.2	4.2	4.2	4.2
Annual Usage [hours]	**Active**	8,760	8,760	8,760	8,760	8,760
AEC [TWh]	**Dry**	46	46	45	43	43
	Liquid	8.5	9.1	9.6	10.2	11.9

Commercial Building Distribution Transformers

- **Distribution transformers step down power distributed at higher voltages to lower voltages, e.g., from 480V to 120V.**
  - Dry-type and liquid-type transformers exist, but dry-type transformers dominate the installed base and shipments for commercial buildings
- **Installed base of commercial building distribution transformers (in rated kVA) projected using approach and data from DOE rulemaking, i.e., gradual diffusion of more efficient units into the market based on AEO projected growth in electricity consumption (uses 32-year average lifetime)**
- **EPAct 2005 mandates increased efficiency for dry-type distribution transformers (meet NEMA TP1-2002 levels)**
  - Assumed to come into effect in 2007; some states have adopted this as a standard before this date, while a level set by an ongoing DOE Rulemaking will take affect after 2007
  - On average, reduces losses by ~35%
  - Modeling leverages ongoing DOE rulemaking activities, reflects estimates of actual loading of transformers and their no-load and loading-dependent losses
- **Otherwise, the energy consumption model does not assume that additional improvements in efficiency occur.**
  - *TIAX learned after completion of this analysis that DOE has proposed a higher standard level – will reduce AEC, particularly at dates further in the future (e.g., 2030)*

Forklifts (lift trucks) account for approximately 60% of commercial non-road electric vehicle electricity consumption.

		2005	2010	2015	2020	2030
Installed Base [thousands]	Lift Trucks	530	605	680	755	905
	Golf Cars	880	1,040	1,240	1,470	2,040
	Burnishers	850	920	990	1,070	1,250
UEC [kWh/year]	Lift Trucks	4,750	4,750	4,750	4,750	4,750
	Golf Cars	990	990	990	990	990
	Burnishers	670	670	670	670	670
AEC [TWh/year]	Lift Trucks	2.5	2.9	3.2	3.6	4.3
	Golf Cars	0.9	1.0	1.2	1.5	2.0
	Burnishers	0.6	0.6	0.7	0.7	0.8

Non-Road Electric Vehicles

- The three primary types of non-road vehicles analyzed appear to account for most current commercial sector energy consumption in this category.
  - Internal combustion engine (ICE) forklifts also account for an appreciable portion of non-electric commercial sector AEC (ITA 2005, EPRI 1996, TIAX Analysis)
  - Electric forklifts also account for a similar quantity electric AEC in the industrial sector (TIAX analysis)
  - Burden carriers are primarily relevant to the industrial sector (EPRI 1996)
  - Utility vehicles are more relevant to the commercial sector but mostly ICE (EPRI 1996)
  - Most walk-behind sweeper-scrubbers use electricity, but their AEC appears to be quite small (EPRI 1996, TIAX analysis)
- **The UEC of all vehicles is assumed not to change in the future**
- **The forecasts do not reflect the possibility of a paradigm shift to fuel-cell vehicles**
  - Non-road vehicles considered a target market for fuel cells
    - Negligible emissions for market with increasingly stringent regulations
    - Relatively high efficiencies
    - Typically used as captive fleets at a location – reduces infrastructure issues
  - If fuel cells became widespread, this would decrease the *electric* UEC of non-road vehicles
- **In the future, truck and rest stop electrification and electric truck refrigeration units could become significant contributors to the non-road electric vehicles category (TIAX 2005).**

Non-Road Electric Vehicles

- **The model for lift trucks takes into account the characteristics of class 1, 2, and 3 devices and segregates the installed base by sector using SIC**
  - Forklifts (class 1 and 2) have much higher UECs than motorized hand lifts (class 3)
- **Lift truck installed base forecasts assume same growth as 2001-2005 period**
  - Class 1, 2, and 3 all have similar growth rates (~3%/year)
  - UEC Values do not change
- **Golf car AEC continues to grow due to overall stock growth and increased electrification**
  - About 65% of golf cars electric in 2005, assumed to grow to 90% by 2030; this future value has appreciable uncertainty
  - Stock of all golf cars grows by 2.1% per year; represents average of low- (only growth in number of golf courses [1.5%]) and high- (growth in # of golf courses and moderate growth in # cars/course [2.8%]) cases developed for California analysis (TIAX 2005)
- **Our analysis focuses on walk-behind burnishers, as most riding burnishers are used in industrial settings and have internal combustion engines**
  - The installed base estimates for burnishers have higher uncertainties than the other vehicles, due to a lack of organized data gathering (e.g., by industry association)
  - Burnisher installed base assumed to grow with commercial sector floorspace

We analyzed three different classes of medical imaging equipment: CT, MRI, and X-ray machines. Together, they consumed more than 5TWh circa 2005 and this value is projected to grow significantly over the coming decades due to increases in both the installed base and per-unit power draw.

Although MRI machines have very high UECs, their relatively small installed base limits their AEC impact in 2005.

		2005	2010	2015	2020	2030
Installed Base [thousands]		7	11	16	22	34
Power Draw [kW]	**Active**	25	33	40	45	50
	Standby	11	16	20	21	22
	Off	7	8	8	8	8
Annual Usage [hours]	**Active**	340	370	400	430	460
	Standby	3,310	3,280	3,250	3,220	3,190
	Off	5,110	5,110	5,110	5,110	5,110
UEC [kWh/year]		81,000	101,000	122,000	128,000	135,000
AEC [TWh/year]		0.6	1.1	1.9	2.9	4.5

Magnetic Resonance Imaging (MRI)

- **MRI market is currently (2005) growing much faster than radiology markets, at ~15% annually**
  - Significant uncertainty in duration of rapid growth trend; market not yet near saturation
  - Number of annual exams estimated to grow between 10% and 15% per year until 2020
  - Installed base of MRI systems estimated to grow 5%-10% per year until 2020
- **Power draw estimates taken from product specification sheets and pre-installation manuals for 0.5 Tesla, 1.5 Tesla, and 3 Tesla MRI systems and weighted based on installed base of each category.**
  - 1.5 Tesla systems account for about 50% of installed base in 2005
  - 2 to 6 Tesla systems are estimated by industry experts to account for 50% of the installed base by 2020
- **Most MRI machines have superconducting magnets that require continuous cryogenic refrigeration, which consumes approximately 8 kW**
- **Active usage comes from conversations with GE Healthcare installation experts and hospital imaging technicians, and from estimates of annual exams**

Although CT scanners have very high UECs, their relatively small installed base limits their AEC impact in 2005.

