EIA Consumption Survey Updates: CBECS Results, New Directions for RECS
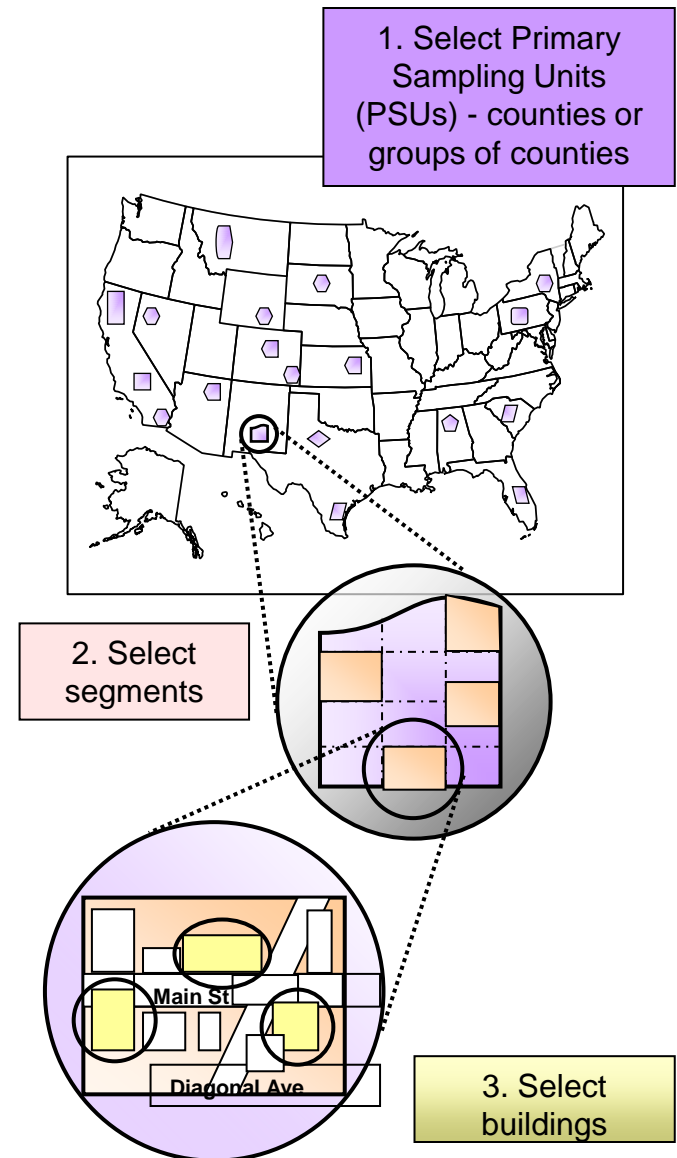
ACEEE Summer Study, Informal Session

August 18, 2014 | Pacific Grove, CA

Tom Leckey, EIA

Director, Office of Energy Consumption and Efficiency Statistics

How is CBECS Conducted?

- No comprehensive source of <u>buildings</u> exists

- Area frame
    - Randomly select small, geographic areas
    - Within them, list and stratify all commercial buildings in those areas
    - Randomly select buildings within strata

- List frames
    - Supplemental lists ensure adequate representation of special buildings   (e.g., hospitals, government buildings, college/universities, airports, or other large buildings)

- Computer Assisted Personal Interview (CAPI); in 2012, data were collected from about 6,700 buildings

- Weighted to represent the population of commercial buildings in the U.S.

