

# Building Technologies Office: R&D Opportunities to Reduce Energy Consumption in Miscellaneous Electric Loads (MELs)



U.S. DEPARTMENT OF  
**ENERGY**

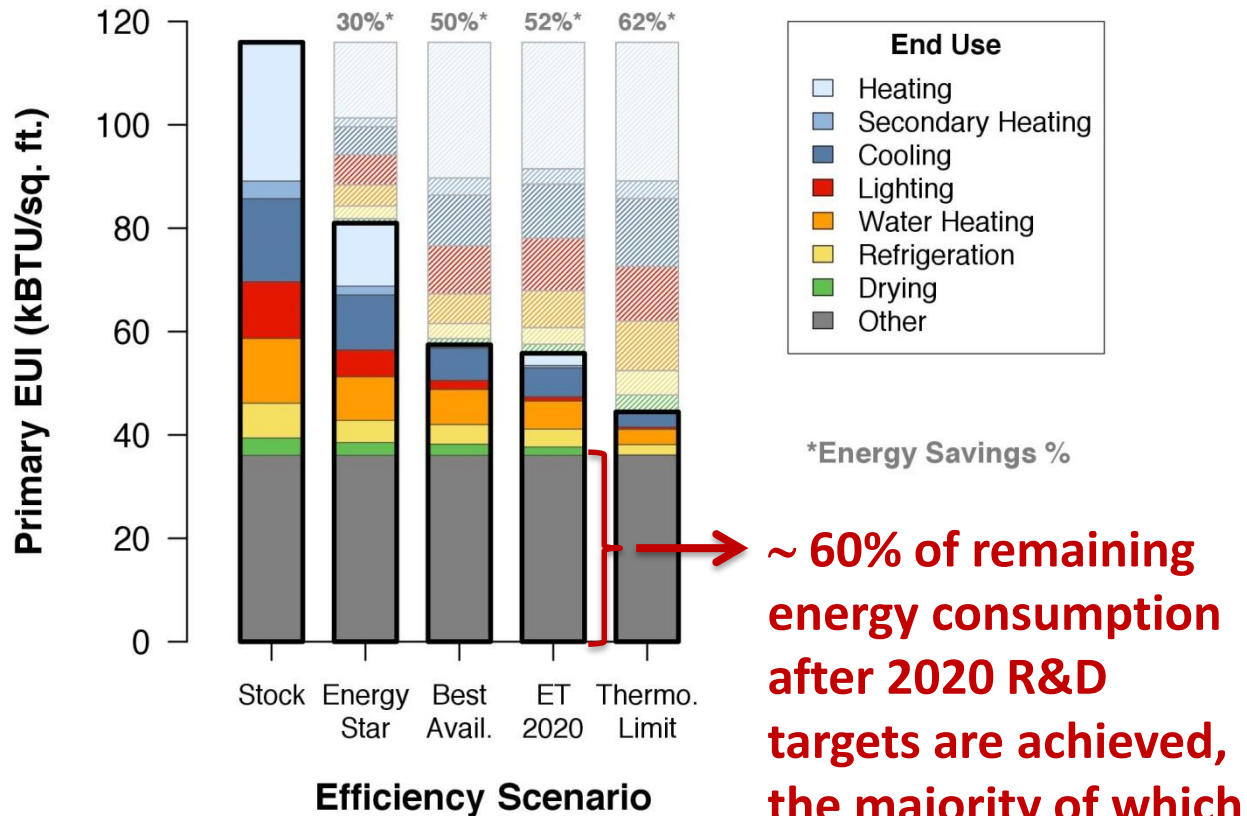
Energy Efficiency &  
Renewable Energy

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BTO Emerging Technologies  
June 3, 2016

# Why Do We Care About MELs?

**Problem:** Fraction of energy consumption due to MELs is rising as other building technologies become more efficient.

Residential Energy (Single Family, All Regions)



DOE Quadrennial Technology Review (2015)

## FY16 Activities:

- Panel discussion at the BTO Peer Review
- This workshop
- RFI

## FY17 Activities:

- Proposed FOA topic

# MELs Definition and Workshop Objectives

**DEFINITION:** Miscellaneous Electric Loads (MELs) are the **electric** loads outside of a building's core functions of heating, ventilation, air conditioning, lighting, water heating, and refrigeration.

## **Workshop Objectives**

- **Determine R&D opportunities that can lead to significant reductions in MELs energy consumption**
  - Near-term commercialization (by 2020)
  - Long-term commercialization (by 2025)
- **Determine if there are “platform” technologies to be developed that can address a number of MELs**
- **Determine draft quantitative metrics and targets for future solicitations**

