APPENDIX B

ANALYSIS OF COMMERCIAL MISCELLANEOUS ELECTRIC LOADS – 2017 UPDATE

PREPARED FOR:

U.S. ENERGY INFORMATION ADMINISTRATION

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EXECUTIVE SUMMARY » OBJECTIVE, SCOPE, AND GOALS

Summary: We characterized energy consumption and installed base for four commercial miscellaneous electric loads (MELs) associated with telecommunication networks and seven MELs associated with commercial office equipment. The evaluation includes projections through 2050.

Objective: Develop an updated and expanded list of the estimated unit and national energy consumption for selected MELs.

MELs covered:

- **Telecommunications:** Traditional PBX, voice-over-IP (VoIP), cellular and PCS networks, ICT Long Haul networks, ICT Access Networks.
- **Office Equipment**: Copiers, scanners, multifunction devices (MFDs), fax machines, printers, shredders, and uninterruptible power supplies (UPS's).

Goals:

- Define each MEL and determine the scope of the technology to be analyzed.
- Characterize the 2012 installed base and unit energy consumption.
- Develop scenario-based projections through 2050.

EXECUTIVE SUMMARY » PROCESS DESCRIPTION

The evaluation used the following procedure:

1. Define the scope of each selected MEL (listed in table below).
2. Estimate the U.S. installed base in number of units or users.
3. Approximate the unit energy consumption (UEC) by determining typical:
   - Usage hours
   - Power consumption (per unit or per user, as appropriate)
4. Characterize relevant market, economic, demographic, and technology trends.
5. Develop projections up to the year 2050 based on expected changes in:
   - Usage hours
   - Power consumption
   - UEC
   - AEC
   - Installed base

Telecommunications	Office Equipment
• Traditional PBX	• Copier
• Voice-over-IP (VoIP)	• Scanner
• Cellular and PCS networks	• Multifunction device
• ICT long-haul networks	• Fax machine
• ICT access networks	• Printer
	• Shredder
	• Uninterruptible power supply (UPS)

EXECUTIVE SUMMARY » TELECOMMUNICATIONS EQUIPMENT

This analysis covered five separate types of telecommunications equipment.

MEL	Definition
Traditional PBX	Standalone on-premise equipment used to route calls over telephone lines (a.k.a. legacy PBX).
VoIP (IP PBX)	Standalone on-premise equipment used to route calls over the Internet (a.k.a. IP PBX and Media Gateway).
Cellular and PCS Networks	Central radio transmitter/receiver, including base station equipment.
ICT Long-haul Networks	System of routers and Ethernet switches interconnected by an optical transport network (OTN) of optical transceivers and amplifiers/repeaters used to transmit data packets over long distances (e.g., between regions or metropolitan areas).
ICT Access Networks	“The last mile" of telecom operator networks. Connect carrier/service provider central offices to end consumers, providing telephone and internet services.

EXECUTIVE SUMMARY » OFFICE EQUIPMENT

This analysis covers seven types of office equipment.

MEL	Definition
Copiers	A photocopier, or copier, is an office machine that duplicates physical documents on paper in a two dimensional format. It is used for reproducing text, images, charts, and graphs.
Scanners	A scanner converts physical documents into two-dimensional digital representations that can be either stored electronically, transmitted to a computer, or both.
Multifunction Devices (MFDs)	An MFD incorporates several, or all, of the operational capabilities of a copier, scanner, fax machine, printer, and the ability to send emails.
Fax Machines	A fax machine is a device that copies documents and transmits this copy via telephonic transmission to a telephone number connected to a printer or an output device.
Printers	A printer transcribes digital documents to two-dimensional representations on paper or an equivalent physical medium.
Shredders	A shredder uses a power source to mechanically cut paper into either strips or fine particles, typically with the aim of destroying documents containing sensitive information.
Uninterruptible Power Supplies (UPS's)	UPS's consists of a combination of convertors, switches and energy storage devices, constituting a power system for maintaining continuity of load power in case of input power failure.

EXECUTIVE SUMMARY » TELECOM TECH TRENDS

- The largest change in the telephone and telecommunications industry over the past ten years is the surfacing and widespread use of converged networks and Unified Communications (UC) – that is, a single network for all data, voice, and video.
- Due to UC, the same network equipment is often used to provide video, voice, and data services, and some parts of telephone networks are no longer separately distinguishable.
- A current trend indicates moving away from even these recent topologies to a cloud-services based concept, where the telephony head-end equipment is located off the private network and managed independently of the actual Local Area Network.
- Energy efficiency will likely improve in the “cloud” model; however, any savings realized through the efficient location and “sharing” of hardware will most likely be offset by an effort to increase available bandwidth and network speeds.
- Wired technologies offer higher bandwidths and energy efficiency per bit of data transfer; however, wireless technologies are growing faster due to consumer demand for mobility.

EXECUTIVE SUMMARY » OFFICE EQUIPMENT TRENDS

- The most significant trend in office-related commercial MELs is the replacement of single-function devices with MFDs.
- Because of combined functionalities, the total installed base of commercial imaging equipment MELs is expected to *decrease* by 9% from 2012 to 2050, even though commercial building floorspace will *grow* by 45%. Spaces that previously required a separate copier, scanner, fax, and printer will simply require one MFD.
- Fax machines are seeing dramatic decreases in installed base. By 2050, these devices are expected to be generally obsolete. This change is the result of the transition from paper to digital document storage, the MFD takeover, and the diminishing use of fax technology as other methods for secure transmission have become available.
- In data centers and other commercial spaces, reliable power supplies are essential to business operations. Growth in data center space will increase quicker than general commercial space because of increased demand for data storage and computing requirements. The installed base of UPS's will grow by 260%. Despite projected efficiency improvements, the AEC will grow by 230%.