1. Select Primary Sampling Units (PSUs) - counties or groups of counties

2. Select segments

3. Select buildings
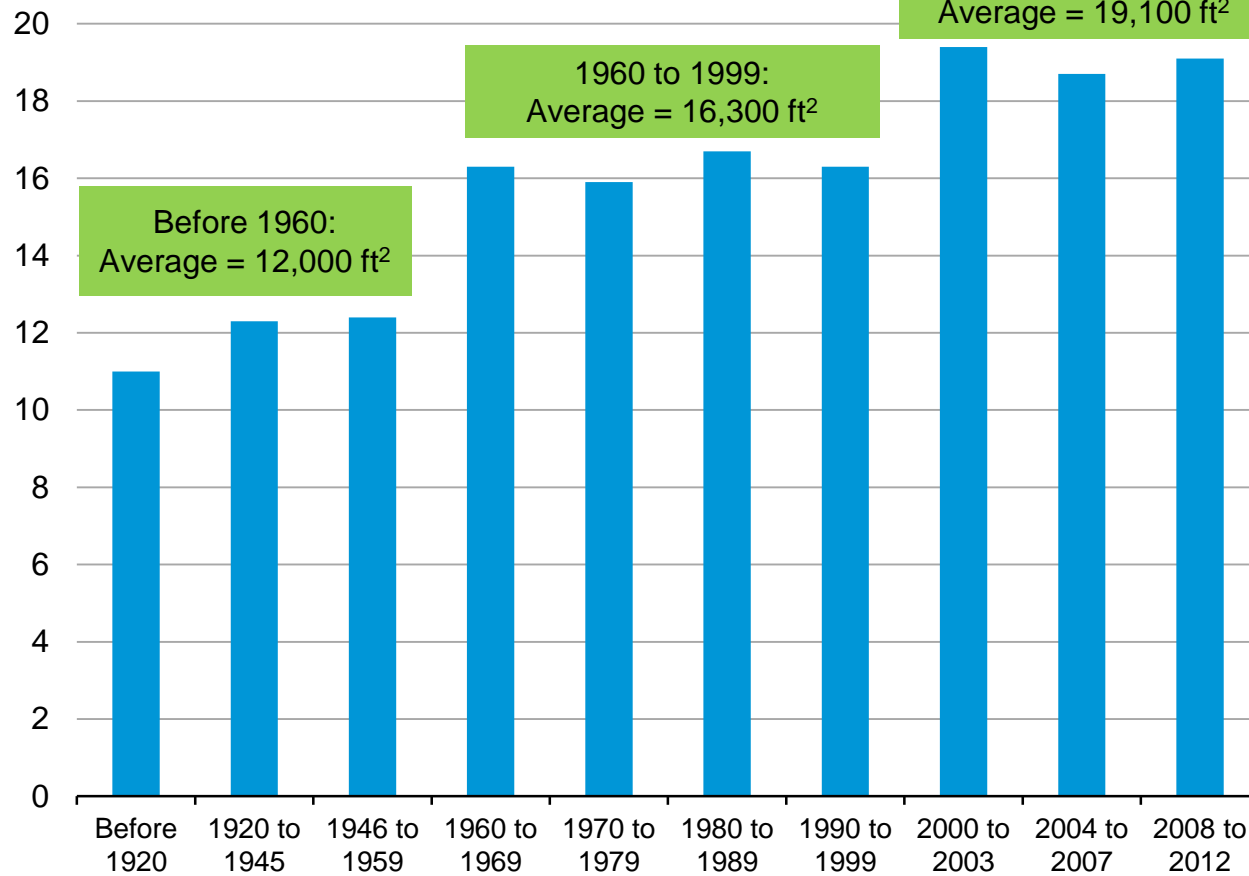
Main St

Diagonal Ave

2012 CBECS preliminary results: in recent years, commercial floorspace has grown more rapidly than the number of buildings
