



# **CBECS 2012: Update on EPA's K-12 Scoring Model**

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# Agenda

- CBECS 2012 Survey
  - Overview
  - Energy Data
- EPA Analysis Plans
  - Timeline
  - Objectives
- ENERGY STAR Score Methodology
- Major Findings from K-12 Model
  - New Measure of Occupancy Variable
- Change in ENERGY STAR Scores
  - What To Expect
- Source Energy
- Next Steps



# CB ECS 2012 Overview

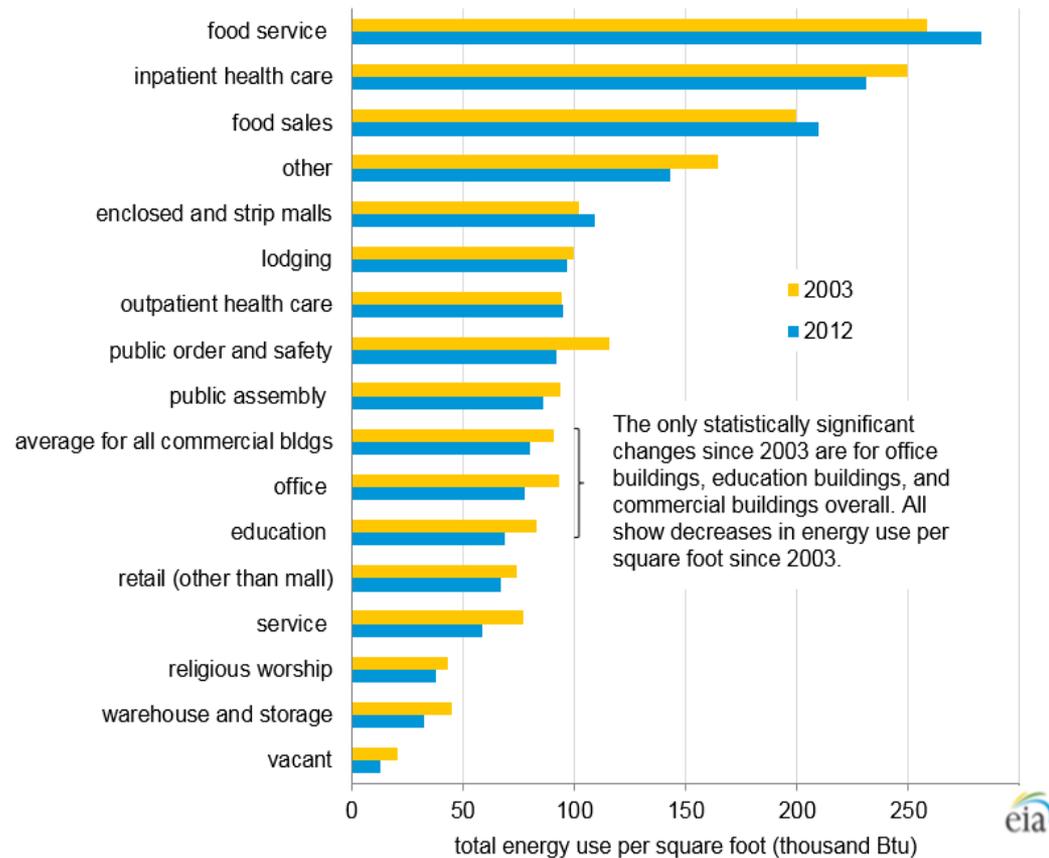
- **2012 survey sample size is over 6,700 observations**
  - 29% larger than 2003 survey
- **Estimate 5.6 million commercial buildings representing 87 billion ft<sup>2</sup>**
  - 14% increase in the number of buildings since 2003
  - 22% increase in floor space since 2003
- **EIA Data**
  - 2012 public use microdata available: <http://www.eia.gov/consumption/commercial/>
  - EIA has published energy comparisons for 2003 and 2012

	Top Market Sectors
1	<b>Office</b> 16.0 Billion ft <sup>2</sup>
2	<b>Warehouse</b> 13.0 Billion ft <sup>2</sup>
3	<b>Education</b> 12.2 Billion ft <sup>2</sup>
4	<b>Mercantile (Retail &amp; Mall)</b> 11.3 Billion ft <sup>2</sup>
5	<b>Lodging</b> 5.8 Billion ft <sup>2</sup>



# CBECS 2012: Energy Use by Sector

- EIA has published a 2003 to 2012 comparison chart
- Only two sectors show statistically significant changes in energy use
  - Education
  - Office
- Note these are overall figures
  - Not normalized for changes in operation



Source: U.S. Energy Information Administration, Commercial Buildings Energy Consumption Survey.