		2005	2010	2015	2020	2030
Installed Base [thousands]		12	19	24	30	38
Power Draw [kW]	**Avg. Operating**	21	21	21	21	21
	Off	1.7	1.7	1.7	1.7	1.7
Annual Usage [hours]	**Avg. Operating**	3,000	3,000	3,000	3,000	3,000
	Off	5,760	5,760	5,760	5,760	5,760
UEC [kWh/year]		73,000	73,000	73,000	73,000	73,000
AEC [TWh/year]		0.9	1.4	1.8	2.2	2.8

CT

- **Rapidly evolving technology, e.g., CT machines have advanced from 4 slices in 1998 to 64 slices in 2005**
  - Greater number of slices increases imaging resolution
- **2005 installed base estimate based on an estimate from an industry expert**
- **Installed base estimated to grow between 3 and 10 percent until 2020. Growth is expected to slow more quickly than MRIs because CT is a more mature technology.**
- **2005 power draw estimates taken from product specification sheets and pre-installation manuals for 16 slice CT scanners (taken as standard unit, based on discussions with manufacturer representatives)**
- **Next generation 64-slice CT scanners do not show increased power draw**
  - Yields projection of no increase in future power draw values
  - Average operating power is dominated by standby power because of very short exposure times. An increase in patient through put per machine will not significantly affect the average operating power.

Non-portable X-ray machines have the largest installed base of – and have a higher AEC than – the other medical imaging equipment types.

		2005	2010	2015	2020	2030
Installed Base [thousands]		160	177	194	213	254
Power Draw [kW]	**Avg. Operating**	4.0	5.0	6.0	7.0	8.0
	Off	1.6	2.0	2.0	3.0	3.0
Annual Usage [hours]	**Avg. Operating**	4,380	4,380	4,380	4,380	4,380
	Off	4,380	4,380	4,380	4,380	4,380
UEC [kWh/year]		24,800	29,900	35,000	41,600	48,200
AEC [TWh/year]		4.0	5.3	6.8	8.9	12

- Dental x-ray machines have a much larger installed base (approximately 440,000 machines), but consume significantly less energy (~0.6 TWh/year) because they draw significantly less power than standard medical x-ray machines and are estimated to be off 75% of the time.
- There are approximately 48,000 mammography machines, 17,000 fluoroscopy machines, and 21,000 non-medical x-ray machines. All have lower power draw and likely lower usage than non-portable x-ray equipment.

X-ray

- **2005 installed base estimate comes from an average ratio of X-ray machines per person calculated from conventional x-ray system registration data from state health agencies (California, Texas, Florida, and Pennsylvania).**
  - Total installed base derived by multiplying ratio by the U.S. population
- **Number of X-ray machines growing more moderately than CT and MRI**
  - Installed base growth mirrors EIA estimates for healthcare floor space growth (~2% per year)
- **2005 power draw estimates taken from GE Healthcare product specification sheets and pre-installation manuals for a standard stationary x-ray system.**
- **2030 power estimate taken from GE Healthcare product specification sheets for a digital x-ray system**
  - Used linear interpolation for values between 2005 and 2030

Elevators account for most vertical transport energy consumption. For elevators, the ready mode denotes that the elevator is fully powered up and ready for transport. In the off mode, the elevator lights and vents turn off after period of nonuse.

		2005	2010	2015	2020	2030
Installed Base [thousands]		590	640	700	760	900
Power Draw [W]	**Active**	10,000	10,000	10,000	10,000	10,000
	Ready	500	500	500	500	500
	Standby	250	250	250	250	250
Annual Usage [hours]	**Active**	300	300	300	300	300
	Ready	8,460	7,365	6,270	5,175	4,080
	Standby	0	1,095	2,190	3,285	4,380
UEC [kWh/year]		7,400	7,000	6,700	6,400	6,200
AEC [TWh/year]		4.4	4.5	4.7	4.9	5.5

Elevators

- **2005 installed base estimate developed from raw CBECS data and extrapolated to 2005.**
- **Future installed base estimates come from 1.7% annual growth rate (based on prior growth rates).**
- **Future off mode assumes that a growing portion of elevators can enter standby mode (i.e., no lights or ventilation) for up to twelve hours per night**
- **Power and usage estimates are weighted averages based on typical building heights and the standard elevator type found in these building height groups.**
  - 80% of elevators are found in buildings with 2 to 7 floors and are typically hydraulic
    - Hydraulic elevators have no regeneration (energy recovery) and require round-the-clock hydraulic fluid heating; additional power draw by lighting and ventilation fans
  - 15% of elevators are found in buildings with 8 to 24 floors and are generally geared traction
    - Geared and gearless traction elevators have regeneration capability; additional standby power for lighting and ventilation fans
  - 5% of elevators are found in buildings with 25+ floors and are generally gearless traction

Although escalators have a much higher UEC than elevators, their much smaller installed base results in a lower AEC.

		2005	2010	2015	2020	2030
Installed Base [thousands]		35	38	41	44	51
Power Draw [W]	**Avg. Operating**	4,671	4,671	4,671	4,671	4,671
	Off*	0	0	0	0	0
Annual Usage [hours]	**Avg. Operating**	4,380	4,380	4,380	4,380	4,380
	Off	4,380	4,380	4,380	4,380	4,380
UEC [kWh/year]		20,500	20,500	20,500	20,500	20,500
AEC [TWh/year]		0.7	0.8	0.8	0.9	1.0

*Although a reliable value for escalator off mode power draw was not found, off mode appears to have a small impact on UEC.

Escalators

- **The 2005 installed base equals an average of CBECS and Elevator World (2000) estimates**
  - CBECS may not have a representative sample of buildings with a large number of escalators, such as airports and train stations
  - The estimate does *not* include moving walkways
- **Future installed base projections assume similar growth rate as between 1992 and 2000 (~1.5% annually)**
- **The UEC was calculated using an escalator energy formula derived by an industry expert (Al-Sharif 1998)**
  - Model developed from actual measurements of *in situ* escalator rise, usage, and energy consumption; calculates UEC based solely on escalator rise and operating time.
  - Average escalator rise based on distribution of rises for a sample of in situ escalators (Enermodal 2004)
  - Assumed an equal number of up and down escalators installed
  - Average operating time is a TIAX estimate

Water distribution in public water systems (PWS) dominates this end use. In addition, large-scale water-transfer projects account for a significant minority of total AEC.