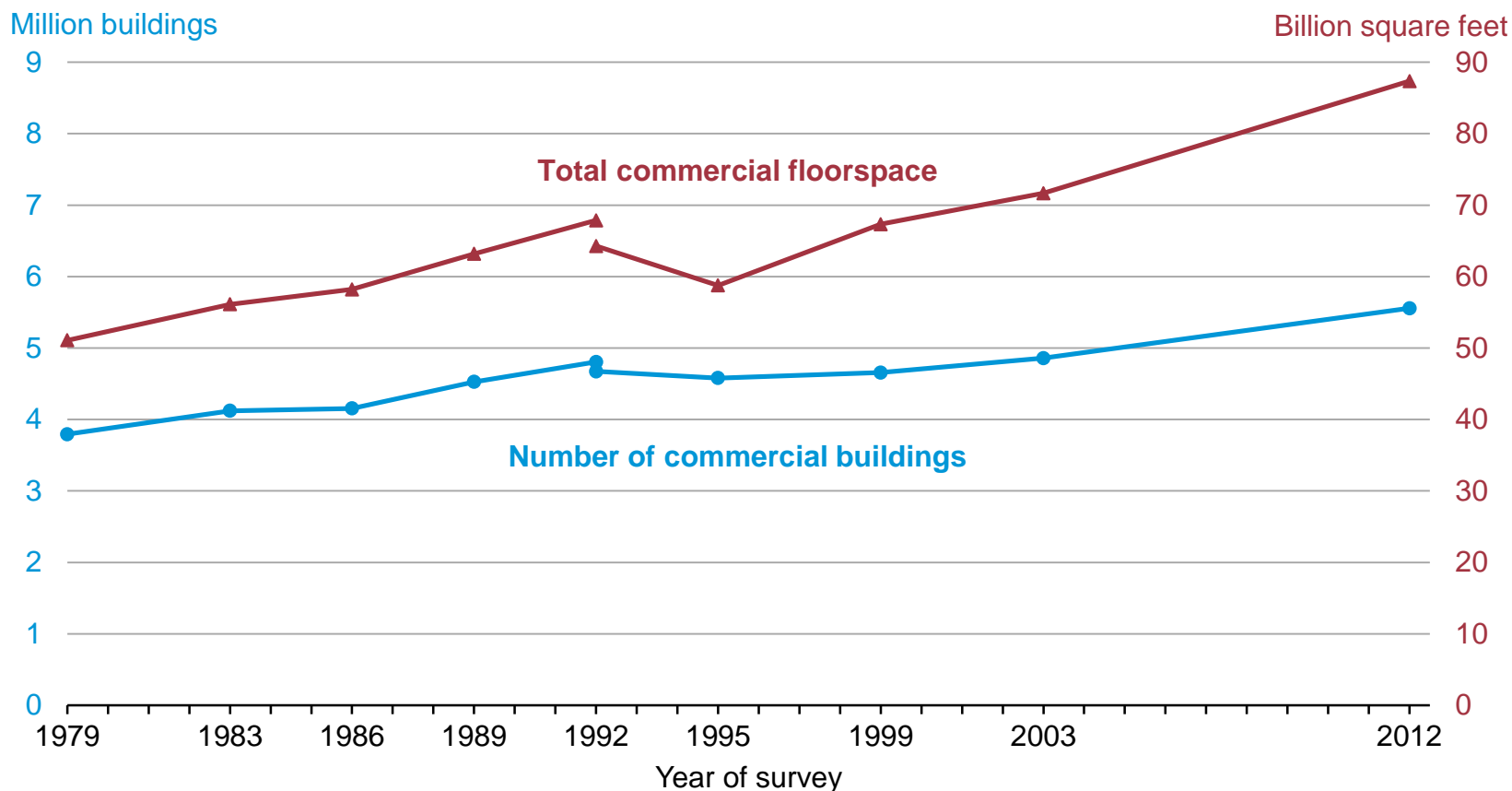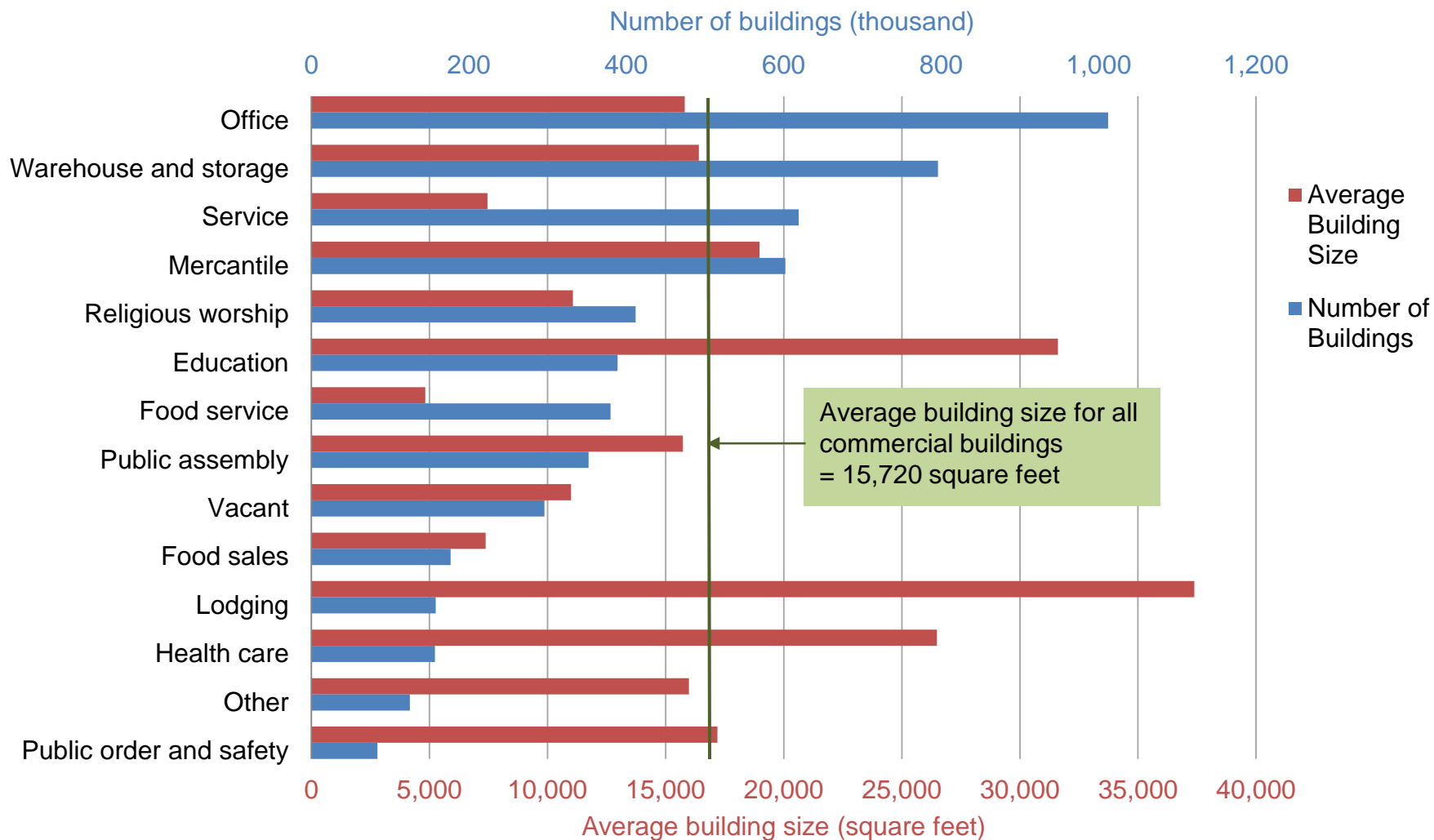

Note: The lower 1992 estimates are adjusted to match the 1995-2012 CBECS definition of target population by removing enclosed parking garages and commercial buildings on manufacturing sites.