# ENERGY STAR Score Objectives

- Evaluate whole building energy use
  - Accounts for combined effects of technology, operation, maintenance, and usage patterns
  - Recognizes that these factors all affect each other and the bottom line measured energy consumption
- Provide a comparative, national benchmark
  - Adjusts for climate and certain business choices (e.g. hours of operation) for fair comparisons
  - Ranks performance relative to existing buildings in the market
- Identify best performers in the market, like the ENERGY STAR for products, so consumers and businesses can make smart choices
- Motivate organizations to develop a strategic approach to energy management



# EPA's Analysis Plans



# ENERGY STAR Score Development Process

- **Analyze national survey data**
  - Commercial Building Energy Consumption Survey (CBECS)
- **Develop regression models**
  - Normalize for different business activities
  - Assign a “normalized mean” to each property based on its operation
- **Compare actual energy use with normalized mean from the model**
  - More efficient: Actual < Normalized Mean
  - Less efficient: Actual > Normalized Mean
- **Create scoring lookup table**
  - Scores are based on the distribution of energy performance across commercial buildings
  - One point on the ENERGY STAR scale represents one percentile of buildings



# EPA Schedule for Score Revisions

- **Perform detailed analysis (~18 months)**
  - Started May 2016
  - Analyze energy performance by property type
  - Explore new variables captured by CBECS
  - Determine appropriate changes to regression models used for score calculations
- **Order of Analysis**
  - Office & Retail / Supermarket
  - Hotel & K-12 School
  - Warehouse & Worship Facility
- **Program new scores into Portfolio Manager (~6 months)**
  - Documentation / extensive testing
- **Release new scores to the public (2018)**



# K-12 School Schedule: Specifics

- The intensive review of CBECS for K-12 School is in our second batch of updates in the 18 month review process
- Lessons learned during the Office and Retail score development were applied during the K-12 School score development process.
- Near the end of the process, all models will be updated with the most current possible source factors prior to release

Activity	Timeframe
Project Launch	November 2016
Intensive Development	November 2016 – February 2017
Re-Assess Model Based on Other Property Types	Ongoing, As Needed
Incorporate Revised Source Energy Factors	July – September 2017
Program and Test in Portfolio Manager	September 2017 – March 2018
Launch new Score	Mid-2018



# What does a regression model look like?

- Example model

$$\begin{aligned} \text{Energy Intensity} = & C_0 + \\ & C_1 * \text{Workers per 1,000 ft}^2 + \\ & C_2 * \text{Computers per 1,000 ft}^2 + \\ & C_3 * \text{Hours of Operation} + \\ & C_4 * \text{Heating Degree Days} + \dots \end{aligned}$$

- Coefficients represent average responses
- Coefficients provide adjustments for each operational characteristic
  - **Does not** add the kWh of each piece of equipment
  - **Does** adjust energy based on correlation between operating characteristic and energy use



# EPA Criteria for Inclusion in Analysis

- Focus on business activity/service provided
- Do not include variables for specific technologies:
  - For example: if 100% LED lighting saves energy, we don't want to compare properties with 100% LED only to each other; we want to compare them to **everyone**. The least efficient among the buildings with 100% LED may still be better than the typical building without.