# Current & Projected MELs Energy Consumption

## “Defined MELs”

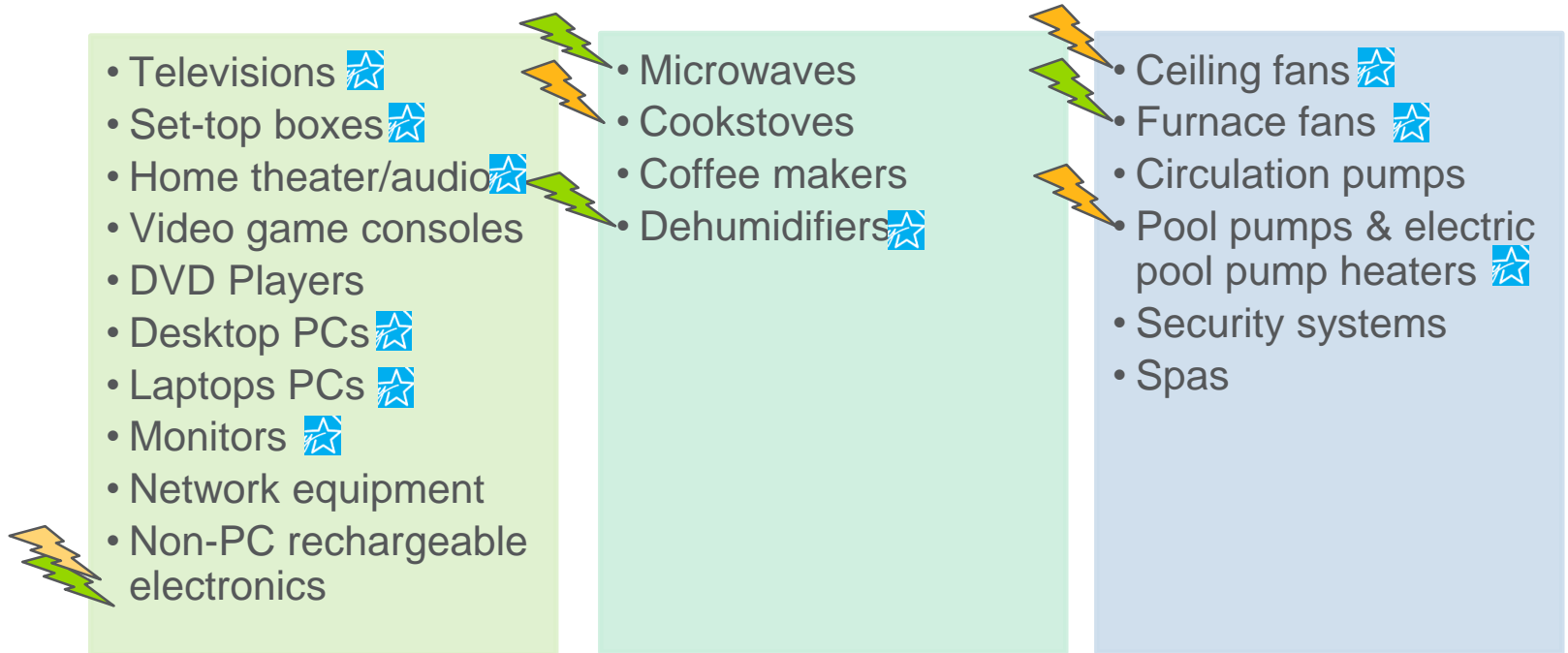
- MELs characterized by EIA for AEO (as part of the National Energy Modeling System [NEMS]), which specifically reference:
  - *Analysis and Representation of Miscellaneous Electric Loads in NEMS. Navigant Consulting, Inc. and SAIC*
  - *Multiple Technical Support Documents of DOE Appliance Standard Rulemakings.*

## “Undefined MELs”

- MELs that have not been specifically characterized by EIA/AEO/NEMS and are aggregated to include technologies which have been deemed too small to characterize individually.

# Defined Residential MELs

EIA investigated and defined the following MELs in their Annual Energy Outlook (AEO). Energy consumption and stock projections are available from AEO 2015 for U.S. households:



DOE Standard in Effect



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ENERGY STAR Covered

# Defined Commercial MELs

EIA investigated and defined the following MELs in their Annual Energy Outlook (AEO). Energy consumption and stock projections are available from AEO 2015 for commercial buildings:

- PC office equipment 
- Non-PC office equipment 
- Video displays 
- Large video boards
- Medical imaging
- Security system

- Cooking equipment
- Coffee brewers 
- Kitchen ventilation
- Water services

- Dry-type distribution transformers
- Elevators
- Escalators
- Laundry
- Fume hoods
- Laboratory refrigerators and freezers



DOE Standard in Effect



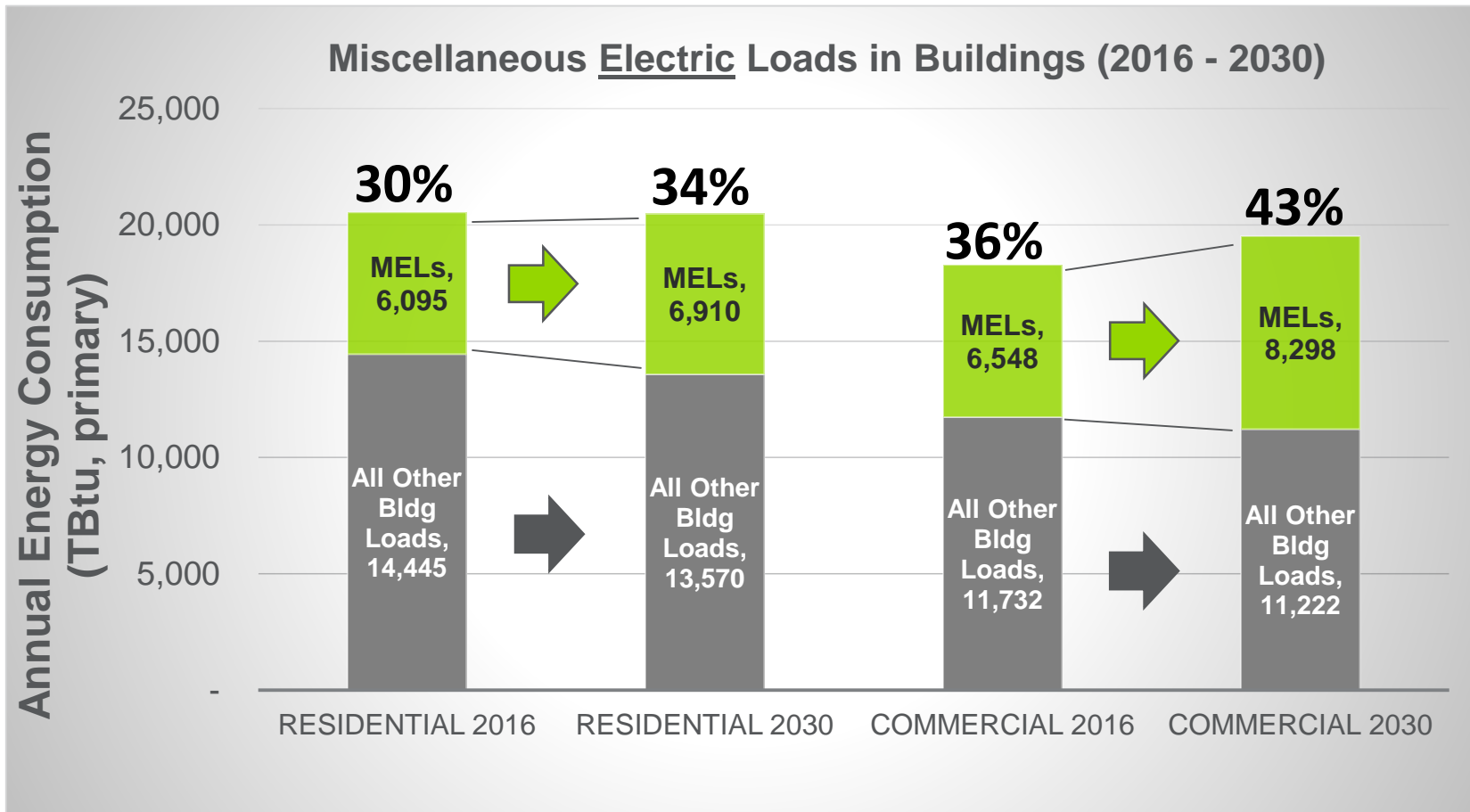
DOE Standard in Development



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# Miscellaneous Electric Loads vs Total Building Energy Use