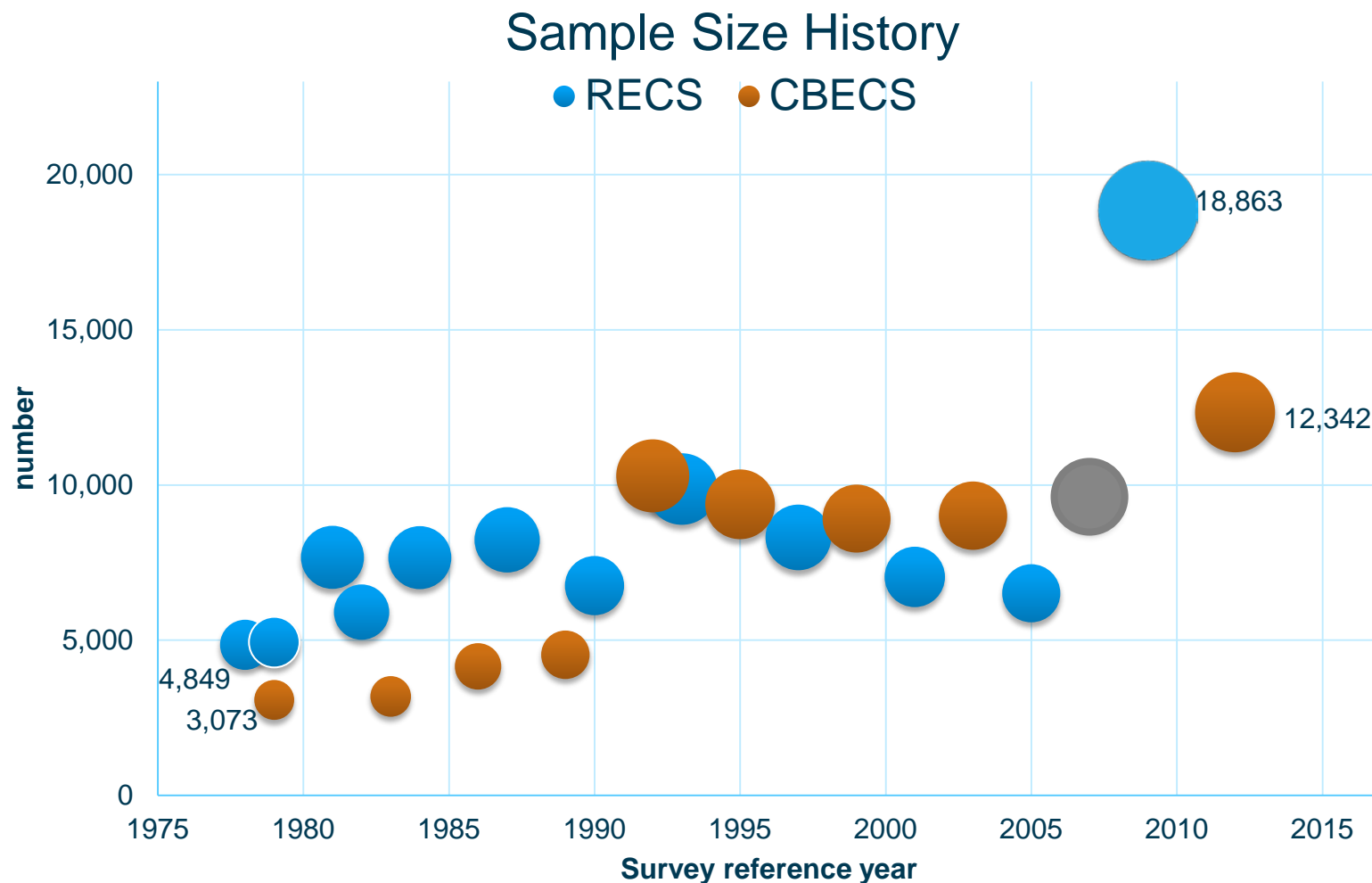# New commercial buildings are larger, on average, than old commercial buildings

Average building size by year constructed
Thousand ft^2

Before 1960:
Average = 12,000 ft^2

1960 to 1999:
Average = 16,300 ft^2

2000 to 2012:
Average = 19,100 ft^2

The CBECS building population is diverse and smaller building types are the most common

Number of buildings (thousand)

Average building size for all commercial buildings = 15,720 square feet

- Average Building Size
- Number of Buildings

Average building size (square feet)

Categories (top to bottom): Office, Warehouse and storage, Service, Mercantile, Religious worship, Education, Food service, Public assembly, Vacant, Food sales, Lodging, Health care, Other, Public order and safety

Over time, rising survey costs have reduced sample size, and periodicity of surveys

Sample Size History

● RECS   ● CBECS

4,849
3,073
18,863
12,342

number

Survey reference year

EIA's Energy Assessment Project
Supplement to the 2012 CBECS

Background

- Based on a recommendation from the National Research Council's study of EIA's consumption surveys
- Follow up to CBECS building interview
- Attempt to combine interviewers' skill at gaining cooperation with assessors' knowledge of energy systems
- Energy Assessments are similar to ASHRAE Level I audits