✓ Characteristics Included	✗ Characteristics Excluded
<ul style="list-style-type: none"> <li>✓ Describe how a building operates</li> <li>✓ Explain physical conditions and parameters</li> <li>✓ Are determined by the business activity and needs</li> </ul>	<ul style="list-style-type: none"> <li>✗ Describe why a building performs a certain way</li> <li>✗ Specify technologies used</li> <li>✗ Reflect market conditions that may motivate behavior but are not related to thermodynamic performance</li> </ul>
<p><i>Examples: Hours, Workers, Floor Area, Computers, Weather</i></p>	<p><i>Examples: Lighting Technology, Window Type, Energy Price</i></p>



# Example: Scoring Two K-12 Schools

- **What is the Same?**
  - Size
  - Climate zone
  - High School (Y/N), Weekend Operation (Y/N)
  - **Energy Use**
  
- **What is Different?**
  - Number of Workers
  - Cooking Facilities (Y/N)
  - **Expected EUI and Score**
  
- **Why?**
  - School B is expected to use more energy
    - More workers and cooking (yes/no)
  - Since it is expected to use more, but actually uses the same → it scores better

	School A	School B
Size	215,000	215,000
High School	Yes	Yes
Weekend Operation	Yes	Yes
Cook Facility Present	No	Yes
Number of Workers	75	160
Expected EUI (kBtu/ft <sup>2</sup> )	120	140
Actual EUI (kBtu/ft <sup>2</sup> )	90	90
ENERGY STAR Score	75	85



# ENERGY STAR Score Interpretation and Application

## The Score Does

- ✓ Evaluate actual billed energy use
- ✓ Normalize for operational characteristics (e.g., size, number of workers, operating hours, climate)
- ✓ Express the performance of a building compared to its peers, as described by a nationally representative survey

## The Score Does Not

- ✗ Sum the energy use of each piece of equipment
- ✗ Evaluate buildings relative to others in Portfolio Manager
- ✗ Normalize for technology choices or market conditions (e.g., type of lighting, energy price)
- ✗ Explain why a building operates as it does



# How does EPA pick the “best” model?

- No single statistic will identify the best model
- EPA will review many alternatives (100+)
- Statistical properties of CBECS to assess:
  - Regression model statistics ( $R^2$ )
  - Individual variable statistics (t-stats)
- Additional factors evaluated with both CBECS and Portfolio Manager
  - Distribution of scores
    - Average score
    - Percent in each 10-point bin
    - Number and percent above 75
  - Residual plots
  - Scatterplots of score as compared with key characteristics (size, workers, hours, etc)
  - Physical understanding of results
  - Relationship between EUI and score

**→ Your data in Portfolio Manager helps us test the models!**



# Objectives of Analysis

- Leverage the most recent market data
  - This will show us if buildings are becoming more or less efficient
  - If the market is getting more efficient, then it may become harder to qualify for ENERGY STAR
- Re-assess key drivers of energy use
  - Have the relationships between existing variables (e.g. computers) and energy intensity changed in the last 10 years?
  - Are there new variables in CBECS that we should be adjusting for going forward?



# New Information in the CBECS Survey

- **New variables in CBECS related to the use of technology in the classroom**
  - Number of laptops
  - Interactive whiteboards
  - TV or video displays
- **Other new variables in CBECS**
  - Occupancy (%)
  - Floor to ceiling height



# Major Findings from K-12 Model

Adjustments in Current K-12 Model Based on 2003 CBECS	Kept?	Adjustments in New K-12 Model Based on 2012 CBECS
Open Weekends (yes/no)	✓	Open Weekends (yes/no)
Presence of Cooking (yes/no)	✓	Presence of Cooking (yes/no)
Whether or not the building is a High School (yes/no)	✓	Whether or not the building is a High School (yes/no)
Weather and Climate (using Heating and Cooling Degree Days)	✓	Weather and Climate (using Heating and Cooling Degree Days)
Percent of the Building that is Heated and Cooled	✓	Percent of the Building that is Heated and Cooled
N/A	New	Number of Workers on Main Shift per 1000 ft <sup>2</sup>
Number of Personal Computers per 1000 ft <sup>2</sup>	✗	N/A
Building Size	✗	N/A
Number of Walk-in Refrigerators	✗	N/A



# Major Findings from K-12 Model

## New K-12 Model Based on 2012 CBECS

- Overall adjusts for very similar characteristics as previous model
- New adjustment for Number of Workers (replaces Number of Computers as primary measurement of occupancy)
- No adjustment for Building Size or Number of Walk-in Refrigerators (not significant)
- Model coefficients based off new updated 2012 data