EXECUTIVE SUMMARY » RESULTS SUMMARY

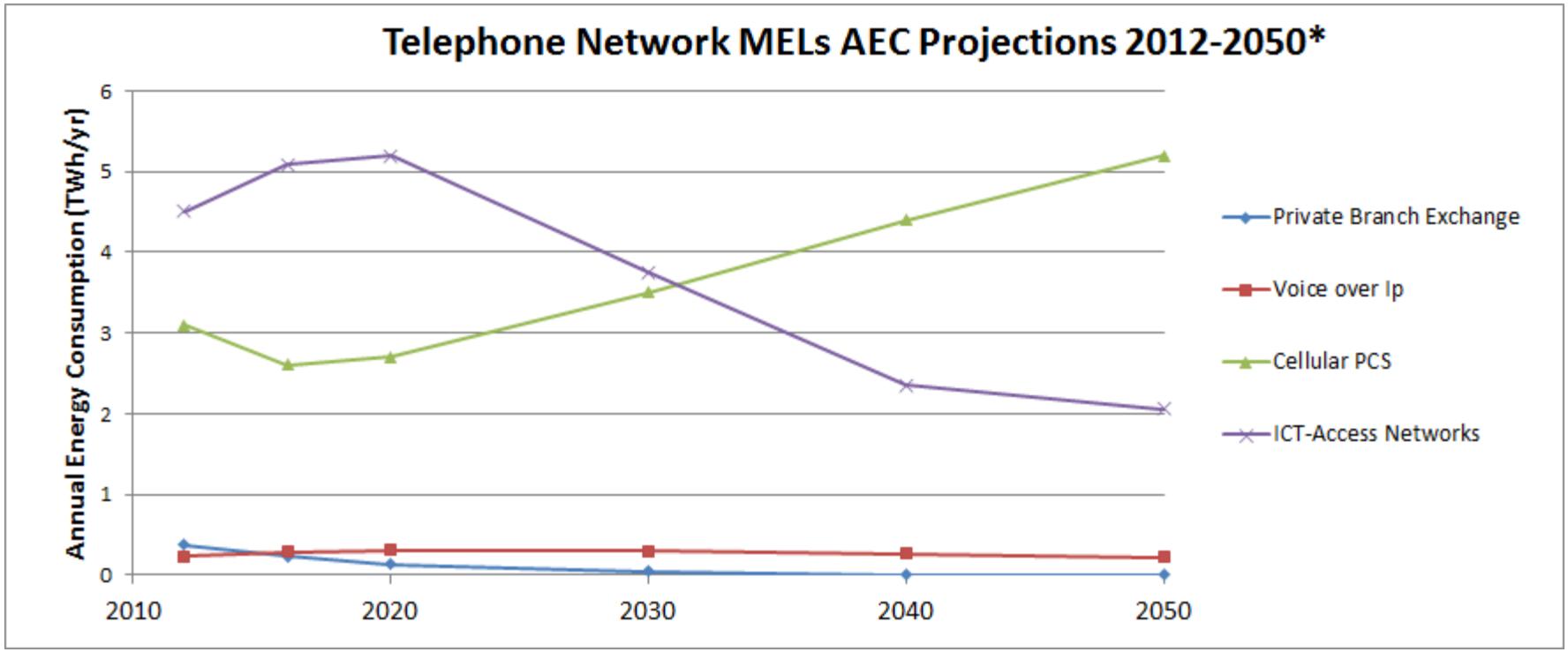
- The selected telecommunications MELs consumed an estimated 13 TWh in 2012.
- The selected office equipment MELs consumed 11 TWh in 2012.
- The MEL with the most significant AEC in 2012 was printers at 4.8 TWh.

Annual Energy Consumption by Building Type (TWh/yr)

AEC (TWh/yr)	Assembly	Education	Food Sales	Food Service	Healthcare	Lodging	Large Office	Small Office	Mercantile & Service	Warehouse	Other	Total
Office MELs												
Copiers	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.05
Scanners	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.02	0.02	0.01	<0.01	<0.01	0.09
Multifunction Devices	0.10	0.11	0.02	0.03	0.06	0.03	0.17	0.34	0.19	0.09	0.05	1.20
Faxes	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Printers	0.27	0.73	0.05	0.10	0.24	0.17	0.80	1.22	0.68	0.34	0.17	4.80
Shredders	<0.01	0.03	<0.01	<0.01	0.02	<0.01	0.06	0.04	0.02	0.02	<0.01	0.23
Uninterruptible Power Supplies	0.30	0.80	0.10	0.10	0.20	0.10	4.50	1.40	0.60	0.40	0.50	4.60
Telephone MELs												
Private Branch Exchange	0.02	0.05	0.00	0.01	0.02	0.01	0.07	0.08	0.05	0.03	0.02	0.4
Voice over IP	0.01	0.03	0.00	0.01	0.01	0.01	0.05	0.05	0.03	0.02	0.01	0.2
Cellular-Personal Comm Service	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.1	3.1
ICT-Long Haul Networks	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	4.5
ICT-Access Networks	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.5	4.5

EXECUTIVE SUMMARY » PROJECTIONS

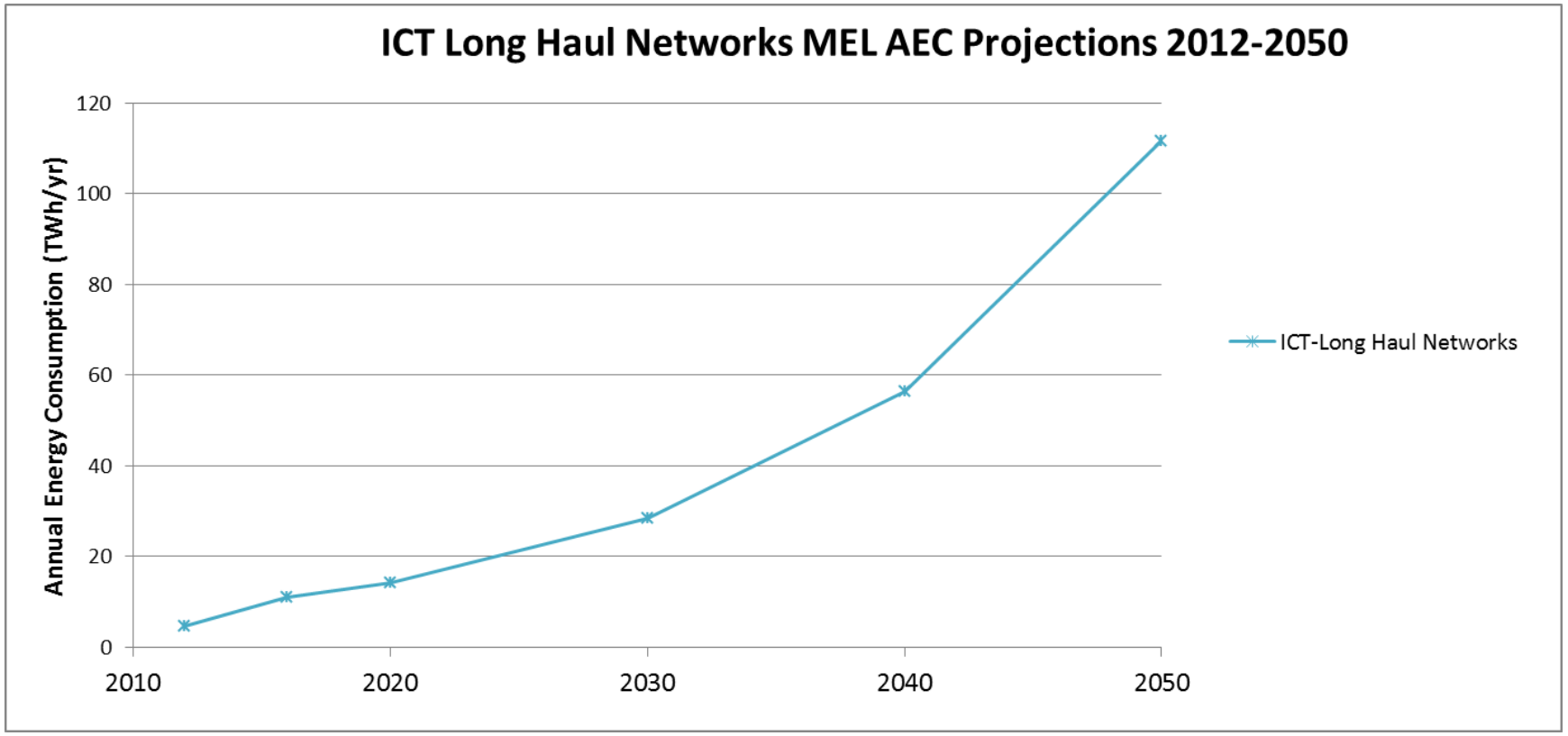
- Traditional PBX are quickly being replaced by IP PBX used for VoIP systems.
- Cellular and PCS network AEC shows steady growth after 2016 as subscribership and demand for wireless data increases.