Scale of the project

- Goal of 200 assessments
- 10 cities in 5 climate zones
- 1,022 CBECS respondents asked to participate
- 554 (49.5%) agreed
- 203 usable assessments completed

Goals

- Evaluate CBECS data quality
- Evaluate and possibly improve post data collection editing

Additional Goals:

- Improve the data collection instrument for future rounds of CBECS
- Determine whether sending an energy auditor to buildings of certain sizes or used for different activities has advantages over conducting the interview with a trained survey interviewer
- Understand the differences in respondent burden for traditional interviews and energy audits
- Decide whether adding an energy audit component to CBECS is feasible and/or desirable

Assessment Checklist Items

- General building information
- Building envelope
- Heating, cooling and ventilation systems, including controls
- Water heating systems
- Lighting systems
- Specialty loads
- Energy use data

EIA's Energy Assessment Project

Annotated Checklist

Selected Results:
Agreement between assessments and CBECS interviews

Square footage:

- 177 of the 203 buildings had a response for exact square footage in both the CBECS interview and EA.
- Of those buildings, 52 (29%) were exact matches
- In the CBECS interview, respondents who cannot answer exact square footage are asked to provide a category
- When we code the EA square footage into a category, 85% of buildings matched

Principal Building Activity from Assessment	Matches CBECS PBA	Does NOT match CBECS PBA	Total cases	Percent match
Nonrefrigerated warehouse	7	0	7	100%
Nursing	3	0	3	100%
Religious worship	2	0	2	100%
Food sales	1	0	1	100%
Laboratory	1	0	1	100%
Refrigerated warehouse	1	0	1	100%
Lodging	9	1	10	90%
Inpatient health care	12	2	14	86%
Public assembly	22	5	27	82%
Education	32	8	40	80%
Service	8	2	10	80%
Public order and safety	1	4	5	80%
Food service	7	2	9	78%
Office	37	12	49	76%
Retail (other than mall)	7	3	10	70%
Outpatient health care	6	5	11	55%
Vacant	0	3	3	0%

EIA's Residential Energy Consumption Survey

http://www.eia.gov/consumption/residential/

## History of RECS Household Survey Completes
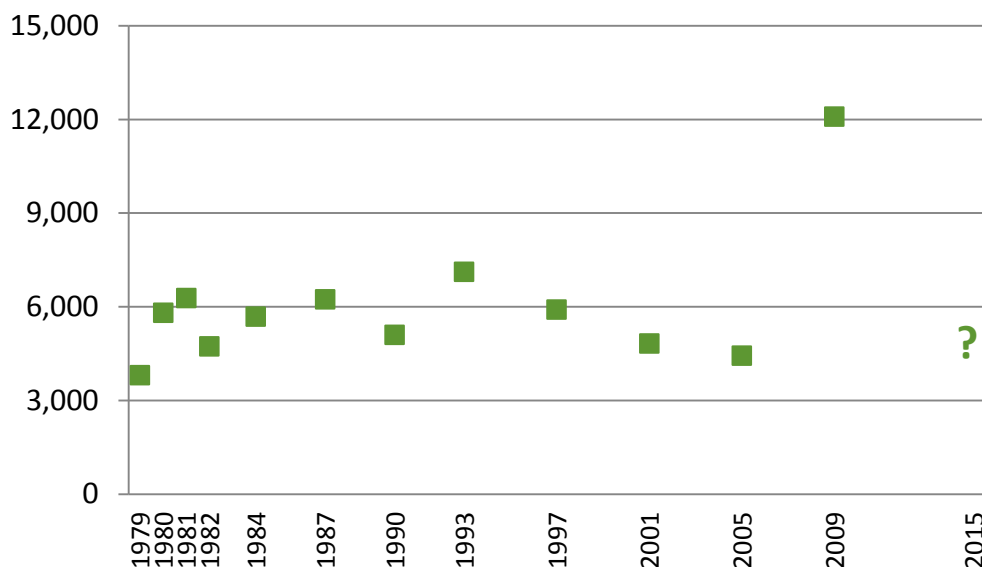
2009 RECS Highlights

- ✓ Funded in part by EERE
- ✓ 3.5 year project to capture and report characteristics, consumption, cost, end-uses
- ✓ 12,083 housing units
- ✓ 16 individual state estimates
- ✓ Household Survey = 50 minutes
- ✓ Billing data collected via Web
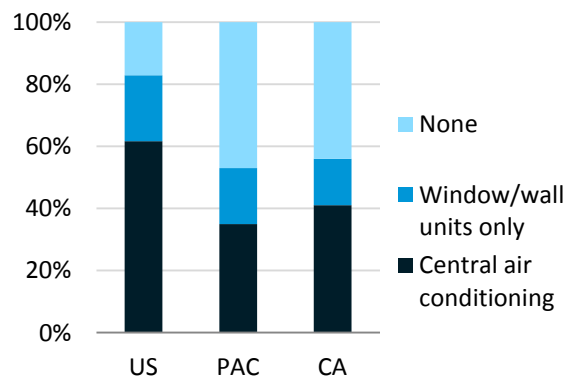- ✓ Non-linear regression models produce disaggregated end-use estimates