	2005	2010	2015	2020	2030
Gallons Supplied by PWS and Commercial Self-Supply (billions/year)	17,700	18,400	19,200	20,000	21,900
UEC [kWh / million gallons]	2,230	2,220	2,200	2,180	2,150
AEC [TWh/year]	40	41	42	44	47

Water Pumping

- **Water distribution from water purification plants accounts for about 62% of U.S. commercial sector water pumping**
- **In general, water pumping AEC will grow with population. Several factors affect the per-unit energy intensity of water pumping:**
  - *Increase*: Flow resistance – and, hence, pumping power – tends to increase in older systems
  - *Decrease*: Move to larger pumping plants, replacement of older equipment (pumps, motors/drives, process equipment) with newer and more-efficient equipment, water conservation programs and standards
- **Three inter-basin water transfer projects account for about 20% of U.S. water pumping energy consumption**
  - The California State Water Project (SWP), the Central Arizona Project, and the Colorado River Aqueduct (CRA) consume approximately 8TWh per year
  - Actual AEC for the SWP and CRA can vary significantly from year to another, depending on water availability
- **Pumps that pump ground and surface water to plants and commercial private pumping ("self-supply") account for the remaining energy consumption**

Water treatment (purification) consumes significantly less energy than Wastewater Treatment and water supply & distribution.

	2005	2010	2015	2020	2030
Purified Gallons per Year (billions)	16,500	17,100	17,900	18,600	20,400
UEC [kWh/million gallons]	65				
AEC [TWh/year]	1.1	1.1	1.2	1.2	1.3

Water Purification

- **Many different sizes and types of water purification plants exist.**
  - Purification accounts for about 9% of energy consumed in fresh water-fed public water supplies, but ground water-fed supplies are much simpler and have negligible purification energy requirements
  - Purification energy tends, however, to vary relatively little with plant size
  - Analysis by EPRI subcontractor took into account the characteristics of an inventory of public water systems maintained by the EPA
  - Assumes 200 gallons per day (gpd) and 150gpd per person served in community and non-community systems, respectively
- **Total purified water consumption growth assumed to track population growth**
- **Several trends will affect the electricity consumed to treat a volume of water, in the future.**
  - *Increase*: Greater processing driven by higher water treatment standards
  - *Decrease*: Move to larger plants, replacement of older equipment (pumps, motors/drives, process equipment) with newer and more-efficient equipment, water conservation programs and standards*

*Overall decrease in electricity consumption, but potential increase in kWh/gallon due to lost economies of scale or operation at off-design conditions (EPRI 2002).

Wastewater Treatment is a very energy-intensive process.

	2005	2010	2015	2020	2030
Gallons Treated per Year (billions)	14,280	14,510	14,750	15,160	15,880
UEC [kWh / million gallons]	1,649	1,716	1,716	1,716	1,716
AEC [TWh/year]	24.5	24.9	25.3	26.0	27.2

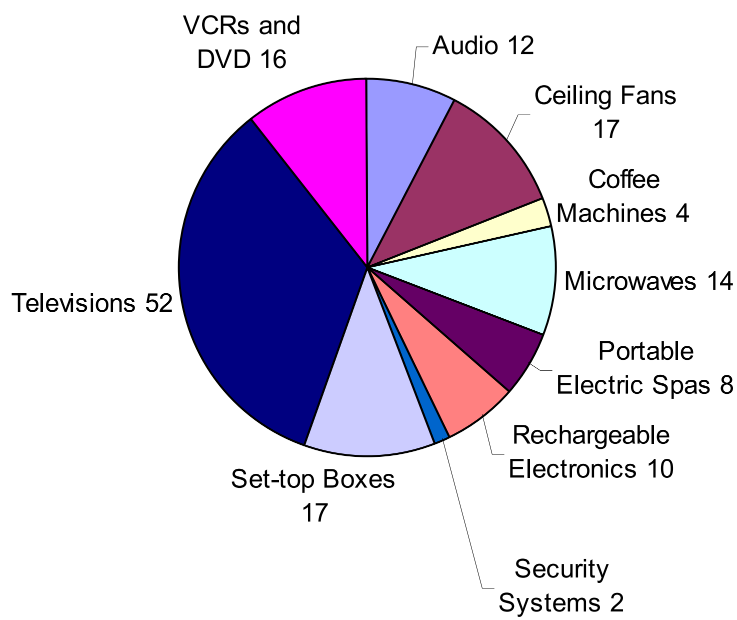
Wastewater Treatment

- **The degree of wastewater treatment – and the associated energy consumption – varies significantly**
  - Clear trend toward increased water treatment over (at least) the last two decades
  - A key EPA report suggests that the need for greater treatment remains (EPA 2003)
- **The degree of wastewater treatment is trending upward, increasing the energy intensity of treatment (i.e., kWh/gallon)**
  - Assumed 0.8% compound annual growth rate from 2000 through 2010, flat thereafter (based on EPRI 2002)
- **It appears, however, that the *volume* of wastewater treatment will hold steady or decrease slightly**
  - This appears to reflect increased water conservation and wastewater reuse
- **The AEC estimates reflects information about the EPA's inventory of publicly owned treatment works and models for the energy intensity of specific wastewater treatment processes.**

Residential Miscellaneous Electric Loads

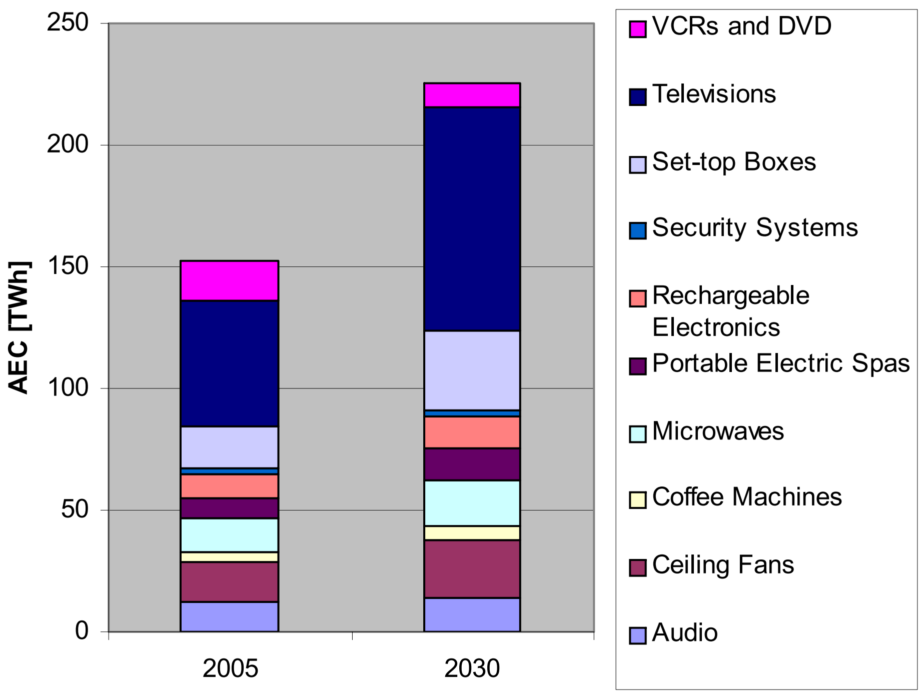
Televisions account for about 1/3rd of the residential sector miscellaneous electric loads evaluated in this study.