* Does not include ICT Long Haul Networks

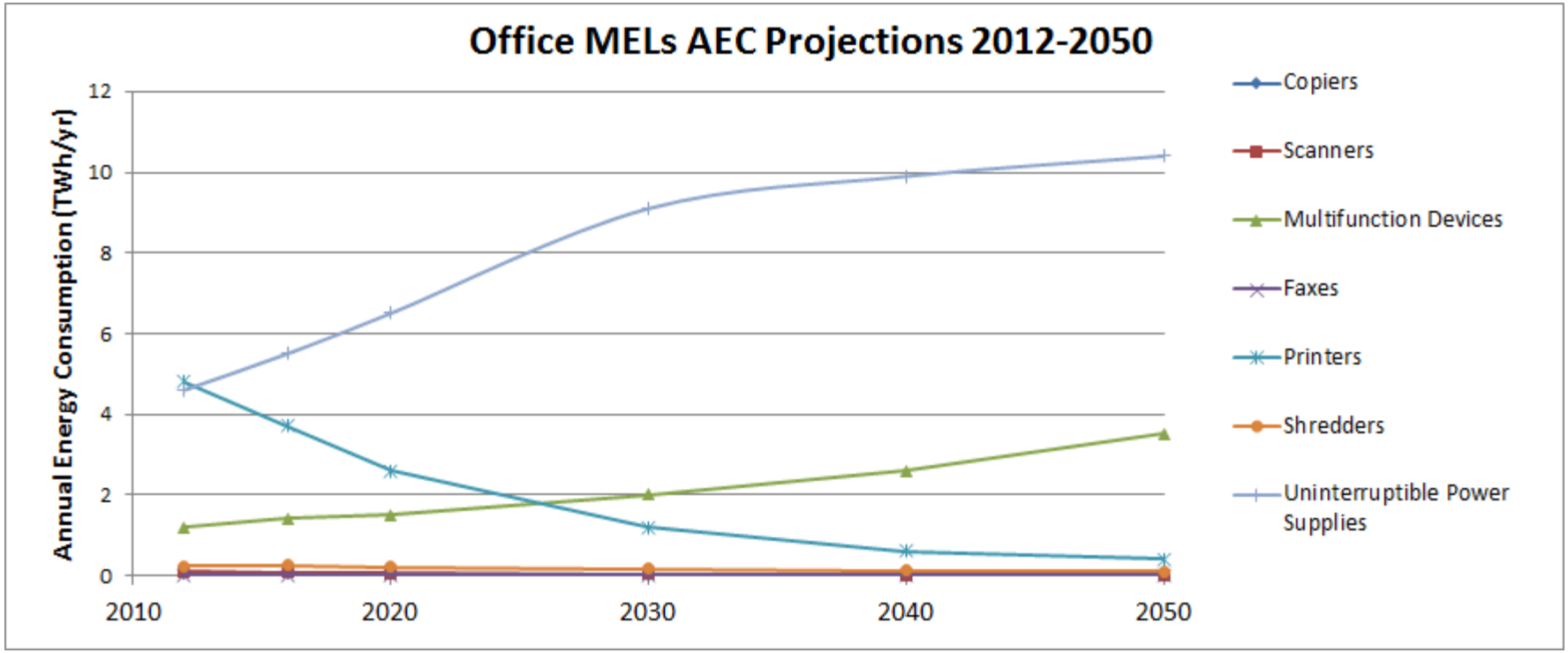
EXECUTIVE SUMMARY » PROJECTIONS CONT.

- ICT long-haul network AEC expected to grow at a CAGR of 9% through 2050 due to increasing data traffic volume



EXECUTIVE SUMMARY » PROJECTIONS CONT.

- The total AEC of the office-related MELs is expected to grow by 30% over the forecast period.
- MFDs will see the largest device-specific AEC growth—an increase of 290% between 2012 and 2050.