RECS Objectives

- Periodic, cross-sectional study of energy characteristics, consumption, and cost in U.S. homes
- Benchmark estimates for EIA (NEMS) forecasts, modelers, and policy-makers
- Critical inputs for appliance and equipment standards
- Analysis of special populations, such as low income households

Legend: Air conditioning · Water heating · Appliances, electronics, lighting · Space heating

1993

5% · 18% · 24% · 53%

2009

6% · 18% · 35% · 41%
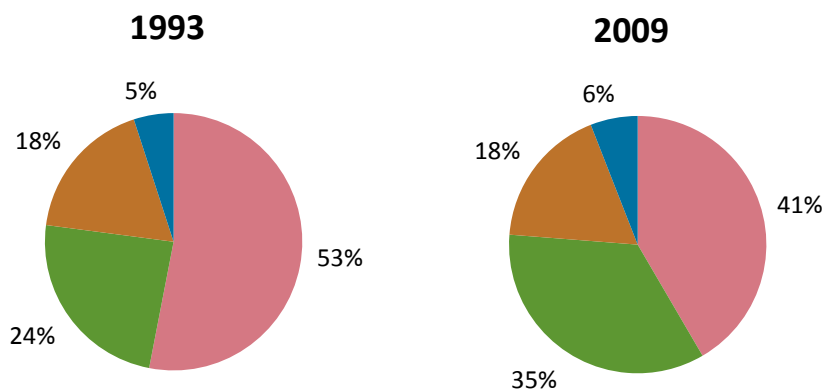
California AC Equipment Use

Legend: None · Window/wall units only · Central air conditioning

The time for change has come

- National Academy of Sciences (NAS) panel report recommended 17 possible changes to RECS
- EIA has chosen to tackle 1) end-use updates and 2) methods for collecting household characteristics
- Share of consumption attributable to appliances/electronics/miscellaneous has increased significantly
- In general, it is getting harder and more expensive to collect data in-person
- Time between RECS cycles is increasing (RECS was initially an annual survey)

End-Use Modeling Improvement Project

Project Objectives

- Redesign the equations, including the addition of engineering parameters where appropriate, or the consideration of a model structure different from the existing one
- Expand publishable list of electricity end-uses
- Significantly reduce or even eliminate the prevalence of unreasonable outlier end-use consumption values
- Explore uses of smart meter and submeter data

Testing New Methods for Collecting Home Energy Data

2014   2015   2016   2017

2015 RECS

Sample Design and Prep	Data Collection	Results

← **Household Characteristics**

Consumption and Cost →

Data Collection	End-Uses & Results

Web/Mail Test #1 "Practicum"

RECS Pilots

Web/Mail Test #2 "Cities Pilot"	Web/Mail Test #3 "Concurrent Pilot"
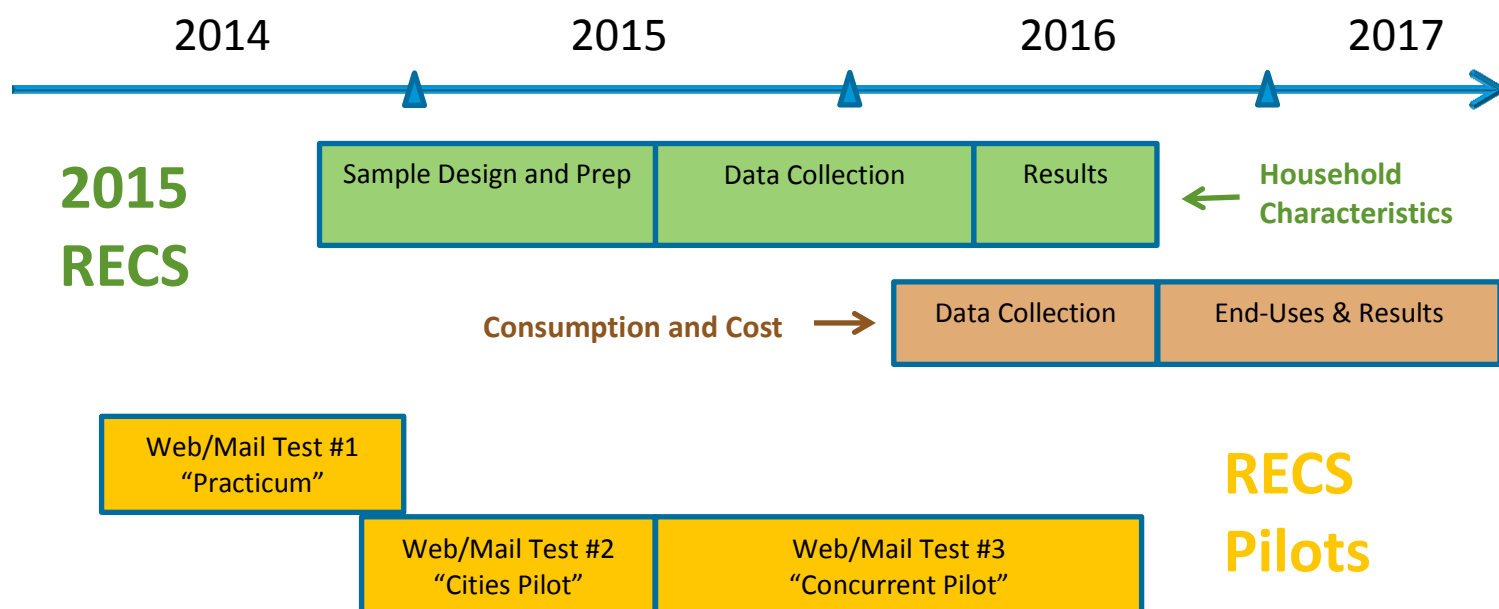
Questions for our Stakeholders and Data Users