Misc. Elec. Load Evaluated, Residential Sector
2005 Total = 152TWh



Overall, this electricity accounts for more than 40% of EIA's residential sector miscellaneous electricity.

In 2030, TVs are projected to account for 40%+ of the energy consumed by the residential sector loads evaluated in this study. The AEC projections for TVs and other consumer electronics (combined ~70% of total) have high uncertainties due to the rapid pace of technological change.



Overall, this electricity accounts for about 20% of EIA's projected residential sector miscellaneous electricity.

The installed base of home audio equipment, consisting primarily of component audio systems and compact audio systems, is projected to grow slowly.

		2005	2010	2015	2020	2030
Installed Base [millions]		98	104	110	116	127
Power Draw [W]	**Active**	33	32	32	32	32
	Idle	30	29	29	28	28
	Off	3	2.7	2.5	2.3	2
Annual Usage [hours]	**Active**	1,510	1,510	1,510	1,510	1,510
	Idle	1,810	1,810	1,810	1,810	1,810
	Off	5,440	5,440	5,440	5,440	5,440
UEC [kWh/year]		119	116	114	112	108
AEC [TWh/year]		12	12	13	13	14

- Clock radios are not included in the analysis. The UEC and AEC of clock radios are estimated to be approximately 15 kWh and 2TWh, respectively, in 2005. Installed growth will likely mirror household growth.
- Portable audio systems (a.k.a. boom boxes) are also not included in the analysis. Their AEC was estimated to be relatively small (~0.5 TWh) in 2005

Component and Compact Audio Systems

- **Component systems and compact systems have approximately the same installed base (based on RECS)**
  - Future installed base growth projected to mimic household growth.
- **2005 unit active, idle, and off power draw estimates reflect the weighted averages of power for component systems (45 W, 43 W, and 3 W) and Compact Systems (22 W, 20 W, and 3 W) based on percentage of installed base for each type.**
- **Future active and idle power are projected to slowly decrease from technology improvements and the phasing out of cassette players.**
- **Future off power is expected to approach current EnergyStar® levels over time.**
  - Lowest values listed by EnergyStar®: component stereo=0.6 W, compact stereo=0.34 W.
- **Component and compact systems have the same music listening usage estimates**
  - *Active usage assumes that 60% of component systems and 22% of compact systems are used when the TV is used (based on 1999 survey data).*
  - *The estimates for time spent in idle and off modes have significant uncertainty because it is not known how often people turn off their stereo systems when not in use. The current analysis assumes a 25%/75% split of inactive time between idle and off modes, respectively.*
- **Increased storage of music in memory formats (e.g., MPEG instead of CD) could effectively decrease the number of components in audio systems in the future, potentially decreasing their idle mode power draw**

The current analysis considers ceiling fan motors only, i.e., it does not take into account lighting-related energy consumption.

		2005	2010	2015	2020	2030
Installed Base [millions]		210	225	245	260	290
Power Draw [W]	**In-Use**	35	35	35	34.5	34
Annual Usage [hours]	**In-Use**	2,310	2,330	2,350	2,370	2,400
UEC [kWh/year]		81	82	82	82	81
AEC [TWh/year]		17	19	20	21	24

Ceiling fan energy consumption is projected to grow as the number of fans installed continues to increase.

- **The installed base projections are based on the number of ceiling fans by region and home vintage**
  - RECS reports the percentage of homes with ceiling fans is greater for newer homes
    - 60% of homes built from 1970 to 1979 had ceiling fans, as compared to 87 % of homes built from 2000 to 2001
  - RECS indicates warmer regions of the country have a greater number of fans per household
  - New households in each region are assumed to have the same number of ceiling fans per household as the 1999-2000 regional averages, while the number of ceiling fans in existing households remains constant
  - Changes in public acceptance of ceiling fans could significantly impact longer-term installed base projections
- **Power draw estimates reflect current and EnergyStar® fan efficiencies**
  - EPAct 2005 pre-empted state-level standards for ceiling fan motors and gave DOE the authority to regulate - ceiling fan energy consumption, but does not set a timeframe for establishing a standard level
  - The current analysis assumes that DOE establishes a ceiling fan minimum efficiency level that takes effect in 2015 equal to the current EnergyStar® standards
    - Current stock is considered to have an efficiency of 70 cfm/W at 2,300 cfm
    - EnergyStar® standards are averaged to be 122 cfm/W at 2,300 cfm
    - Without a standard, UEC and AEC would increase by approximately 4% relative to 2030 projected values.
  - The model for ceiling fan power draw assumes that all new households after 2015 utilize higher efficiency, EnergyStar® fans
- **Annual fan usage estimates take into account usage by different regions/climates, weighted by the average number ceiling fans per household in each region**
  - Number of operating days for each region came from an EnergyStar® cost estimation, which cites an LBNL source for hours of use per day per region
    - This yielded a national average annual operational hours estimate for 2001 very close to prior estimates
  - A national average for annual operating hours equals the sum over all regions of the products of the percentage of total residential ceiling fans in a region and annual usage in that region

Coffee machine UEC and AEC are projected to increase slowly over time.

		2005	2010	2015	2020	2030
Installed Base [millions]		69	74	78	83	90
Power Draw [W]	**Active**	1,000	1,000	1,000	1,000	1,000
	Ready	70	70	70	70	70
	Off	0.4	0.6	0.8	1.0	1.0
Annual Usage [hours]	**Active**	38	38	37	37	37
	Ready	229	229	229	229	229
	Off	8,493	8,493	8,494	8,494	8,494
UEC [kWh/year]		58	59	60	61	61
AEC [TWh/year]		4.0	4.3	4.7	5.1	5.5

Coffee Machines

- **The installed base of coffee machines is projected to grow linearly with the number of households**
  - Gustatory/cultural trends will have a major impact –very challenging to forecast
- **Coffee machine active mode UEC takes into account estimates of the number of cups of coffee consumed at home per day, as well as the average cup size**
  - The size of an average cup of coffee has significant uncertainty and UEC estimates are very sensitive to this, e.g., changing from 9oz to 6oz decreases UEC by ~25%
  - Projections for future coffee consumption (cups/day) scales with projections for the U.S. population 18+, assuming that cups/day/person in that age group doesn't change
  - Warming times reflect detailed data from RECS and are assumed to remain constant
  - Gustatory/cultural trends will have a major impact –very challenging to forecast
- **Coffee brewer power draw by mode is not projected to change appreciably because power draw for the two major modes influencing power draw, "active" and "heating," depend upon energy consumed to heat a volume of water and that used to maintain coffee temperature in standard design footprints**
  - Heating mode accounts for most energy consumption
  - Standby power draw increase reflects greater penetration of units with standby power draw (e.g., for display or digital timer)

The microwave oven installed base and AEC will likely grow incrementally faster than the number of U.S. households.