Background & Methodology

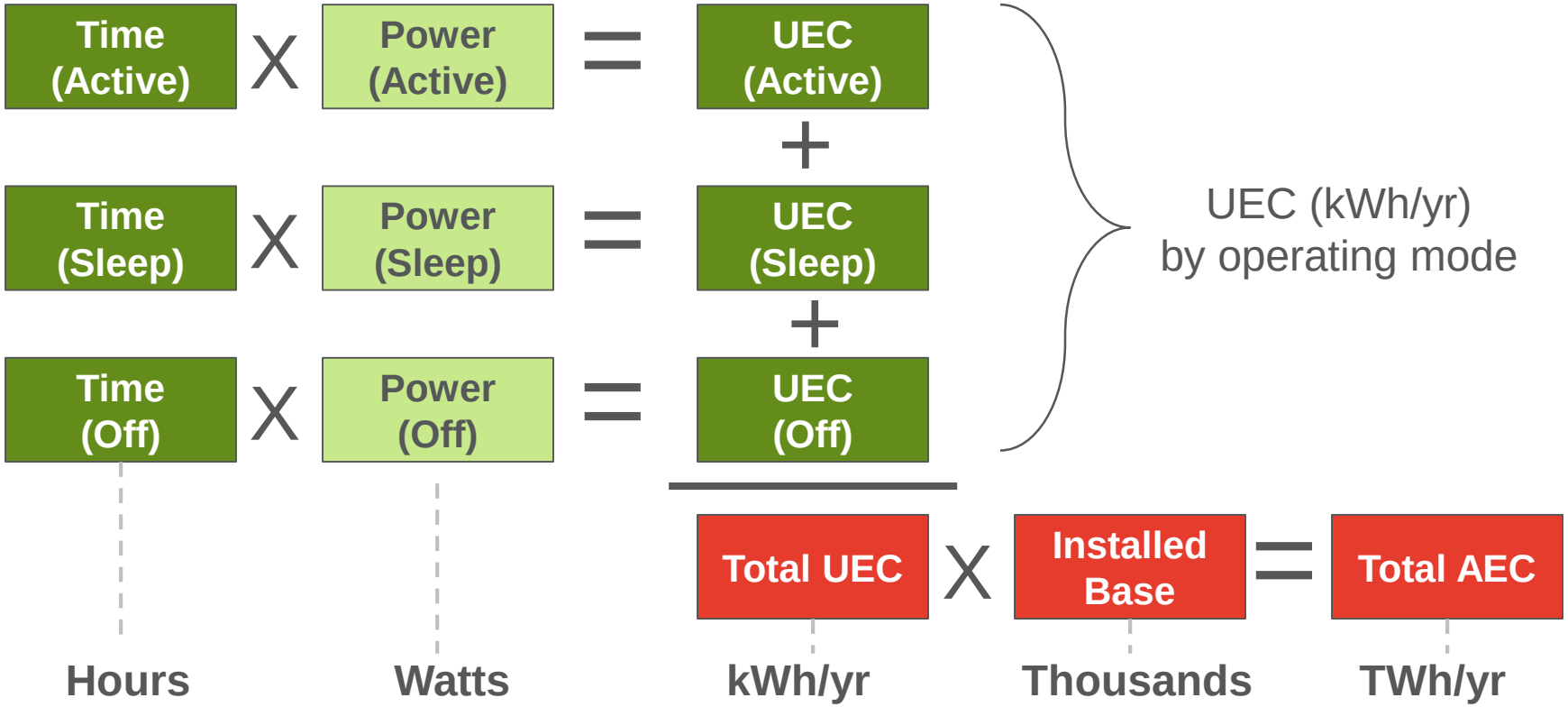
BACKGROUND » MEL DEFINITION

- **Miscellaneous electric loads (MELs)** are the loads outside of a building's core functions of heating, ventilating, air-cooling, lighting, and water heating.*
- This study focuses on a subset of MELs for:
  - Telecommunication networks.
  - Office equipment.
- Wherever workable, we followed the same methodology, reporting framework, and outputs as we provided in the past to ensure consistency. The primary model leveraged was from "Analysis and Representation of Miscellaneous Electric Loads in NEMS," Dec, 2013.**

*Source: Emily Rauch and Michael Baechler, Pacific Northwest National Laboratory, Sept 2011, "Assessing and Reducing Miscellaneous Electric Loads (MELs) in Banks" Available at: http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20973.pdf
**Available: https://www.eia.gov/analysis/studies/demand/miscelectric/pdf/miscelectric.pdf

METHODOLOGY » OVERVIEW

When sufficient data were available*, we followed a bottom-up methodology to calculate the three primary outputs for each MEL: unit energy consumption (UEC), installed base, and annual energy consumption (AEC).



* Based on the Contractor's judgment of whether available data were sufficient to formulate credible, bottom-up estimates.

METHODOLOGY » ENERGY USE

When sufficient data were not available for a complete bottom-up analysis of energy consumption*, we customized the approach to develop the best estimates possible.

Example: Fax Machines

- Very little data were available on hours of operation and energy consumption in individual modes. Accordingly, we based UEC estimates directly on a study by the California Energy Commission.

* Based on the Contractor's judgment of whether available data were insufficient to formulate credible, bottom-up estimates.

METHODOLOGY » INSTALLED BASE

Installed base estimates were developed using one or more of the following available resources:

- Field surveys (e.g., Commercial Building Energy Consumption Survey [CBECS])
- Useful life and annual sales data
- Other recent studies that developed estimates

Unique case: MFDs

- While the installed base of copiers, scanners, and printers was gathered from CBECS 2012, the installed base for MFDs was not available.
- CBECS questions did not necessarily elicit distinctions from respondents regarding whether a device serves multiple functions, thus introducing a challenge to distinguish between single-function devices and MFDs. To overcome this challenge, we:
    1. Determined if multiple imaging devices were in each building.
    2. Assumed that the MEL with the smallest number of units represented the MFD count for each building.
    3. Subtracted the MFD count from the CBECS counts, with the remainder representing the numbers of copiers, printers, and scanners. E.g., if CBECS data indicated 3 copiers, 5 scanners, and 7 printers in a building, then our count was 3 MFDs, 2 scanners, and 4 printers.

METHODOLOGY » PRODUCT TYPES

Consideration was made for varying product sizes/capacities and product subtypes.

- In general, we developed projections based on a “typical” unit for each MEL, in terms of size/capacity and usage.
  - Such a composite unit may not exist in the real world; it represents the average unit in the U.S.
- Exceptions were made where product subtypes have markedly different power and usage hours.
  - For Cellular and PCS Networks, we projected each subtype separately and calculated the weighted average at the end.
- We developed a unique projection approach for each MEL, generally based on observed trends in:
  - Past sales data and effective useful life.
  - Reported installed base data.
  - Product specifications from manufacturer datasheets.

METHODOLOGY » PROJECTIONS

We projected UEC, installed base, and AEC for each MEL out to 2050.

- Where data were available, we based energy projections on individual growth rates for annual hours of use and power consumption for each MEL.
- For MELs that did not have use and power data available, we projected UEC directly.
- In general, we developed projections based on a composite unit for each MEL, which is defined by an average that is weighted by the installed base of each product subtype.
  - E.g., the composite shredder, used for all shredder projections, comprises models of all sizes.
- We based projections for each MEL on unique trends in:
  - Population
  - Building floor space or stock
  - Gross Domestic Product (GDP)
  - Past sales data and effective useful life
  - Other market trends, such as the decline in paper use in the U.S.

METHODOLOGY » BREAKDOWN BY BUILDING TYPE

We split MEL estimates by building type, using the National Energy Modeling System (NEMS) definitions, which are closely correlated to the CBECS 2012 definitions.

Building Type	Description
Assembly	Public assembly (stadium, gym, library), religious
Education	College, K-12 schools (elementary, middle, high)
Food Sales	Grocery stores and convenience stores
Food Service	Restaurant, fast food, cafeteria
Healthcare	Hospitals providing inpatient health services
Lodging	Hotel, motel, dormitory, nursing home
Large Office	Offices > 50k sq ft of floor space
Small Office	Offices < 50k sq ft, including outpatient healthcare
Mercantile and Service	Retail, service shops, strip malls, enclosed malls
Warehouse	Refrigerated and non-refrigerated storage
Other	Public order (police, fire), vacant, other

For buildings with multiple functions, the largest usage of floor area determines principal activity.

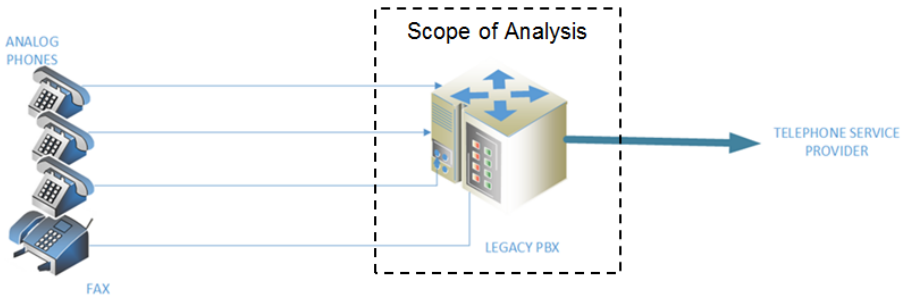
Results – Telecommunications Equipment

TELECOM MELS » TRADITIONAL PBX

Scope: Traditional or legacy Private Branch Exchanges (PBX) used by commercial enterprises to route and switch calls in a building over Plain Old Telephone Service (POTS) lines. Does not include IP PBX systems used to support VoIP networks.