How can EIA accurately measure engineering model variables from residential respondents?

What end-uses should we extract from the "appliance/electronics/miscellaneous" category?

What is the ideal frequency for the RECS program?

How would our stakeholders and data users like to interact with the RECS program?

How are utilities using smart meter data and what benefits of interval level data are there for the RECS program?

What are the benefits and potential roadblocks for developing monthly consumption and expenditures estimates?

What sub-populations and geographic areas are most important for EIA to study?

Annual Energy Outlook + AEO Table Browser
http://www.eia.gov/oiaf/aeo/tablebrowser/

The online *AEO* Table Browser shows sector-level *Annual Energy Outlook* projections by fuel and end use, with projected equipment stock and efficiency for certain equipment types. The online table browser has select regional concepts presented at the Census division level, as well as data graphing and download capabilities.

The Buildings Consumption & Efficiency Analysis team also maintains detailed residential and commercial output databases that contain Census division-level detail for consumption, equipment, and sector drivers.

U.S. Census divisions
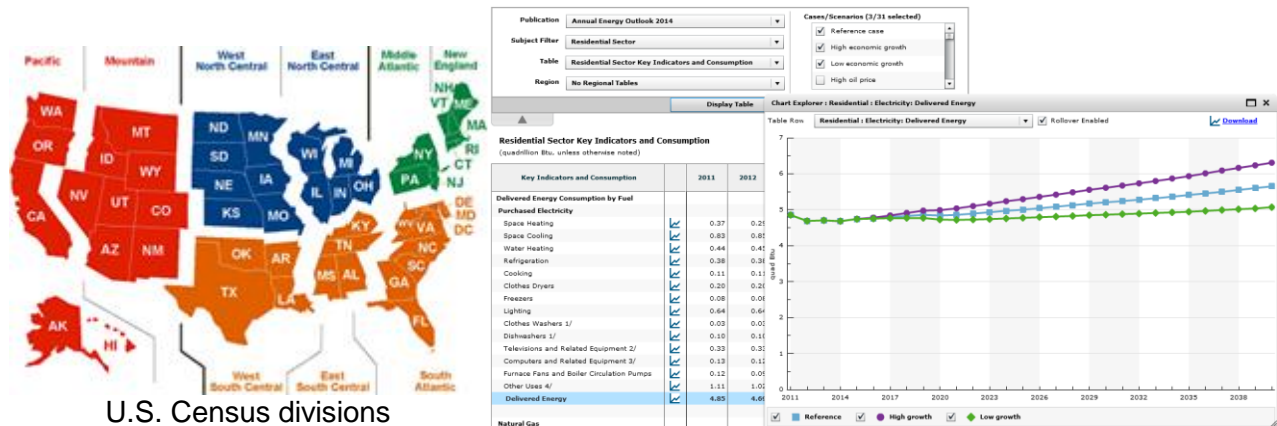
Technology Characterization Reports
www.eia.gov/analysis/studies/buildings/equipcosts/

Efficiency levels and equipment costs projected for most major end use equipment types through 2040.

Residential equipment: Heaters (gas & oil furnaces and boilers; air-source, ground-source, & natural gas heat pumps), air conditioners (room units, central systems, and heat pumps), water heaters (gas, oil, electric resistance, heat pump, instantaneous, solar), refrigerators, freezers, cookstoves, clothes washers, clothes dryers, dishwashers, and lighting.

Commercial equipment: Heaters (gas and oil furnaces; gas, oil, and electric boilers; rooftop and ground source heat pumps; electric resistance), air conditioners (rooftop units; gas-fired engine-driven rooftop units; reciprocating, screw, & scroll chillers; and heat pumps), water heaters (gas; oil; electric resistance; instantaneous; and gas & electric boosters); ventilation (constant & variable air-volume); refrigeration (display cases, reach-in and walk-in coolers & freezers; beverage merchandisers; ice makers; and vending machines); and lighting.

Miscellaneous Electric Loads
www.eia.gov/analysis/studies/demand/miscelectric/

Power draws and usage patterns used to form annual per-unit energy consumption. These projections are multiplied by projected equipment stock to form end use consumption estimates through 2040.