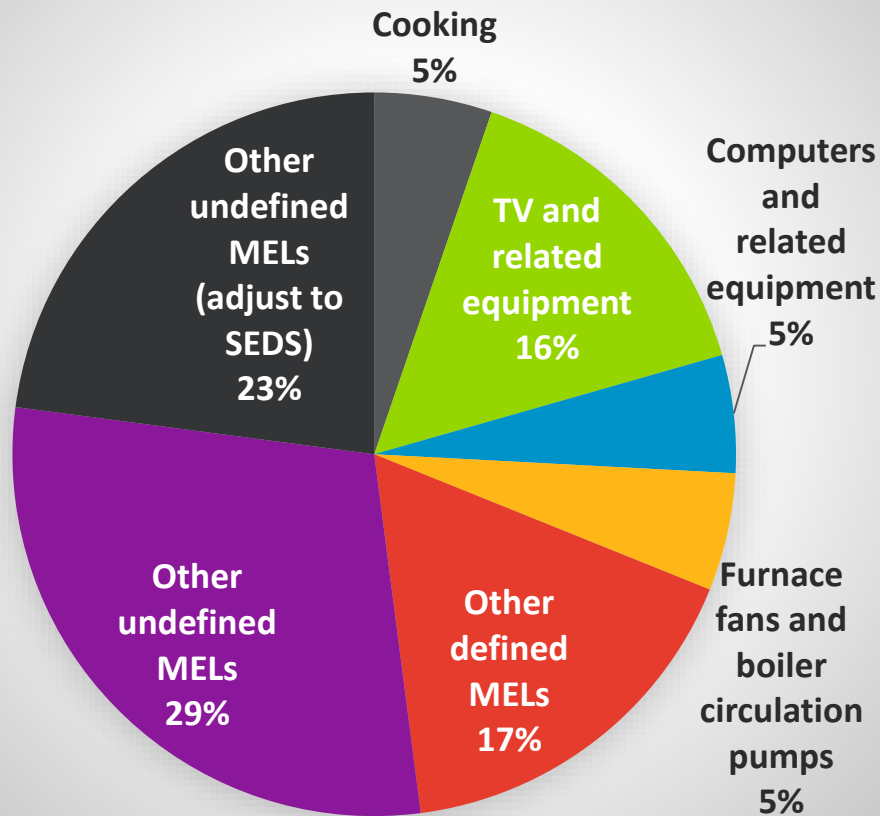
According to EIA Annual Energy Outlook (AEO, 2015), under business-as-usual scenario, contribution of Miscellaneous Electric Loads (MELs, electric) to total building energy consumption is projected to increase from **30% to 34%** for the residential sector and from **36% to 43%** for the commercial sector for 2016 – 2030.



# Residential MELs: Energy Use Breakdown (2020)

## Residential MELs in 2020

Primary Energy Use: 6,310 TBtu



EIA Annual Energy Outlook, 2015

- **TV & related equipment:** TVs, set-top boxes, home theater systems, DVD players, video game consoles.
- **Computers & related equipment:** desktop PCs, laptop PCs, monitors, networking equipment
- **Cooking:** cookstoves
- **Furnace fans & boiler circulation pumps**
- **Other defined MELs:** non-PC rechargeable electronics (battery chargers), ceiling fans, coffee machines, dehumidifiers, microwaves, pool pumps, pool heaters, security systems, and portable spas.