		2012	2016	2020	2030	2040	2050
Installed Base	**(000s)**	21,400	13,100	7,900	2,200	0	0
Average Power Draw	**watts**	1.96	1.96	1.96	1.96	1.96	1.96
Annual Usage	**hours**	8,760	8,760	8,760	8,760	8,760	8,760
UEC	**kWh/yr**	17	17	17	17	17	17
AEC	**TWh/yr**	0.4	0.2	0.1	0.04	0.0	0.0

- Traditional PBX systems are rapidly being upgraded or replaced with Voice over Internet Protocol (VoIP) and unified communications (UC) technologies such as IP PBX systems and hosted/cloud-based services.
- Traditional PBX units come in a variety of user capacities from tens of users to thousands of users.
- Market data indicate that sales of new PBX units virtually stopped by 2012.
- Installed base data were only available in terms of PBX-connected phone lines (i.e., end users).*



* The terms lines and end users refer to individual people, rather than buildings

TELECOM MELS » TRADITIONAL PBX CONT.

2012 Base Year Data	Installed Base (000s)	UEC (kWh/yr)	AEC (TWh/yr)
Assembly	1,225	17	0.02
Education	2,642	17	0.05
Food Sales	284	17	0.00
Food Service	833	17	0.01
Healthcare	1,039	17	0.02
Lodging	744	17	0.01
Large Office	4,326	17	0.07
Small Office	4,675	17	0.08
Mercantile & Service	3,191	17	0.05
Warehouse	1,544	17	0.03
Other	898	17	0.02

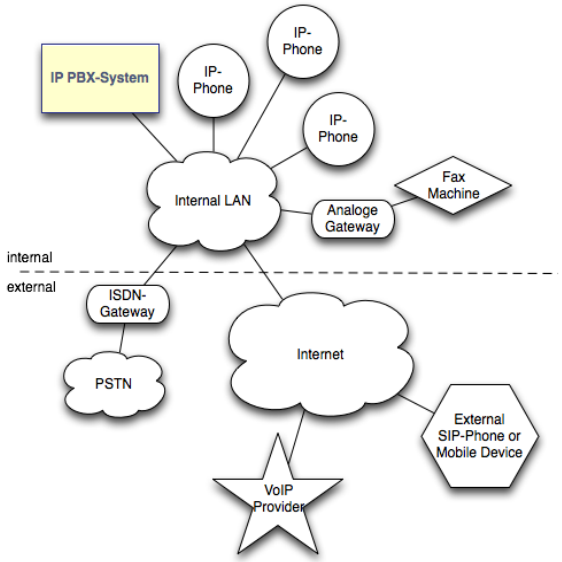
- This analysis allocates the installed base across building types based on total workers by building type from CBECS 2012.
- Power draw varies little by operating mode or call activity.
- This analysis assumes 24x7x365 operation with an average power draw of 1.96 watts per user.
- Efficiency is constant through 2050 since new units are not being installed after 2012.

TELECOM MELS » VoIP

Scope: Onsite equipment used to route voice calls on a VoIP network, often referred to as an IP PBX. Does not include connected communication devices (e.g., VoIP phones), analog gateways, computers, servers, or other networking or IT equipment, or hosted VoIP networks where the equipment resides on the host IT servers.

		2012	2016	2020	2030	2040	2050
Installed Base	**(000s)**	89,200	112,700	123,600	130,400	131,000	131,100
Average Power Draw	**watts**	0.29	0.28	0.28	0.26	0.23	0.19
Annual Usage	**hours**	8,760	8,760	8,760	8,760	8,760	8,760
UEC	**kWh/yr**	2.5	2.5	2.4	2.3	2.0	1.7
AEC	**TWh/yr**	0.2	0.3	0.3	0.3	0.3	0.2

- VoIP technology for business applications began in the mid 1990's and is currently growing rapidly.
- While on-premise VoIP systems continue to grow, businesses are increasingly moving to hosted VoIP solutions to cut costs and increase flexibility.
- Installed base data for on-premise systems was only available in terms of IP PBX-connected lines (i.e., end users).*



* The terms lines and end users refer to individual people, rather than buildings

TELECOM MELS » VoIP CONT.

2012 Base Year Data	Installed Base (000s)	UEC (kWh/yr)	AEC (TWh/yr)
Assembly	5,106	2.5	0.01
Education	11,011	2.5	0.03
Food Sales	1,186	2.5	0.00
Food Service	3,471	2.5	0.01
Healthcare	4,330	2.5	0.01
Lodging	3,101	2.5	0.01
Large Office	18,032	2.5	0.05
Small Office	19,485	2.5	0.05
Mercantile & Service	13,300	2.5	0.03
Warehouse	6,435	2.5	0.02
Other	3,744	2.5	0.01

- Average power draw per line determined by dividing total power draw by the number of connected users at 75% of user capacity for a representative sample of equipment.
- Rate of energy efficiency improvement assumed to match that of IT Equipment from.

TELECOM MELS » CELLULAR AND PCS NETWORKS

Scope: Equipment associated with the central radio transmitter/receiver and associated equipment, together known as a base station, that communicates with mobile telephones and other devices in order to provide wireless service in a geographic area. Both macro and micro/small base stations are included. Does not include connected communication devices (phones, tablets, computers, etc.), mobile switching, core transmission, data centers.

		2012	2016	2020	2030	2040	2050
Installed Base	**(000s)**	360	420	520	780	1,040	1,300
Average Power Draw	**watts**	980	720	580	510	470	450
Annual Usage	**hours**	8,760	8,760	8,760	8,760	8,760	8,760
UEC	**kWh/yr**	8,600	6,300	5,100	4,500	4,200	4,000
AEC	**TWh/yr**	3.1	2.6	2.7	3.5	4.4	5.2

- Base stations typically include several pieces of equipment that consume power, such as amplifiers, transceivers, power conversion modules, equipment air conditioning units, and signal processors. For the purpose of this analysis the entire base station is considered a single piece of end-use equipment.
- This analysis includes both large and small base stations. Large, or macro, base stations typically include large towers and have a range of 10 miles or more. Small, or micro, base stations are often located on top of buildings and a range of about 1 mile.
- Very small (Femto) cells are not included as they are typically behind the meter

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TELECOM MELS » CELLULAR AND PCS NETWORKS CONT.