		2005	2010	2015	2020	2030
Installed Base [millions]		109	116	124	131	145
Power Draw [W]	**Active**	1,500	1,500	1,500	1,500	1,500
	Off	3	3	3	3	3
Annual Usage [hours]	**Active**	70	70	70	70	70
	Off	8,690	8,690	8,690	8,690	8,690
UEC [kWh/year]		131	131	131	131	131
AEC [TWh/year]		14	15	16	17	19

Microwaves

- **2005 installed base estimate based on 96% household saturation.**
  - This does not include combination units (e.g., convection/broiler/microwave)
- **Future installed base projected to follow household growth and a slight increase in saturation up to 98% in 2030.**
- **Active mode power draw assumed to remain constant over time**
  - Active mode energy consumption accounts for 80% of total energy
  - Prior DOE rulemaking suggests little room for improvement
  - Historically, oven sizes have trended upwards
- **Standby power draw is not expected to drop in the future**
  - No regulatory pressure in U.S., not covered by EnergyStar® program
- **Usage is not expected to vary significantly in the future**
  - Potential for increase if consumption of microwavable prepared foods (e.g., frozen) grows

Portable electric spas have two primary operating states: in-use and standby. While in-use, the spa pump provides jet, filtering, and circulation functions, while the spa maintains a temperature set point and periodically runs the pump at low speed for filtering in standby mode.

		2005	2010	2015	2020	2030
Installed Base [thousands]		3,300	3,500	3,950	4,400	5,350
Power Draw [W]	**In-Use**	4,350	5,600	6,100	6,150	6,150
	Standby	275	270	260	255	255
Annual Usage [hours]	**In-Use**	25	25	25	25	25
	Standby	8,735	8,735	8,735	8,735	8,735
UEC [kWh/year]		2,525	2,500	2,400	2,375	2,375
AEC [TWh/year]		8.3	8.8	9.5	10.5	12.7

Portable Electric Spas

- **The projection includes a 2% increase in spa sales per year, slightly higher than projected population growth**
  - With an estimated 370,000 spas sold in 2006, 2% may be conservative, i.e., annual unit sales have approximately doubled over the past 10 years
  - Annual unit sales can vary greatly based on economic factors due to spas' relatively high cost and non-necessity.
- **Power draw is estimated based on a previous ADL model of various spa models and climates**
  - ADL modeled two types of spas, an older "vintage" spa and a new "prototype" spa, which were estimated to turn over a period of ten years for this projection.
  - Standby power draw reflects the time-average value for heating and low-speed pumping
  - Additionally, a third type of spa was included that takes into account new California standards for standby power draw and trends in spa features (more water jets, more advanced controls with backlighting); it is used to represent all new spa sales with a 15-year turn over.
- **The usage profile reflects data from a 2003 survey of California residents**
  - Profile assumes that spas in standby mode maintain water temperatures equal or close to operational temperature when in standby mode
    - California RASS suggests very different behavior
    - TIAX decided to use this assumption because, without constant heating, electric spas would take many (up to ten) hours to attain operational temperatures after days of non-use
  - There are some notable discrepancies in the frequency of use data between a market survey completed for the Association of Pool and Spa Professionals (APSP) and the CEC's RASS.
    - APSP data indicating usage at around every other day, which qualitatively appeared to be skewed toward higher usage.
    - RASS showed a much lower usage pattern and was deemed more reliable.
  - The uncertainty in the usage profile is mitigated by the much higher contribution of the standby mode to UEC.
  - Projections of future spa UEC assume that individuals' usage pattern will not change appreciably.

Rechargeable electronics includes a wide range of products, but our analysis identified four product categories that appear to account for most (~80%+) of total energy consumption in residences. Of those, cordless phones represent about half of the total energy consumed in 2005.

		2005	2010	2015	2020	2030
Installed Base [Millions]	Cordless Phones	180	170	160	155	140
	Cellular Phones	200	235	260	285	310
	Power Tools	107	125	145	170	220
	Hand Vacuums	21	23	24	25	28
UEC [kWh]	Cordless Phones	30	28	26	26	26
	Cellular Phones	3	3	3	3	3
	Power Tools	31	28	25	25	25
	Hand Vacuums	24	22	20	20	20
	AEC [TWh/year]	10	10	9	10	11

Note: The AEC value presented equals the some of the AEC values for the four products discussed. A preliminary estimate indicates that it represents approximately 85% of the total rechargeable electronics AEC.

Rechargeable Electronics

- **This category excludes office equipment, such as laptop/notebook PCs. It includes stand-alone battery chargers and devices that incorporate their own rechargeable batteries, including:**
  - Cordless phones, cell phones, cordless power tools, cordless vacuums, battery chargers, cordless electric toothbrushes, PDAs, camcorders, rechargeable digital still cameras, cordless gardening equipment, portable audio and video equipment, cordless trimmers and shavers.
- **The installed base of cordless vacuums is assumed to grow with households**
- **The installed base of cordless phones is assumed to decrease by 5% every 5 years due to a decreasing number of landlines (due to cell phones, VoIP)**
  - A precipitous decrease in the number of landlines could occur, increasing the rate of decay
- **The installed base of power tools are projected to grow more rapidly, i.e., with U.S. gross domestic product**
- **Significant uncertainty exists for power tool usage estimates**
  - Two basic usage profiles – do-it-yourselfer (more common, used in this analysis) and intensive user (e.g., contractor who charges devices at home)
  - Power draw values have less uncertainty
- **The future UEC of several devices is projected to decrease due to higher power supply and battery charger efficiency, driven by the California energy efficiency regulations that come into effect in 2007**

The installed base of home security systems projects to increase significantly.

		2005	2010	2015	2020	2030
Installed Base [millions]		25	35	40	45	55
Power Draw [W]	**Standby-Active**	9	7	5	5	5
	Standby-Passive	8	6	5	5	5
Annual Usage [hours]	**Standby-Active**	4,990	4,990	4,990	4,990	4,990
	Standby-Passive	3,770	3,770	3,770	3,770	3,770
UEC [kWh/year]		74	55	46	44	44
AEC [TWh/year]		1.9	2.0	1.8	2.0	2.4

Home Security Systems

- **Increased concerns about security are projected to rapidly increase the installed base of home security systems**
  - From ~18-20% circa 2001 to ~29% circa 2010
  - Projections beyond then reflect assumption that 40% of new homes built after 2009 have a security system
- **Power draw by mode estimates have significant uncertainty**
  - Few measurements exist for home security system power draw, particularly for hard-wired units (challenging to measure)
  - Four U.S. measurements from the 1990s suggest ~15W+ on, 14W+ standby for hard-wired units
  - Recent measurements of external power supply (EPS)-based units for the U.S. and measurements from Australia show much lower power draw (~5-6W) for EPS-based units
  - Almost all measurements of EPS-based systems suggest that power draw does not vary appreciably by mode
    - *Consequently, security system usage by mode does not appear to be an important variable for these systems*

Set-top box AEC is growing rapidly as both installed base and power draw increase.