### Undefined MELs include:

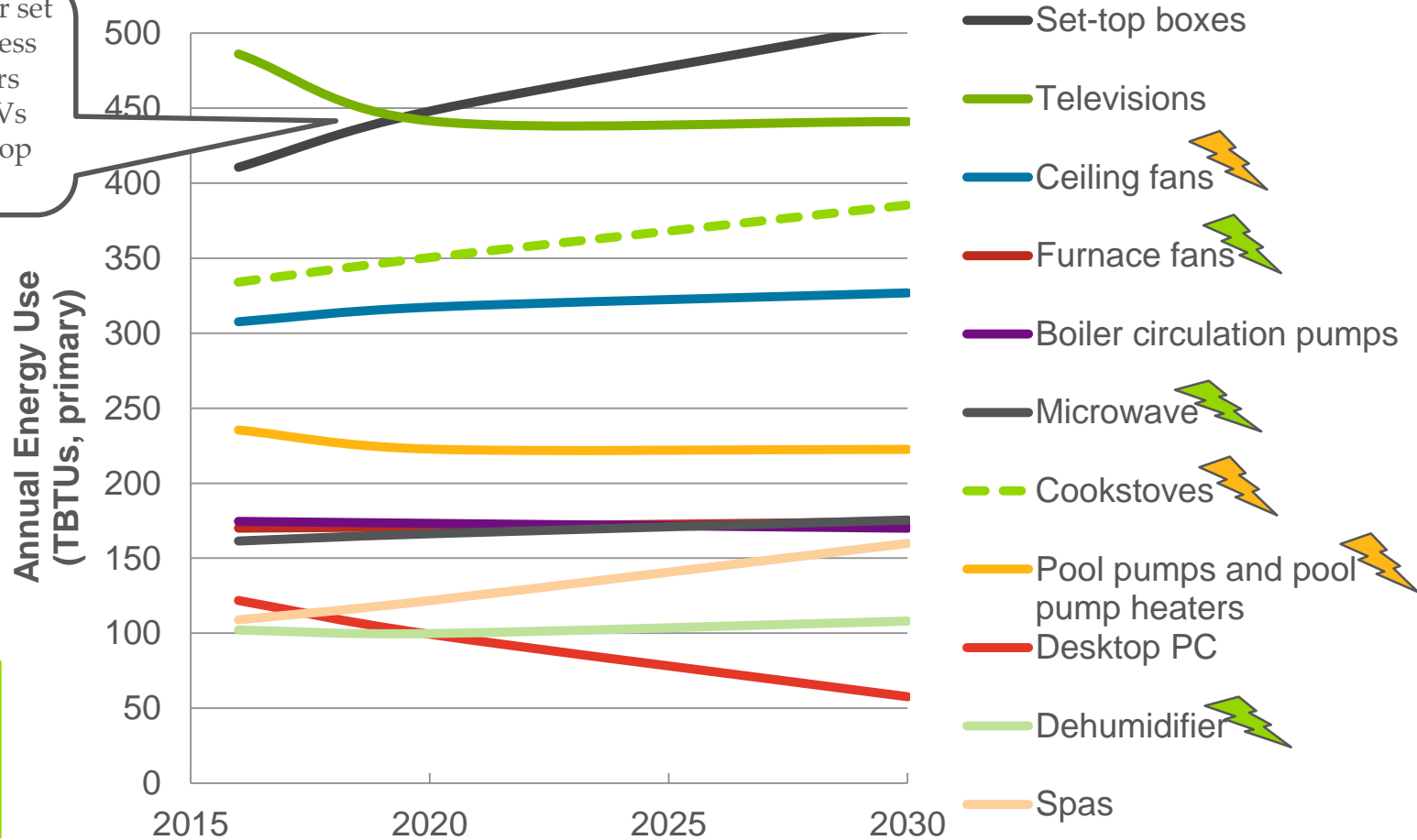
- **Other MELs** which were deemed too small to characterize by EIA/AEO/NEMS.
- **Adjustment to State Energy Data System (SEDS):** a proportion of load EIA uses to reconcile supply-side (SEDS) and end-user estimates (RECS / CBECS). (Based on Table 2.1.5, Buildings Energy Data Book. March 2012).



# Defined Residential MELs: Energy Use Projections

AEO 2015 projects 13% growth in Miscellaneous Electric Loads' energy consumption in homes between 2016 and 2030.

Updated projections for set top boxes may show less increase to consumers switching to smart TVs rather than OTT Set-top Boxes.



Only defined MELs with annual energy use > 100 TBTUS (2016-2030) are presented in this chart.

# Residential MELs: 2020 Energy Use Distribution

Residential Load/End-Use	Primary 2020 Energy Consumption (TBtu)
Undefined MELs	3,290
Set-top box	448
Televisions	442
Cooking	350
Ceiling fans	317
Pool pumps and pool pump heaters	223
Boiler circulation pumps	173
Furnace fans	171
Microwave	166
Spas	122
Dehumidifier	100
Desktop PC	99
Laptop	95
Monitors	56
Coffee maker	50
Network equipment	48
Non-PC rechargeable electronics	46
Home theater/audio	39
DVD	30
Security systems	24
Video game consoles	21
<b>MELs Total Electricity Use</b>	<b>6,310</b>

# Further Breakdown of Select Residential MELs

AEO Category	Further Breakdown	2020 Annual Energy Use (TBtu, primary) (1)	% Energy Use Breakdown (2)
Pool Pumps & Electric Heaters	Pool Pumps	227	97%
	Electric Pool Heaters		3%
Set-Top Boxes	Cable	448	38%
	Satellite		46%
	IPTV		11%
	Over-the-top (OTT)		5%
Televisions	CRT	442	4%
	LCD		41%
	Plasma		56%

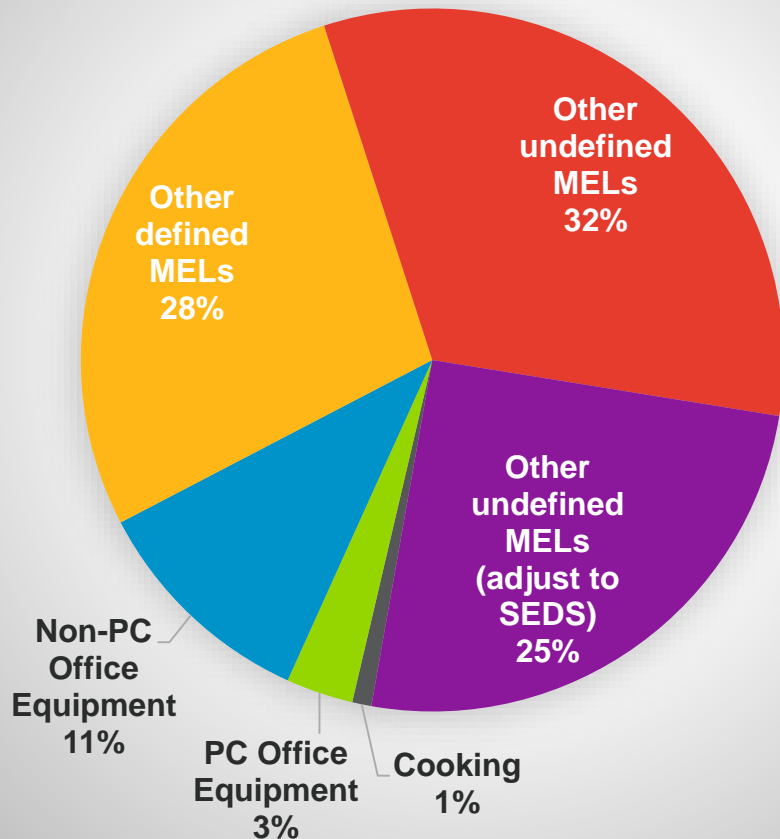
1) Energy consumption estimates based on AEO 2015 projections for 2020.

2) Percentages calculated based on data from Navigant's calculations for Analysis and Representation of Miscellaneous Electric Loads in NEMS. December 2013. Prepared for U.S. EIA by Navigant Consulting, Inc. and SAIC.