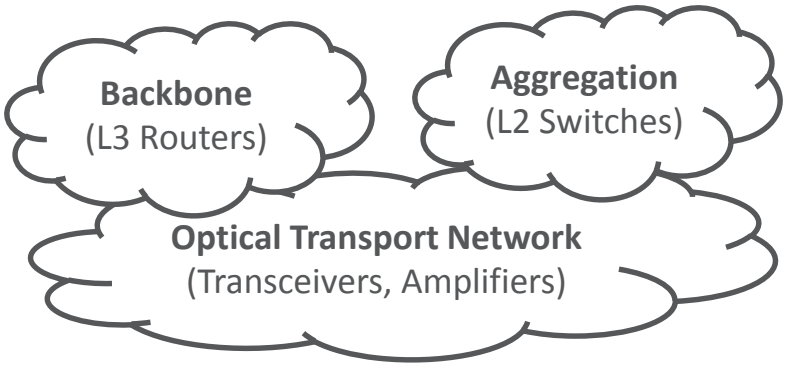
- The Wireless Industry Association (CTIA) tracks the number of macro base stations in service.
- Micro base station installed base data was not available, however, an estimate was obtained through personal communication with cell tower leasing company Steel in the Air.
- Although power draw varies depending on data traffic, the traffic often comes in bursts and varies widely among cell sites.
- This analysis assumes “always on” operation and uses an average power draw for macro and micro base stations.

TELECOM MELS » ICT LONG-HAUL NETWORKS

Scope: This analysis includes equipment in 3 network segments: (1) backbone, (2) aggregation, and (3) optical transport. The backbone segment includes layer 3 (L3) internet protocol/multiprotocol label switching (IP/MPLS) routers interconnected via an Optical Transport Network (OTN) platform. The aggregation segment includes layer 2 (L2) carrier-grade Ethernet switches interconnected via metro/regional OTN rings (Lange, 2011). OTNs are composed mainly of optical transceivers and amplifiers. Data centers, mobile radio networks, and access networks are not included. Overhead energy user for equipment cooling and power conditioning is also not included.

		2012	2016	2020	2030	2040	2050
AEC - Backbone	**TWh/yr**	1.3	5.1	6.7	13	27	53
AEC - Optical Transport	**TWh/yr**	0.8	1.2	1.6	3.1	6	12
AEC - Aggregation	**TWh/yr**	2.4	4.5	5.9	12	23	47
AEC - Total	**TWh/yr**	4.5	11	14	28	56	112

- Due to network complexity and data availability, this analysis utilizes an alternative, top-down estimation method. As a result, installed base, power draw, usage, and UEC data were not quantified.
- The consumption in network segments with aggregated traffic (aggregation and core networks) is proportional to the traffic volume. (Lange, 2011)



TELECOM MELS » ICT LONG-HAUL NETWORKS CONT.

- Annual Energy Consumption (AEC) was calculated for each network segment by multiplying worldwide telecom operator network energy consumption by the relative share of each network segment and by the U.S. share of worldwide broadband subscriptions, then dividing by an overhead factor.
- The backbone, aggregation, and optical transport network segments accounted for about 6%, 11%, and 3.5% of energy consumption in telecom operator networks in 2012 (Lange, 2011).
- The U.S. share of worldwide fixed telephone and broadband subscriptions was about 12.7% in 2012 and 11.8% in 2016 (ITU, 2016).*
- To avoid double-counting, overhead energy consumption for supplemental cooling and power conditioning requirements of long-haul network equipment was removed by dividing by an overhead factor of 1.5 per (Baliga, 2011).
- Projections for 2016-2050 assume equipment efficiency will improve 10% per year (Baliga, 2011 and Ishii, 2015) and internet traffic volume will increase 19% per year (Cisco, 2016).

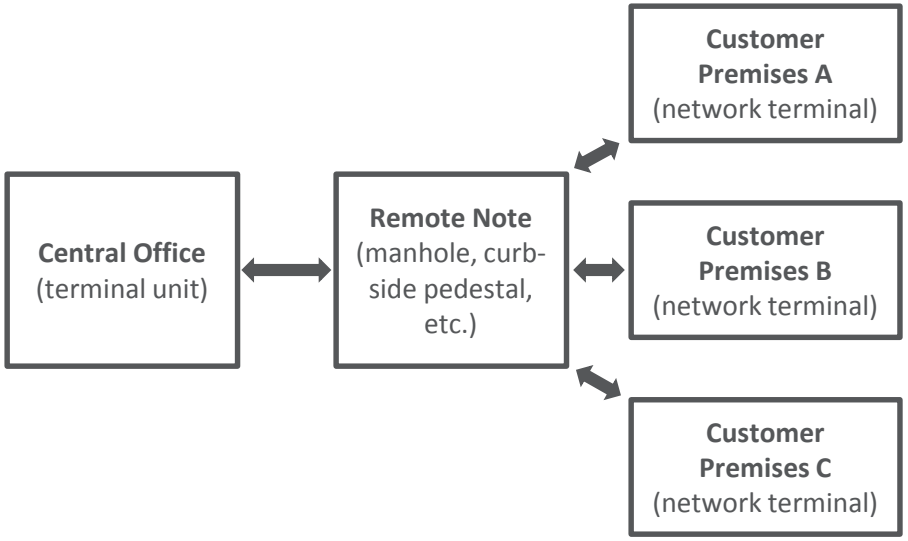
* Note that a single subscription is often shared by multiple or many individual end users, especially in commercial spaces.

TELECOM MELS » ICT ACCESS NETWORKS

Scope: This end-use includes terminal units in central offices and equipment in remote nodes (manholes, curbside pedestals, etc.). Customer premise equipment such as modems, routers, and network terminals located behind-the-meter are not included in this analysis to avoid double-counting. Overhead energy for equipment cooling and power conditioning in central offices is also not included.

		2012	2016	2020	2030	2040	2050
Installed Base	**(000s)**	93,000	102,000	110,000	123,000	133,000	141,000
Average Power Draw	**watts**	5.5	5.7	5.4	3.5	2.0	1.7
Annual Usage	**hours**	8,760	8,760	8,760	8,760	8,760	8,760
UEC	**kWh/yr**	48.5	49.9	47.2	30.5	17.7	14.6
AEC	**TWh/yr**	4.5	5.1	5.2	3.8	2.4	2.1

- Common types of access networks include cable, DSL, fiber-to-the-node (FTTN), and fiber-to-the-premise (FTTP).
- Depending on the connection type, signals may be sent over optical fiber, copper wires, or a combination of both.
- For many connection types, a remote node (e.g., manhole, curbside pedestal) located between the consumer and central office to split, aggregate, and/or amplify signals.



TELECOM MELS » ICT ACCESS NETWORKS CONT.