		2005	2010	2015	2020	2030
Installed Base [millions]		96	160	141	123	134
Power Draw [W]	**Active**	20	22	25	28	28
	Off	20	21	23	27	27
Annual Usage [hours]	**Active**	6,450	6,480	6,500	6,520	6,570
	Off	2,310	2,280	2,260	2,240	2,190
UEC [kWh/year]		178	188	213	244	244
AEC [TWh/year]		17	30	30	30	33

- *Widespread use of point-of-deployment (POD) slot functionality in televisions would dramatically affect the future energy predictions by lowering STB installed base. TVs with POD slots can provide STB-like capabilities via a POD installed in the television. This obviates the need for a separate STB.*

The types of equipment included under set-top boxes (STBs) include cable boxes (analog and digital), direct broadcast satellite (DBS) receivers, multifunctional DVRs, and digital television adaptors (DTAs). STBs are evolving rapidly.

- **2005 installed base estimate developed from RASS survey data**
- **2010 installed base assumes continued growth of DBS STBs and digital STBs (especially DVR STBs), zero analog STBs, along with rapid growth of DTAs as broadcast TV switches to digital**
  - Beyond 2010, the installed base of DTAs is expected to decline to zero by 2020 as digital TVs replace the remaining analog TVs, while digital STBs and satellite receivers grow at the same rate as the number of households
- **2005 active power estimated using weighted average of active power for various STB types. STB power estimates come from limited measurement data**
  - 2005 off power for most STBs is only slightly lower than active power
- **Future active power is expected to increase**
  - High-definition (HD) TV STBs and multifunctional DVR products become more widespread
  - Implementation of an efficiency standard could alter this trend
- **2005 usage estimate comes from TV usage estimates by Nielsen Media**
  - In addition to the time the TV is on, STBs are estimated to be on 60% of the time the TV is not on because people fail to turn them off.

Televisions have the highest AEC of all residential miscellaneous electric end uses.

		2005	2010	2015	2020	2030
Installed Base [millions]		270	296	317	342	392
Power Draw [W]	**Active**	113	133	143	149	158
	Off	3.9	3.3	2.7	2.2	1.0
Annual Usage [hours]	**Active**	1,460	1,450	1,460	1,460	1,450
	Off	7,300	7,310	7,300	7,300	7,310
UEC [kWh/year]		193	217	230	233	236
AEC [TWh/year]		52	64	73	80	92

Televisions

- **2005 installed base estimate developed from combination of sales data and survey data**
- **Future installed base is expected to grow rapidly until the digital broadcast switch in 2009, at which point many analog TV's will be retired. Total installed TVs is expected to grow steadily after 2015 when digital becomes the dominant TV type**
- **2005 usage reflects from estimates of TV active hours per household per day (9.5) and TVs per household (2.4)**
  - Broadcast television hours/household comes from Nielsen Media.
  - Additional usage added for home video, video games, and simultaneous viewing
- **Future usage per household is expected to slowly climb, but the number of TVs per household is expected to grow more rapidly causing an overall slow decrease in active usage per TV. The rapid retirement of analog TVs circa 2010 causes a slight variation in this general trend.**

Televisions

- **2005 active power estimated using a weighted average of active power for large (>40 in.) and small (<40 in.) analog and digital TVs based on their respective percentages of installed base. Active mode dominates (~85%) TV UEC and is projected to do so to an even greater degree in the future. Currently, however, no up-to-date test procedure exists for TV active power.**

Installed TV breakdown for 2005 and 2015 [power draw from Ostendorp et al. 2005]

TV Type	TV Size	Avg. Active Power [W]	Percent of Intalled TVs 2005	Percent of Intalled TVs 2015
Analog	<40"	86	69%	10%
	>40"	156	16%	2%
Digital, SDTV	<40"	96	~0%	34%
	>40"	166	~0%	~0%
Digital, ED/HD TV	<40"	150	8%	34%
	>40"	234	8%	19%

- **Future average active power increases as larger HDTVs become more common**
  - Widespread market penetration of OLED- or carbon nanotube-based displays could markedly reduce television active power draw.
- **Projections of off mode power draw values assume that entire installed base of TVs meet current EnergyStar® level (≤1 W) by 2030, although UEC is relatively insensitive to off mode draw. Current TVs draw as little as 0.1 W when off.**
  - The mass acceptance of TVs with POD slots would increase the off mode power draw of TVs.

DVDs and VCRs comprise the home video products analyzed.

		2005	2010	2015	2020	2030
Installed Base [millions]	**DVD**	100	160	171	182	208
	VCR	100	53	20	7	1
Power Draw [W]	**Active**	17	16	15	14	12
	Idle	13	12	11	10	8
	Off	3.3	2.3	1.7	1.3	1.0
Annual Usage [hours]	**Active**	170	160	180	177	150
	Idle	5,150	5,160	5,150	5,150	5,170
	Off	3,430	3,440	3,430	3,433	3,440
UEC [kWh/year]		78	71	63	57	47
AEC [TWh/year]		16	15	12	11	10

The installed base of home video equipment could be radically lower in the future if other approaches for content delivery become much more popular (e.g., video on demand, movies stored on hard drives).

- **Future installed base estimates show continued DVD player growth until ~2010 when the market saturates, while VCRs are projected to fade away in the future**
- **Average future unit active and idle power draws are projected to decrease slightly as suggested by past data trends**
- **Future off power decreases as VCRs are phased out and as the average DVD player power draw converges to the EnergyStar® level (≤1 W)**
  - Widespread penetration of DVD player + *recorder* units could significantly increase video active and idle mode power draw (based on limited measurement from Energy Efficient Strategies 2006)
- **2005 usage estimate comes from prior household home video usage estimates, adjusted to account for household with multiple home video units**
  - Per household usage of home video is projected to slowly decrease overall because DVRs are used to record and playback TV rather than VCRs
    - Future active usage per unit increases slightly circa 2015 because the number of video units per household drops as VCRs disappear; subsequently, the active usage per unit slowly declines.
    - Units in households with multiple home video units (~60% of households) have greater idle and off time per unit
  - Assumes that 60% of the time not in active mode spent in idle mode because people fail to turn their home video system off.