Residential MELs: Televisions, set top boxes, desktop & laptop computers, monitors, audio equipment, modems & routers, DVD players, pool heaters & pumps, ceiling fans, dehumidifiers, portable electric spas, home security systems, and rechargeable devices

Commercial MELs: Distribution transformers, kitchen ventilation, desktop and laptop computers, monitors, data center servers, IT equipment, security systems, water distribution, lab refrigerators & freezers, medical imagining equipment, video displays, and large format video boards.

EIA Buildings Analysis Team members attending 2014 Summer Study:
Owen Comstock   owen.comstock@eia.gov
Kevin Jarzomski   kevin.jarzomski@eia.gov

Today in Energy

Today in Energy features brief, timely articles about a variety of energy trends and concepts, including energy efficiency and demand in the buildings sectors. Published daily on the EIA homepage, *Today in Energy* highlights various EIA data and analysis products and other news in the energy industry.
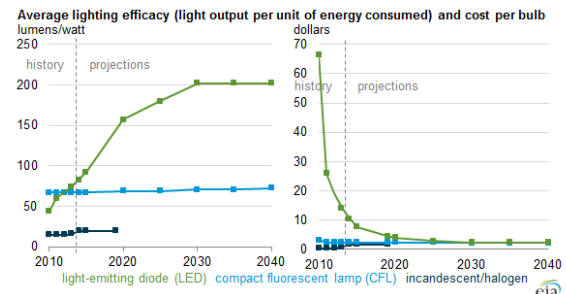
Have a suggestion for a future article? Send ideas to todayinenergy@eia.gov.

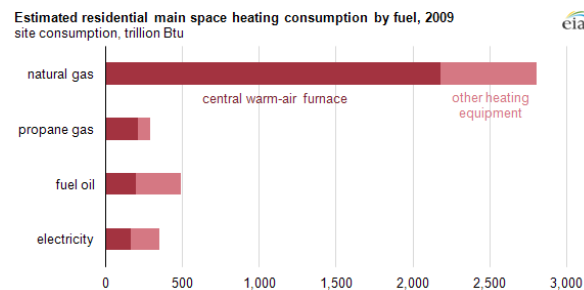Want to subscribe to *Today in Energy*? Visit http://www.eia.gov/tools/emailupdates/.

Lower U.S. electricity demand growth would reduce fossil fuels' projected generation share
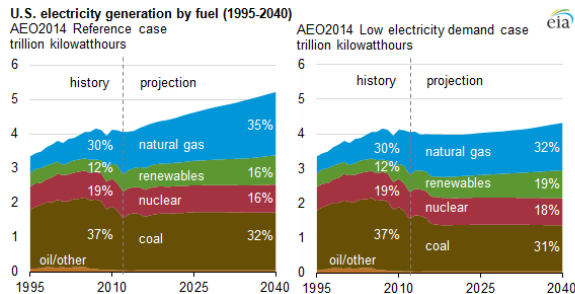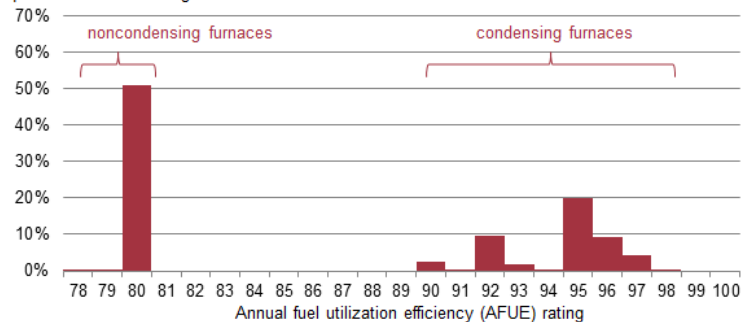

LED bulb efficiency expected to continue improving as cost declines

Gas furnace efficiency has large implications for residential natural gas use

EIA Buildings Analysis Team Current Projects

- Longitudinal analysis of Residential Energy Consumption Surveys (RECS) over time.
    - This analysis decomposes changes in consumption from 1980 through 2009, accounting for factors such as geography, building type, square footage, and weather to identify those changes attributable to energy-intensity improvements.
- Distributed generation analysis and updates to existing characterizations of buildings-sector solar photovoltaics, wind turbines, and combined heat & power units
- Historical data for shipment-weighted efficiency of several residential equipment types
- Characterization of costs associated with switching across different fuels and equipment types in households
- Working group meetings that discuss changes in *Annual Energy Outlook* assumptions and projections

Other useful AEO & buildings links:

Annual Energy Outlook	www.eia.gov/aeo
Model Documentation	www.eia.gov/reports/index.cfm
Distributed Generation	www.eia.gov/analysis/studies/distribgen/system
	www.eia.gov/forecasts/aeo/nems/2013/buildings
Energy Efficiency (EM&V)	www.eia.gov/analysis/studies/emv/coollight
	www.eia.gov/efficiency/programs/inventory