- In 2012, cable, DSL (including FTTN), and FTTP accounted for 56%, 34%, and 7% of broadband subscriptions in the U.S.*
- FTTP subscribership is increasing faster than any other access network type due to higher available access rates (i.e., internet speeds). The eventual replacement of DSL and cable with FTTP will also yield energy savings due to higher efficiency of FTTP networks.
- Terminal units and equipment at remote nodes are assumed to be loaded to 80% of max capacity per (Baliga, 2011). Since power does not scale with utilization, this results in a 25% increase in power draw per user compared to fully loaded conditions.
- Data was not available on the share of DSL connections supported by fiber-to-the-node (FTTN). The analysis assume a 50/50 split of all copper DSL and FTTN DSL.
- This analysis does not distinguish between residential and commercial subscribers due to a lack of available data on commercial access networks. All subscribers are treated as residential in terms of power draw and subscriber capacity of equipment. This may underestimate UEC and AEC since commercial subscribers are likely more energy intensive than residential subscribers due to higher access rates and connected users/devices per subscription. Commercial subscriptions represent about 9% of subscriptions.
- This analysis assumes increasing power demands from increasing access rates are approximately equivalent to power reductions from energy efficiency improvements on a watts per user basis.

* Note that a single subscription is often shared by multiple or many individual end users, especially in commercial spaces.

Results –
Office Equipment

OFFICE MELS » COPIER

Scope: This end-use includes single-function copiers only, i.e., those with the single function of copying and not those built into multifunction devices or having multiple functions, (e.g., copying and scanning).

		2012	2016	2020	2030	2040	2050
Installed Base	(000s)	270	240	190	100	50	30
UEC	kWh/yr	180	170	160	140	120	110
AEC	TWh/yr	0.049	0.041	0.030	0.014	0.006	0.003

- Copiers have the lowest installed base of all imaging equipment in this study.
- Formerly commonplace in every office, standalone copiers are becoming less common as:
  - Multifunction devices often take their place.
  - Paper-based documents are increasingly being used only in electronic formats.

Photo Source: http://www.amazon.com

OFFICE MELS » COPIER CONT.

2012 Base Year Data	Installed Base (000s)	UEC (kWh/yr)	AEC (TWh/yr)
Assembly	24	180	0.0042
Education	26	180	0.0046
Food Sales	2	180	0.0004
Food Service	3	180	0.0005
Healthcare	16	180	0.0029
Lodging	6	180	0.0011
Large Office	46	180	0.0083
Small Office	82	180	0.0150
Mercantile & Service	33	180	0.0060
Warehouse	18	180	0.0030
Other	11	180	0.0020

- Most standalone copiers utilize analog copying methods, which are correlated with a high UEC.
- Digital copiers are typically more efficient than their analog counterparts.
- However, since digital copiers use scanning technology, they often incorporate the functionality of a stand-alone scanner, and those that do are thus classified as MFDs.

OFFICE MELS » SCANNER

Scope: This end-use includes document scanners used to convert physical documents into digital form. Excluded are film scanners, hand-held scanners for 3-D printing, and large-scale industrial drum scanners used in publishing.

		2012	2016	2020	2030	2040	2050
Installed Base	(000s)	2,400	2,000	1,500	800	600	500
UEC	kWh/yr	37	35	33	30	29	28
AEC	TWh/yr	0.09	0.07	0.05	0.02	0.02	0.01

- Stand-alone scanners are most common in small offices (as well as in homes, which are outside the scope of this study).
- Large offices are more likely to use MFDs for all document imaging and printing needs due to higher volume requirements, which help justify the purchase of larger, more robust equipment.

Photo Source: http://pngimg.com/

OFFICE MELS » SCANNER CONT.

2012 Base Year Data	Installed Base (000s)	UEC (kWh/yr)	AEC (TWh/yr)
Assembly	140	37	0.005
Education	370	37	0.014
Food Sales	26	37	0.001
Food Service	46	37	0.002
Healthcare	120	37	0.004
Lodging	91	37	0.003
Large Office	410	37	0.015
Small Office	620	37	0.023
Mercantile & Service	350	37	0.013
Warehouse	180	37	0.007
Other	89	37	0.003

- Scanners have the lowest UEC of the characterized MELs.
- 87% of scanners sold in 2008 were ENERGY STAR qualified. This number reached 99% in 2010.
- After 2010, ENERGY STAR stopped releasing data for standalone scanners, which is believed to be a result of scanners commonly being incorporated into MFDs.
- ENERGY STAR imaging products are roughly 30% more efficient than non-ENERGY STAR products, according to the EPA.

OFFICE MELS » MFD

Scope: This end-use includes all-in-one small desktop units; multifunction devices for small office/home office use (i.e., desktop products); and full-size office multifunction devices (i.e., floor-standing products).

		2012	2016	2020	2030	2040	2050
Installed Base	(000s)	6,300	8,500	9,400	13,000	17,000	23,000
UEC	kWh/yr	190	170	160	150	150	150
AEC	TWh/yr	1.2	1.4	1.5	2.0	2.6	3.5

- MFDs combine multiple imaging equipment functions into one package, including printing, scanning, copying, and faxing.
- The MFD market has been growing steadily as improved imaging technology makes it possible for devices to perform multiple functions.
- Laser MFDs constitute the majority of the market. These units have high energy use due to the heat intensive process of fusing ink to paper.

Photo Source: https://www.energystar.gov/

OFFICE MELS » MFD CONT.

2012 Base Year Data	Installed Base (000s)	UEC (kWh/yr)	AEC (TWh/yr)
Assembly	540	190	0.10
Education	560	190	0.11
Food Sales	100	190	0.02
Food Service	180	190	0.03
Healthcare	290	190	0.06
Lodging	150	190	0.03
Large Office	900	190	0.17
Small Office	1,800	190	0.34
Mercantile & Service	1,000	190	0.19
Warehouse	470	190	0.09
Other	250	190	0.05

- In 2010, 99% of MFD shipments were ENERGY STAR qualified.
- After 2010, ENERGY STAR reports combined MFD and printing shipments, highlighting the takeover of printer market by MFDs.

- Power consumption is expected to decrease by 30% over the forecast period. This change is primarily because of changes in idle-state power consumption.

OFFICE MELS » FAX MACHINE

Scope: This includes all standalone fax machines, including inkjet, laser, and thermal technologies.

		2012	2016	2020	2030	2040	2050
Installed Base	(000s)	90	61	31	6	2	1
UEC	kWh/yr	57	52	47	40	34	31
AEC	TWh/yr	0.0051	0.0032	0.0015	0.0002	0.00007	0.00003

- The use of stand-alone fax machines is on the decline due to:
  - Proliferation of electronic document transmission as pdf files via email and, to a smaller extent, by fax-over-IP (FoIP).
  - Documents are being increasingly used in only electronic formats.
  - Multifunction devices are taking their place.
  - The acceptance of electronic signatures for sensitive documents
  - Multiple advances in secure data transmission reduce the value of faxes
- By 2050, only very few units will still be in use in niche applications; but will be obsolete for most intents and purposes.

Photo Source: https://www.cpsc.gov/

OFFICE MELS » FAX MACHINE CONT.