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References for Commercial Sector Loads

Commercial Building Distribution Transformers Enter references in each of the following cells –

		2005	2010	2015	2020	2030
Installed Base (billion KVA)	Dry	DOE (2004), AEO (2006)				
	Liquid					
Average Total Losses [W/kVA]	Dry	DOE (2004)				
	Liquid					
Annual Usage [hours]	Active	DOE (2004)				
AEC [TWh]	Dry	Calculations				
	Liquid					

Commercial-Style Coffee Brewers

		2005	2010	2015	2020	2030
Installed Base [thousands]		Industry Sources	Industry Sources and AEO (2006)			
Power Draw [W]	**Active**	Bunn, Bloomfield, and Flavia Product Literature; Industry Sources				
	Ready					
	Off	Nipkow and Bush (2006)*				
Annual Usage [hours]	**Active**	National Coffee Association (2005), Bunn Product Literature, Nelson (2001), Industry Sources				
	Ready	TIAX Estimates				
	Off					
AEC [TWh]		Calculations				

*Value for residential-style brewer.

Non-Road Electric Vehicles

		2005	2010	2015	2020	2030
Installed Base	Lift Trucks	ITA (2006), EPRI (1997)				
	Golf Cars	National Golf Federation (2005), TIAX (2005), EPRI (1996)				
	Burnishers	EPRI (1996), TIAX Estimates				
UEC [kWh/year]	Lift Trucks	TIAX (2005)				
	Golf Cars	EPRI (1996)				
	Burnishers	TIAX (2005)				
AEC [kWh/year]	Lift Trucks	Calculations				
	Golf Cars					
	Burnishers					

MRI

		2005	2010	2015	2020	2030
Installed Base		Bell (2004), Bell (2006)				
Power Draw [kW]	**Active**	GE Healthcare (2005), GE Healthcare (2005 (2)), GE Healthcare (2002), Siemens Medical Solutions USA (2005), Bell (2004)				
	Standby					
	Off					
Annual Usage [hours]	**Active**	Johnson (2006), Isom (2006)				
	Standby	CIHI (2004)				
	Off	Calculated				
UEC [kWh/year]		Calculated				
AEC [TWh/year]		Calculated				

CT

<table>
<tr><th></th><th></th><th>2005</th><th>2010</th><th>2015</th><th>2020</th><th>2030</th></tr>
<tr><td colspan="2">Installed Base</td><td colspan="5">Bell (2004), Bell (2006)</td></tr>
<tr><td rowspan="2">Power Draw [kW]</td><td>Avg. Operating</td><td colspan="5">GE Healthcare (2006)</td></tr>
<tr><td>Off</td><td colspan="5">Siemens Medical Solutions USA (2005 (2))</td></tr>
<tr><td rowspan="2">Annual Usage [hours]</td><td>Avg. Operating</td><td colspan="5">CIHI (2004)</td></tr>
<tr><td>Off</td><td colspan="5">Calculated</td></tr>
<tr><td colspan="2">UEC [kWh/year]</td><td colspan="5">Calculated</td></tr>
<tr><td colspan="2">AEC [TWh/year]</td><td colspan="5">Calculated</td></tr>
</table>

X-Ray Machines

<table>
<tr><th colspan="2"></th><th>2005</th><th>2010</th><th>2015</th><th>2020</th><th>2030</th></tr>
<tr><td colspan="2">Installed Base (thousands)</td><td>Data from State Health Departments (CA, TX, FL, NY, PA)</td><td colspan="4">Mirrors U.S. healthcare floor space growth (AEO 2006)</td></tr>
<tr><td rowspan="2">Power Draw [kW]</td><td>Avg. Operating</td><td rowspan="2">GE Healthcare (2005 (2))</td><td colspan="3" rowspan="2">Linear extrapolation</td><td rowspan="2">GE Healthcare (2004)</td></tr>
<tr><td>Off</td></tr>
<tr><td rowspan="2">Annual Usage [hours]</td><td>Avg. Operating</td><td colspan="5">Isom (2006)</td></tr>
<tr><td>Off</td><td colspan="5">Calculated</td></tr>
<tr><td colspan="2">UEC [kWh/year]</td><td colspan="5">Calculated</td></tr>
<tr><td colspan="2">AEC [TWh/year]</td><td colspan="5">Calculated</td></tr>
</table>

Elevators

		2005	2010	2015	2020	2030
Installed Base (thousands)		EIA (2001)	Growth rate from Elevator World (1999)			
Power Draw [W]	**Active**	Enermodal (2004)				
	Standby	Enermodal (2004)				
	Off	TIAX estimate				
Annual Usage [hours]	**Active**	Enermodal (2004)				
	Standby	Enermodal (2004)	Powell (2006)			
	Off	Calculated				
UEC [kWh/year]		Calculated				
AEC [TWh/year]		Calculated				

Escalators

		2005	2010	2015	2020	2030
Installed Base (thousands)		Elevator World (2000), EIA (2001)	Elevator World (1996), Elevator World (2000)			
Power Draw [W]	**Avg. Operating**	Al-Sharif (1999)				
	Off	Conversation with Otis Representative				
Annual Usage [hours]	**Avg. Operating**	TIAX Estimate				
	Off	Calculated				
UEC [kWh/year]		TIAX Estimate based on average escalator rise from distribution in Enermodal (2004)				
AEC [TWh/year]		Calculated				

Water Pumping

	2005	2010	2015	2020	2030
Distributed Gallons per Year (billions)	Solley et al. (1998), Huston et al. (2003)				
UEC [kWh/million gallons]	Calculations				
AEC [TWh/year]	EPRI (2002), Wilkinson (2000), State of California (2005), Crosby (2006)				

Water Purification

	2005	2010	2015	2020	2030
Purified Gallons per Year (billions)	EPRI (2003), Hutson et al. (2004)				
UEC [kWh/million gallons]					
AEC [TWh/year]	EPRI (2002)				

Wastewater Treatment

	2005	2010	2015	2020	2030
Gallons Treated per Year (billions)	EPA (2003), EPRI (2002)				
UEC [kWh / million gallons]					
AEC [TWh/year]	EPRI (2002)				

References for Residential Sector Loads

Home Audio

		2005	2010	2015	2020	2030
Installed Base [millions]		EIA (2001), CEC (2004)				
Power Draw [W]	**Active**	Nordman and McMahon (2004), EnergyStar® website, Rosen and Meier (1999b)				
	Standby					
	Off					
Annual Usage [hours]	**Active**	Rosen and Meier (1999b), TIAX Television Usage Estimates				
	Standby					
	Off					
UEC [kWh/year]		Calculations				
AEC [TWh/year]		Calculations				