# Commercial MELs: Energy Use Breakdown (2020)

## Commercial MELs in 2020

Primary Energy Use: 6,830 TBtu



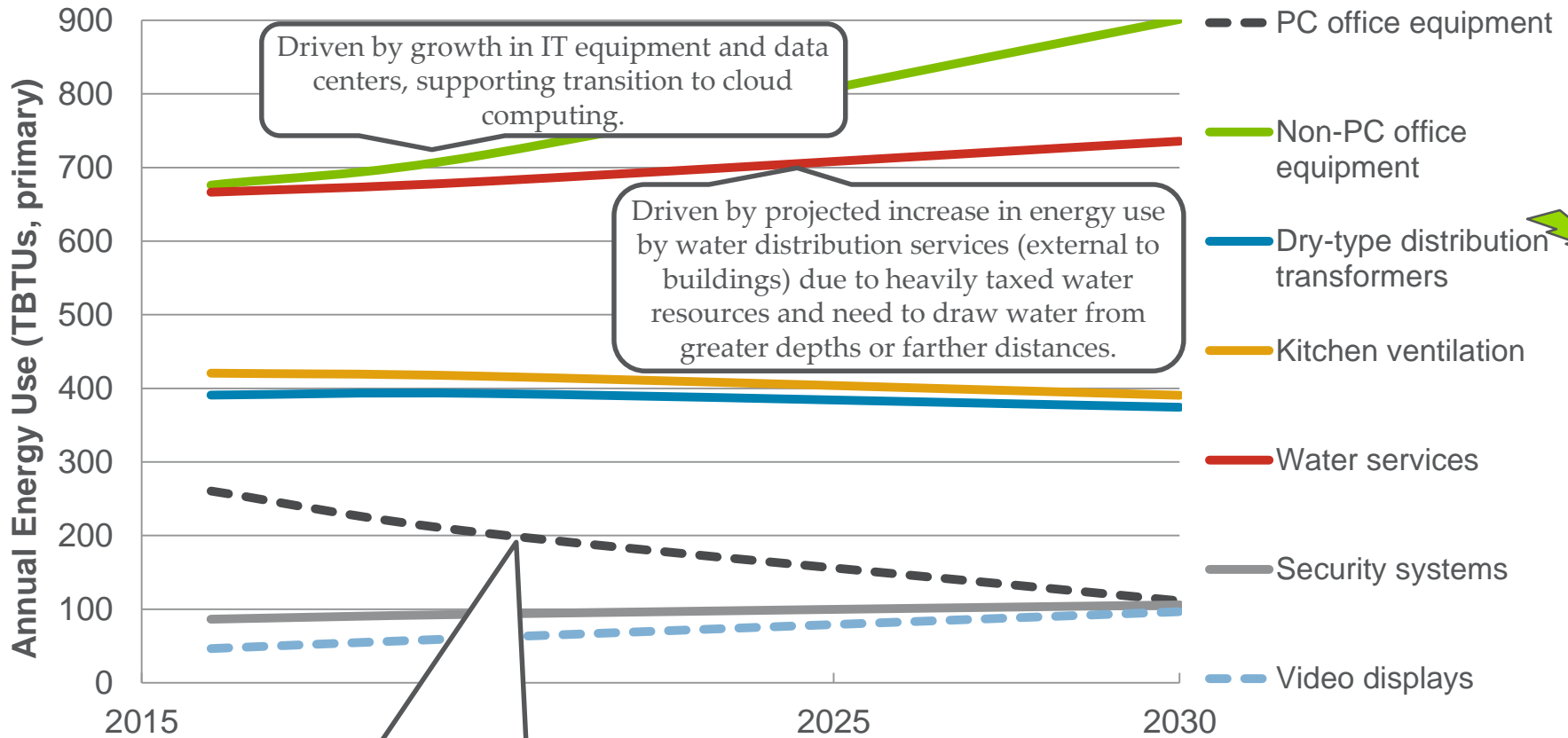
- **PC Office Equipment**
- **Non-PC Office Equipment**
- **Cooking**
- **Other Defined MELs:** dry-type distribution transformers, elevators, escalators, laundry, fume hoods, laboratory refrigerators and freezers, coffee brewers, kitchen ventilation, water services, video displays, large video boards, medical imaging, security systems

### Undefined MELs include:

- **Other MELs** which were deemed too small to characterize by EIA/AEO/NEMS.
- **Adjustment to State Energy Data System (SEDS):** a proportion of other electric load that EIA uses to reconcile supply-side (SEDS) and end-user estimates (RECS / CBECS). Based on Table 3.1.5, Buildings Energy Data Book. March 2012).

# Defined Commercial MELs: Energy Use Projections

AEO 2015 projects 27% growth in MEL energy consumption in commercial buildings between 2016 and 2030.



Desktop computers are losing market share to laptops and tablets, which are more energy efficient. Plus, although stock is increasing, UEC is projected to decrease for laptops and monitors.

Only defined MELs with annual energy use > 100 TBtus (2016-2030) are presented in this chart.

 DOE Standard in Effect

# Commercial MELs: 2020 Energy Use Distribution

Commercial Load/End-Use	Primary 2020 Energy Consumption (TBtu)
Undefined MELs	3,970
Non-PC office equipment	718
Water services	681
Kitchen ventilation	416
Dry-type transformers	393
PC office equipment	203
Security systems	93
Fume hoods	72
Cooking	67
Video displays	61
Lab refrigerators & freezers	43
Coffee brewers	32
Medical imaging	31
Elevators	30
Laundry	14
Escalators	6
Large video boards	1
<b>MELs Total Electricity Use</b>	<b>6,830</b>

Energy Efficiency & Renewable Energy



# Further Breakdown of Select Commercial MELs

AEO Breakdown	Further Breakdown	2020 Annual Energy Use (TBtu, primary)	% Energy Use Breakdown
Non-PC Office Equipment (1)	Servers (data centers)	718	10%
	Servers (in other buildings)		62%
	Printers		21%
	Copiers		5%
	Multi-Function Devices		1%
	Scanners		0%
	Fax Machines		1%
PC Office Equipment (2)	Desktop PC	203	54%
	Laptop PC		6%
	Monitors		40%
Municipal Water Services (1)	Wastewater Treatment	681	45%
	Water Distribution & Purification		55%

1) Percentages calculated based on data from *Commercial Miscellaneous Electric Loads: Energy Consumption Characterization and Savings Potential in 2009 by Building Type*. Kurtis McKenney, Matthew Guernsey, et al. TIAX LLC. May 2010.