2012 Base Year Data	Installed Base (000s)	UEC (kWh/yr)	AEC (TWh/yr)
Assembly	8.9	57	0.00051
Education	6.2	57	0.00035
Food Sales	3.0	57	0.00017
Food Service	5.2	57	0.00030
Healthcare	0.2	57	0.00001
Lodging	2.4	57	0.00014
Large Office	1.5	57	0.00009
Small Office	27	57	0.0015
Mercantile & Service	23	57	0.0013
Warehouse	9.3	57	0.00053
Other	3.6	57	0.00021

- As of 2008 only 4% of fax shipments were Energy Star certified.
- This number rose to just 7% in 2013, when EPA stopped tracking shipments volumes.
- ENERGY STAR imaging products are about 30% more efficient than non-certified products.

- Due to decreasing demand for faxes, there is little incentive for the development and introduction of new, power-saving idle modes.

OFFICE MELS » PRINTER

Scope: This includes standalone ink-jet printers and standalone laser printers. Not covered are 3-D printers, plotters, thermal printers (e.g., cash registers), dye-sublimation printers, dot-matrix printers, line printers, liquid ink electrostatic printers, and photo printers.

		2012	2016	2020	2030	2040	2050
Installed Base	(000s)	20,000	17,000	13,000	7,000	4,000	3,000
UEC	kWh/yr	240	220	200	170	150	140
AEC	TWh/yr	4.8	3.7	2.6	1.2	0.6	0.4

- Printers currently have the largest installed base of all the imaging equipment MELs in this study.
- However, the growth of the MFD market will continue to erode the printer market as manufacturers are able to cheaply introduce other functionalities into single-function devices.
- Between the years 2020 and 2030, the total MFD installed base will surpass that of printers.

Photo Source: https://www.cpsc.gov/

OFFICE MELS » PRINTER CONT.

- Like MFDs, laser printers consume significantly more power than similar inkjet models.
- The technologies used for decreased idle-state power consumption in printers are identical to those used in MFDs. Together, the large installed bases and industry size will drive improvements in technology, including idle-state power.

2012 Base Year Data	Installed Base (000s)	UEC (kWh/yr)	AEC (TWh/yr)
Assembly	1,100	243	0.3
Education	3,000	243	0.7
Food Sales	200	243	0.05
Food Service	400	243	0.1
Healthcare	1,000	243	0.2
Lodging	700	243	0.2
Large Office	3,300	243	0.8
Small Office	5,000	243	1.2
Mercantile & Service	2,800	243	0.7
Warehouse	1,400	243	0.3
Other	700	243	0.2

OFFICE MELS » SHREDDER

Scope: This end-use includes paper shredders connected to an electric power source in a commercial space. Excluded are mobile paper-shredding box trucks.

		2012	2016	2020	2030	2040	2050
Installed Base	(000s)	5,700	5,900	5,600	5,100	4,800	4,800
Power Draw (W)	Active	550	550	550	550	550	550
	Idle/Ready	2.8	2.7	2.4	1.7	1.0	0.4
	Off	0	0	0	0	0	0
Annual Usage (hrs)	Active	30	30	30	30	30	30
	Idle/Ready	8,730	8,730	8,730	8,730	8,730	8,730
	Off	0	0	0	0	0	0
UEC	kWh/yr	41	40	37	31	25	20
AEC	TWh/yr	0.23	0.24	0.21	0.16	0.12	0.10

- Paper shredders preserve confidentiality by destroying sensitive documents.
- Approximately 60% of total power consumption occurs in idle mode since shredders are estimated to operate an average of only five minutes per day.
- With the emerging trend of power-saving idle modes, the idle power consumption will decrease significantly by 2050.

Photo Sources: http://www.abe-online.com/, http://rilane.com/

OFFICE MELS » SHREDDER CONT.

2012 Base Year Data	Installed Base (000s)	UEC (kWh/yr)	AEC (TWh/yr)
Assembly	220	40	0.009
Education	770	40	0.031
Food Sales	80	40	0.003
Food Service	240	40	0.010
Healthcare	540	40	0.021
Lodging	220	40	0.009
Large Office	1,200	50	0.060
Small Office	1,200	33	0.039
Mercantile & Service	570	40	0.023
Warehouse	450	40	0.018
Other	250	40	0.010

- With the continued transition from physical to digital information sharing, the decrease in paper use will diminish the need for shredders in commercial spaces.
- In the last decade, the market for outsourced shredding has grown significantly, further eroding the market for in-office shredders. Third-party outsourcing companies pick up documents from the client and shred them securely with their own equipment, typically built into a truck.

OFFICE MELS » UPS

Scope: This end-use includes those that support electronic equipment in an office, including in server closets and server rooms, and data centers.

		2012	2016	2020	2030	2040	2050
Installed Base	(000s)	9,000	11,000	13,000	19,000	21,000	23,000
Power Draw (W)	25% Load	90	90	89	88	86	86
	50% Load	61	61	61	59	58	58
	75% Load	55	55	55	53	52	52
	100% Load	53	53	53	52	51	50
Annual Usage (hrs)	25% Load	430	430	430	217	217	0
	50% Load	2,410	2,410	2,410	1,752	1,220	217
	75% Load	3,290	3,290	3,290	4,163	4,065	2,874
	100% Load	2,630	2,630	2,630	2,628	3,258	5,669
UEC	kWh/yr	510	500	500	480	470	450
AEC	TWh/yr	4.6	5.5	6.5	9.1	9.9	10.4

- There are 3 kinds of UPS:
  - Voltage and Frequency Dependent (VFD) - lower power ratings; used for equipment not sensitive to voltage and frequency fluctuations.
  - Voltage Independent(VI) - low to medium power ratings and can be a cheap alternative to VFIs for sensitive equipment.
  - Voltage and Frequency Independent(VFI) – medium to high power ratings and are used for sensitive equipment, like data center servers.

Photo Source: https://www.energystar.gov/

OFFICE MELS » UPS CONT.

2012 Base Year Data	Installed Base (000s)	UEC (kWh/yr)	AEC (TWh/yr)
Assembly	300	1,000	0.3
Education	800	1,000	0.8
Food Sales	100	1,000	0.1
Food Service	100	1,000	0.1
Healthcare	200	1,000	0.2
Lodging	100	1,000	0.1
Large Office	4,500	1,000	4.5
Small Office	1,400	1,000	1.4
Mercantile & Service	600	1,000	0.6
Warehouse	400	1,000	0.4
Other	500	1,000	0.5

- ~50% of the UPS installed base is in data center applications (included in the large office NEMS category). Splits across other building types is assumed to be equal to split of servers from CBECS.
- Data centers use larger-than-average UPSs in the range of ~5 to ~50 kVA.
- VFI UPS's are often used in data centers. They convert incoming AC current to DC current and then convert the DC back to AC before delivering it to the load. This double conversion makes them ideal for sensitive equipment (better protections) but also makes them the least efficient type of UPS.

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