Ceiling Fans

		2005	2010	2015	2020	2030
Installed Base [millions]		AEO (2006), RECS (2001)				
Power Draw [W]	**In-Use**	DOE Priority Setting (2006), Roberts (2006)				
Annual Usage [hours]	**In-Use**	AEO (200), RECS (2001), www.weather.com (2006)				
UEC [kWh/year]		Calculations				
AEC [TWh/year]						

Residential Coffee Machines

		2005	2010	2015	2020	2030
Installed Base [millions]		RECS (2001), AEO (2006), U.S. Census Bureau (2006)				
Power Draw [W]	**Active**	Product Literature, ADL (1998)				
	Ready	ADL (1998),				
	Off	ADL (1998), Nordman and McMahon (2004)				
Annual Usage [hours]	**Active**	National Coffee Association (2005), Installed Base, Nelson (2001), U.S. Census (2000)				
	Ready	RECS (2001)				
	Off	Calculation				
UEC [kWh/year]		Calculation				
AEC [TWh/year]						

Home Security Systems

		2005	2010	2015	2020	2030
Installed Base [millions]		CEA (2005), Parks Associates (2005)	Parks Associates (2005), AEO (2006), TIAX Projections, CEC (2004)			
Power Draw [W]	**Standby-Active**	McAllister and Farrell (2004), Floyd and Webber (1998), Australian Greenhouse Office (2005), Nordman and McMahon (2004)				
	Standby-Passive					
Annual Usage [hours]	**Standby-Active**	Huber (1997)				
	Standby-Passive					
UEC [kWh/year]		Calculations				
AEC [TWh/year]		Calculations				

Microwave Ovens

		2005	2010	2015	2020	2030
Installed Base [millions]		Appliance (2005)	AEO (2006)			
Power Draw [W]	**Active**	ADL (1998), Nordman and McMahon (2004)				
	Standby					
Annual Usage [hours]	**Active**	CMPCO (1997)				
	Standby					
UEC [kWh/year]		Calculations				
AEC [TWh/year]		Calculations				

Portable Electric Spas

		2005	2010	2015	2020	2030
Installed Base [thousands]		Davis Energy Group (2004), APSP (2005)				
Power Draw [W]	**In-Use**	ADL (2001)				
	Standby	ADL (2001)	ADL (2001), CEC (2006)			
Annual Usage [hours]	**In-Use**	CEC (2004), ADL (2001)				
	Standby					
UEC [kWh/year]		Calculations				
AEC [TWh/year]						

Rechargeable Electronics

		2005	2010	2015	2020	2030
Installed Base [Millions]	Cordless Phones	CEA (2005), Bates (2006)	AEO (2006)			
	Cellular Phones	CTIA (2006)				
	Power Tools	EPA (2006)				
	Hand Vacuums	CCAP (2005), Appliance (2005)				
UEC [kWh]	Cordless Phones	McAllister and Farrell (2004), Rosen et al. (2001), CEC (2006)				
	Cellular Phones	Ostendorp et al. (2004), CCAP (2005)				
	Power Tools	McAllister and Farrell (2004), CEC (2006)				
	Hand Vacuums	CCAP (2005), CEC (2006)				
	AEC [TWh/year]	Calculation				

Set-top Boxes

		2005	2010	2015	2020	2030
Installed Base [millions]		CEC (2004), TIAX (2006), Amann (2004), FCC (2006)				
Power Draw [W]	**Active**	Foster (2005)				
	Off					
Annual Usage [hours]	**Active**	Nielsen Media (2005), Harrison (2006)				
	Off					
UEC [kWh/year]		Calculations				
AEC [TWh/year]		Calculations				

Televisions

		2005	2010	2015	2020	2030
Installed Base [millions]		CEA (2005), EIA (2001), Ostendorp et al. (2005), RASS (2004)	AEO (2006) and TIAX Analyses			
Power Draw [W]	**Active**	Ostendorp et al. (2005)	Ostendorp et al. (2005), TIAX estimates for distribution of TVs by size and technology			
	Standby		Ostendorp et al. (2005), EnergyStar®			
Annual Usage [hours]	**Active**	Nielsen Media (2000), Rosen and Meier (1999a)				
	Standby					
UEC [kWh/year]		Calculations				
AEC [TWh/year]		Calculations				

Home Video

<table>
<tr><th></th><th></th><th>2005</th><th>2010</th><th>2015</th><th>2020</th><th>2030</th></tr>
<tr><td rowspan="2">Installed Base [millions]</td><td>DVD</td><td rowspan="2">EIA (2001), Appliance (2005)</td><td colspan="4">AEO (2006)</td></tr>
<tr><td>VCR</td><td colspan="4">TIAX Estimates</td></tr>
<tr><td rowspan="3">Power Draw [W]</td><td>Active</td><td colspan="5" rowspan="3">Nordman and McMahon (2004), Energy Efficient Strategies (2006), Rosen and Meier (1999a)</td></tr>
<tr><td>Standby</td></tr>
<tr><td>Off</td></tr>
<tr><td rowspan="3">Annual Usage [hours]</td><td>Active</td><td colspan="5">Rosen and Meier (1999a), Installed Base</td></tr>
<tr><td>Standby</td><td colspan="5" rowspan="2">Harrison (2006)</td></tr>
<tr><td>Off</td></tr>
<tr><td colspan="2">UEC [kWh/year]</td><td colspan="5">Calculation</td></tr>
<tr><td colspan="2">AEC [TWh/year]</td><td colspan="5">Calculation</td></tr>
</table>

Preliminary Analyses for Devices Begun but Not Completed

A full analysis of commercial-sector video surveillance cameras was not completed when a preliminary analysis indicated that they account for relatively little energy consumption in 2005.

		2005	2010	2015	2020	2030
Installed Base (millions)		21	Not Investigated Further			
Power Draw [W]	**Active**	5				
	Standby	1				
Annual Usage [hours]	**Active**	8,760				
	Standby	0				
UEC [kWh/year]		44				
AEC [TWh/year]		0.9				

Video Surveillance Cameras

- 2005 installed base estimate comes from 2005 CCTV revenue, cost per system, and cameras per system estimates from Security Sales and Integration magazine website.
- Future number of units expected to continue to grow briskly, driven by security concerns
- Power draw estimates come from an average of various product specification sheets
  - Estimates likely high, appear to reflect rated rather than actual power draw
- 2005 usage estimate assumes cameras operate in active mode all the time. Motion activation may allow cameras to spend some time in a standby mode.
- Future video surveillance camera power draw expected to decrease significantly due to greater market share for CMOS-based cameras (and devices using Power over Ethernet)

Video Surveillance Cameras

		2005
Installed Base (millions)		Security Sales and Integration (2006)
Power Draw [W]	Active	Various product datasheets
	Standby	N/A
Annual Usage [hours]	Active	TIAX estimate
	Standby	TIAX estimate
UEC [kWh/year]		Calculated
AEC [TWh/year]		Calculated