2) Percentages calculated based on data from Navigant's calculations for *Analysis and Representation of Miscellaneous Electric Loads in NEMS*. December 2013. Prepared for U.S. EIA by Navigant Consulting, Inc. and SAIC.

# Further Breakdown of Select Commercial MELs (continued)

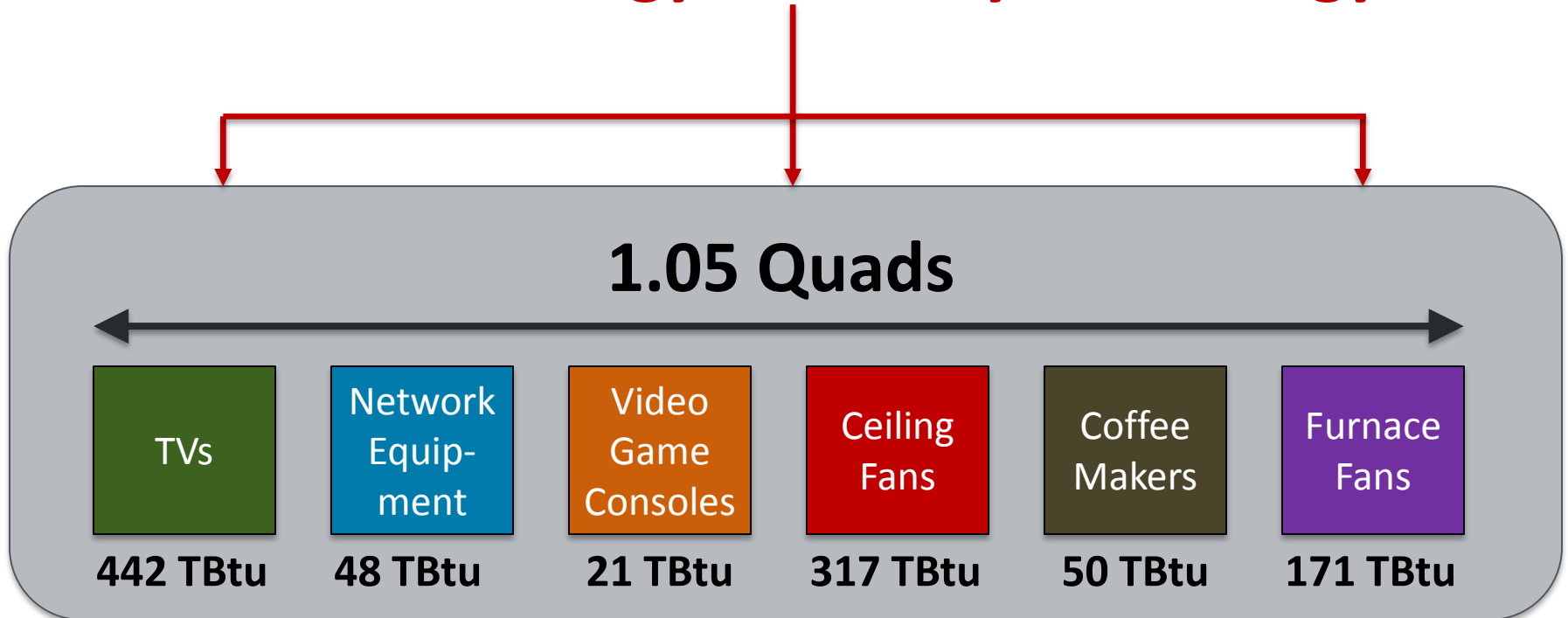
AEO Category	Further Breakdown	2009 Annual Energy Consumption (TBtu, primary) (1)
<b>Other Undefined MELs (MELs likely included by EIA in AEO's "other MELs" category, characterized independently by TIAx, 2010)</b>	<b>Mobile Phone Towers</b>	<b>45</b>
	<b>Irrigation</b>	<b>37</b>
	<b>Slot Machines</b>	<b>28</b>
	<b>Automated Teller Machines</b>	<b>12</b>
	<b>Arcades</b>	<b>12</b>
	<b>Fitness Equipment</b>	<b>12</b>

1) Data from *Commercial Miscellaneous Electric Loads: Energy Consumption Characterization and Savings Potential in 2009 by Building Type*. Kurtis McKenney, Matthew Guernsey, et al. TIAx LLC. May 2010.



# MELs “Platform” Technologies

## Platform Energy-Efficiency Technology



Platform technologies enable energy consumption reduction across a number of MELs.

Example: wide bandgap power converters

# Summary of MELs Panel at the BTO Peer Review

## Presenters:

Name	Organization	Presentation Title
Harvey Sachs	ACEEE	Miscellaneous Electric Loads
Alan Meier	LBNL	Plug Loads: There's Something Using Electricity and We Don't Really Know What It Is
Kurt Roth	Fraunhofer Ctr for Sust. Energy	Managing MELs Energy Consumption: Making it Work for People
Isik Kizilyalli	ARPA-E	Improving Efficiency using Wide Band Gap Semiconductor (WBG) Power Electronics in Building Technologies

- **Security/privacy concerns from increasing connectivity, i.e., Internet of Things**
- **Incremental energy consumption of networked vs. non-networked devices**
- **System cost vs. materials cost, especially for wide bandgap devices**
- **Fully embedded technology solutions “upstream” of the consumer**
- **Other comments: explosive growth of medical devices, impact of LEDs + controls, innovations in power supplies**

# What Is NOT In the Scope of This Workshop

- **Minimum efficiency standards or other regulatory actions**
- **Deployment actions (e.g., increasing uptake of existing commercialized technologies)**
- **Improved power conversion efficiency through advanced low power semiconductors, including wide bandgaps**
  - **Already addressed in other efforts, such as the \$140M PowerAmerica Advanced Manufacturing Institute at North Carolina State University and \$60M ARPA-E SWITCHES and ADEPT Programs**
- **Behavioral strategies**

# Speakers

- **Leo Rainier, LBNL**

Leo Rainer is an engineer with the Building Technologies and Urban Systems Division at Lawrence Berkeley National Laboratory. He has more than 30 years of experience in many areas of building energy efficiency including simulation, monitoring, miscellaneous energy use, and codes and standards. Mr. Rainer is currently responsible for the development and maintenance of the Home Energy Saver web services. Mr. Rainer earned his B.S. in Mechanical Engineering from the University of California at Davis in 1981.



- **Mangesh Basarkar, PG&E**

Mangesh Basarkar manages the Energy Efficiency Product Management team at PG&E. Over his 14-year career, Mangesh has successfully helped launched several innovative products and services targeted at understanding the drivers, and helping devise strategies, to reduce or eliminate unnecessary energy use in buildings. He has a Master's degree in Mechanical Engineering and an MBA from the UC Berkeley Haas School of Business.



- **Felix Villanueva, CEC**

An Energy Commission Specialist for the California Energy Commission for 4 years. Works under the Research and Development Division under the Energy Efficiency Research Office. He specializes in building energy efficiency research. In the last year, has been working on plug loads research. He was solicitation manager of last year's Electric Program Investment Charge's grant solicitation: Plug Load Technologies and Approaches for Buildings.



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# Reference Slides

# Minimum Efficiency Standards: Consumer Products

For consumer products, the Energy Policy and Conservation Act (EPCA) authorizes the Department to incorporate products into its program, see EPCA Section 322(a) (19) and (b), and 42 U.S.C. 6292(a)(19) and (b). New consumer products are candidates to be added if they use or are designed to use energy, and be distributed to “any significant extent . . . for personal use or consumption by individuals.” EPCA Sections 321(1) and 322, 42 U.S.C. 6291(1) and 6292. For coverage of consumer products under EPCA, the Department must demonstrate that:

- (1) including the product as a “covered product” is “necessary or appropriate” to carry out the purposes of EPCA and
- (2) the average energy use for that type of product by a household using it is likely to exceed 100 kWh per year.

And, for the Department to prescribe energy conservation standards for a covered consumer product, the Department must determine that:

- (A) the average per household energy use within the United States by products of such type (or class) exceeded 150 kWh (or its Btu equivalent) for any 12-month period ending before such determination;
- (B) the aggregate household energy use within the United States by products of such type (or class) exceeded 4.2 billion kWh (or its Btu equivalent) for any such 12-month period;
- (C) substantial improvement in the energy efficiency of products of such type (or class) is technologically feasible; and
- (D) the application of a labeling rule under . . . [EPCA] to such type (or class) is not likely to be sufficient to induce manufacturers to produce, and consumers and other persons to purchase, covered products of such type (or class) which achieve the maximum energy efficiency which is technologically feasible and economically justified.

# Minimum Efficiency Standards: Commercial Equipment (1/2)

The Department's authority to classify industrial or commercial equipment as covered under EPCA, however, is limited to certain types of equipment. Under EPCA section 341(a) and (b), the Secretary of Energy is authorized to classify commercial products as covered equipment if classification is "necessary" to improve the efficiency of industrial equipment (which includes commercial refrigeration equipment) in order to conserve energy. EPCA section 340(1) lists several specific types of "industrial equipment" as "covered equipment."

- (1) The term "covered equipment" means one of the following types of industrial equipment:
  - (A) Electric motors and pumps.
  - (B) Small commercial package air conditioning and heating equipment.
  - (C) Large commercial package air conditioning and heating equipment.
  - (D) Packaged terminal air-conditioners and packaged terminal heat pumps.
  - (E) Warm air furnaces and packaged boilers.
  - (F) Storage water heaters, instantaneous water heaters, and unfired hot water storage tanks.
  - (G) Any other type of industrial equipment which the Secretary classifies as covered equipment under section 6312(b) of this title.

The Department's authority to classify industrial or commercial equipment as covered under EPCA, however, is limited to certain types of equipment. This is because section 340(2) defines "industrial equipment" as being limited to twelve product categories listed in section 340(2)(B), in addition to the types of products specifically listed as covered in section 340(1).

- (B) The types of equipment referred to in this subparagraph are as follows:
  - (i) compressors;
  - (ii) fans;
  - (iii) blowers;

# Minimum Efficiency Standards: Commercial Equipment (2/2)

- (iv) refrigeration equipment;
- (v) electric lights;
- (vi) electrolytic equipment;
- (vii) electric arc equipment;
- (viii) steam boilers;
- (ix) ovens;
- (x) kilns;
- (xi) evaporators; and
- (xii) dryers.

Thus, DOE has authority to cover equipment within these twelve categories, if it can demonstrate that regulating this equipment is necessary or appropriate to meet the purposes of EPCA.

To prescribe an energy conservation standard for commercial equipment that the Secretary classifies as covered, DOE would have to determine that the equipment meets criteria analogous to those for consumer products, namely:

- (1) [T]he average per establishment<sup>1</sup> energy use within the United States by products of such type (or class) exceeded 150 kilowatt-hours (or its Btu equivalent) for any [previous] 12-month period;
- (2) [T]he aggregate establishment<sup>1</sup> energy use within the United States by products of such type (or class) exceeded 4.2 billion kWh (or its Btu equivalent) for any such 12 month period;
- (3) [S]ubstantial improvement in the energy efficiency of products of such type (or class) is technologically feasible; and
- (4) [T]he application of a labeling rule under ... [EPCA] to such type (or class) is not likely to be sufficient to induce manufacturers to produce, and consumers and other persons to purchase, covered products of such type (or class) which achieve the maximum energy efficiency which is technologically feasible and economically justified.

and “other motors” (from AEMTCA 2012)

**Reference: “Analysis Interim Report on Ceiling Fans, ER/BR Reflector Lamps, Torchieres, Commercial Refrigeration Equipment and Beverage Vending Machines and Merchandisers,” Navigant Consulting Inc., 2005.**

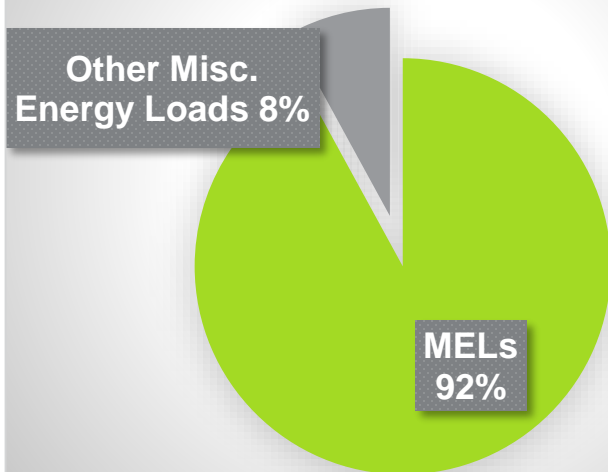


# Miscellaneous Energy Loads vs Miscellaneous Electric Loads

Electric loads make up the largest portion of all Miscellaneous Energy Loads. AEO projects the percent share of energy use for Miscellaneous Electric Loads (MELs) versus miscellaneous energy loads of all fuels to stay relatively constant during 2016 – 2030 timeframe.

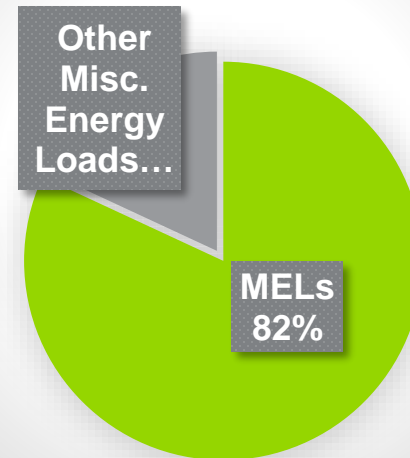
## Residential MELs, 2020

Primary Energy Use: 6,850 TBtu



## Commercial MELs, 2020

Primary Energy Use: 8,380 TBtu



*EIA Annual Energy Outlook, 2015*

# RESIDENTIAL MELS DEFINITIONS

- **Televisions** – LCD, plasma, and CRT models
- **Set-top boxes** – satellite, cable, internet (i.e., IPTV), and over-the-top (OTT)
- **Home theater / audio** – A/V receiver-based component systems (surround sound and stereo including sound bars), compact audio systems, and Home Theater in a Box (HTIB)
- **Video game consoles** – excluding handheld/rechargeable
- **DVD Players** – players, recorders, and DVD-VCR combos
- **Desktop PCs** – all-in-one computers and standalone computers (excluding monitor)
- **Laptops** – standard laptops
- **Monitors** – standalone external monitors for laptops or desktops
- **Network equipment\*** – modems and routers
- **Non-PC rechargeable electronics\*** – cameras, smart phones, other small devices, including losses from external power supplies (i.e., battery chargers)

\* Preliminary assumption based on AEO context and Navigant's prior work for BTO and EIA

## RESIDENTIAL MELS DEFINITIONS (CONT.)

- **Microwaves** – standard residential models
- **Cookstoves** – units with an oven and a cooktop
- **Coffee makers** – typical common models
- **Dehumidifiers** – self-contained, electrically operated, and mechanically refrigerated
- **Ceiling fans** – permanently-installed only (excludes energy from associated lighting)
- **Furnace fans** – for circulation of heated air from forced-hot air space heating system
- **Boiler circulation pumps** - for hot water heating systems
- **Pool pumps and electric pool pump heaters**
- **Security systems** – network of mechanical and motion sensors used to detect intruders (does not include video surveillance)
- **Spas** – portable, pre-fabricated, self-contained electric spas or hot tubs (does not include ‘in-ground’ units [such as those attached to a pool], other permanently installed residential spas, public spas, or spas that are operated for medical treatment or physical therapy.)

# COMMERCIAL MELS DEFINITIONS

- **PC office equipment** – laptops, desktops (including all-in-ones), monitors
- **Non-PC office equipment\*** – servers, printers, copiers, multifunction devices, scanners, fax machines, IT equipment (routers/switches/firewall)
- **Cooking\*\*** – electric and induction ranges (4 burner), ovens, and griddles
- **Video displays** – digital signage using electronic displays or screens (such as LCD or plasma) to deliver entertainment, information and/or advertisement in public or private commercial spaces
- **Large video boards** – extremely large format video displays typically installed at sports stadiums and arenas
- **Medical imaging** – MRI, CT, X-ray, ultrasound
- **Security systems** – video surveillance, access control, intrusion and fire detection, and anti-theft controls for merchandise
- **Coffee brewers** – all equipment

\*AEO does not provide a clear definition of “Non-PC office equipment.” Navigant’s research suggests that AEO’s category is based on this definition developed by TIAX (2010).

\*\*Navigant’s understanding of the AEO documentation is that the cooking category excludes other common cooking equipment types, including broilers and fryers; many chefs prefer these products to use natural gas, so electric use may be limited.

Refer to the sources #2, 5, 6, listed on slide 40 of this slide deck.

# COMMERCIAL MELS DEFINITIONS (CONT.)

- **Kitchen ventilation** – exhaust hood and fan systems, including energy from exhaust fans, makeup-air fans, and conditioning of the make-up air.
- **Water services** – public-supplied water distribution/purification and treatment serving all commercial buildings as well as any residential buildings and industrial facilities served by public systems. In addition, this includes self-supplied commercial water distribution/purification/treatment for those commercial buildings that are not on a public water main and operate their own systems. This excludes electricity used for distribution within a building and any distribution/purification/treatment done by industrial facilities.\*
- **Dry-type distribution transformers** – customer-side of the meter only (excludes all utility-owned transformers)
- **Elevators** – all elevators
- **Escalators** – all escalators
- **Laundry** – commercial-scale washers and dryers and dry-cleaning equipment
- **Fume hoods** – local ventilation chambers in laboratories
- **Laboratory refrigerators & freezers** – general purpose and ultra-low temp freezers

\* AEO does not provide a clear definition of “Water services,” but Navigant’s research suggests that AEO’s category is based on this definition developed by TIAX (2010).

# Wrap-Up

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- **What would be an ideal R&D team?**
- **Any insights (data, references, etc.) to untangle the “undefined MELs” category?**
- **Next steps**
  - Energetics will synthesize the notes
  - RFI (soon)
  - Proposed FOA topic in FY17
- **Get on our mailing list:**
  - <http://energy.gov/eere/buildings/building-technologies-office>

**Thanks!**