## Major Findings from K-12 Model

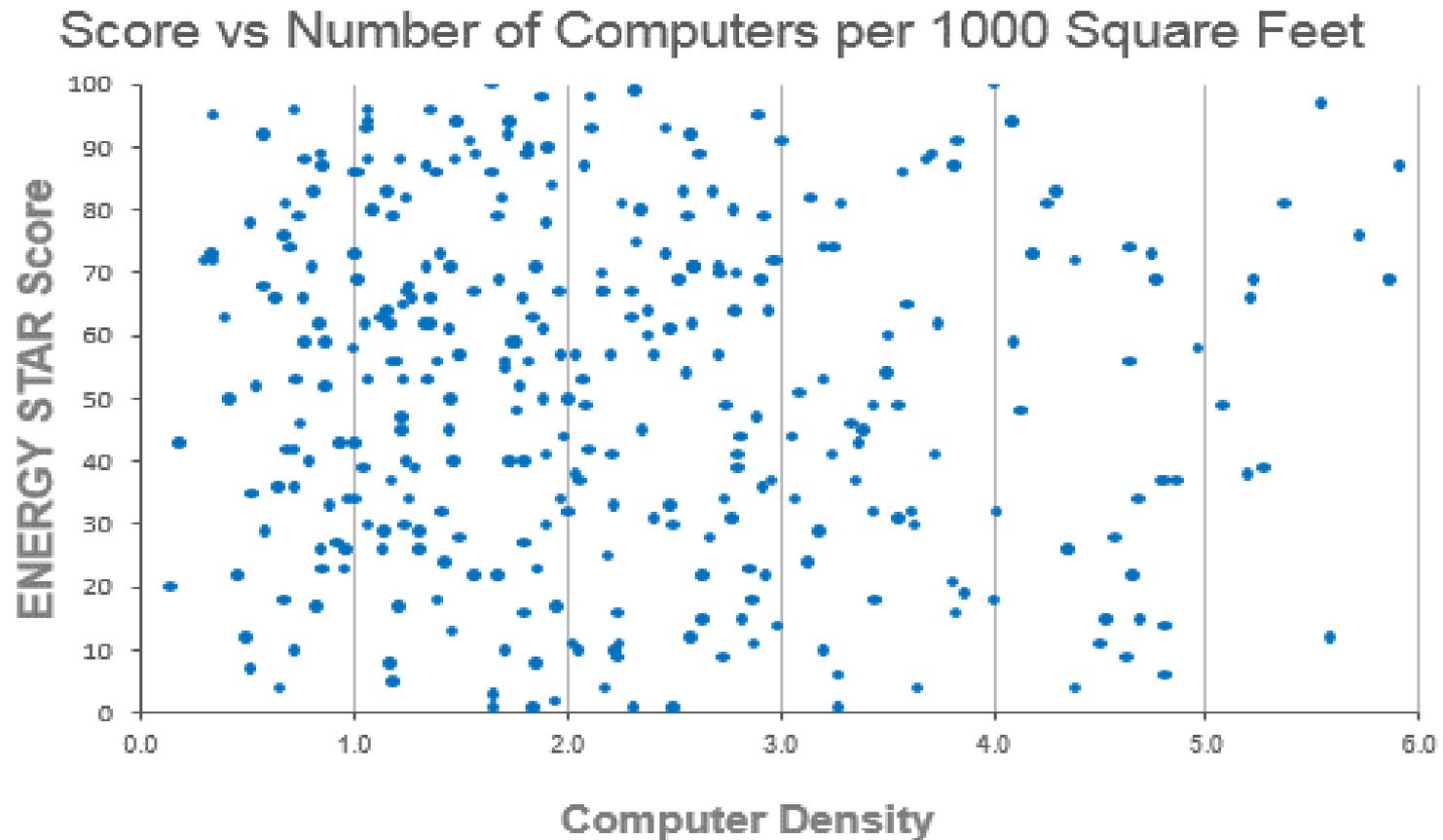
### Why no adjustment for Number of Personal Computers?

- Schools have begun to use netbooks and other tablet devices.
  - These devices use less energy than traditional computers.
  - These devices may also be taken home with students and charged outside of school.
  - There is confusion about the definition of which computers should be included in this count.
- Feedback from stakeholders indicated that personal computers are not a key driver of energy use. Our analysis supported this.
- Our analysis shows that the model scores schools equitably if we include a new Number of Workers adjustment.



# Score and Number of Computers

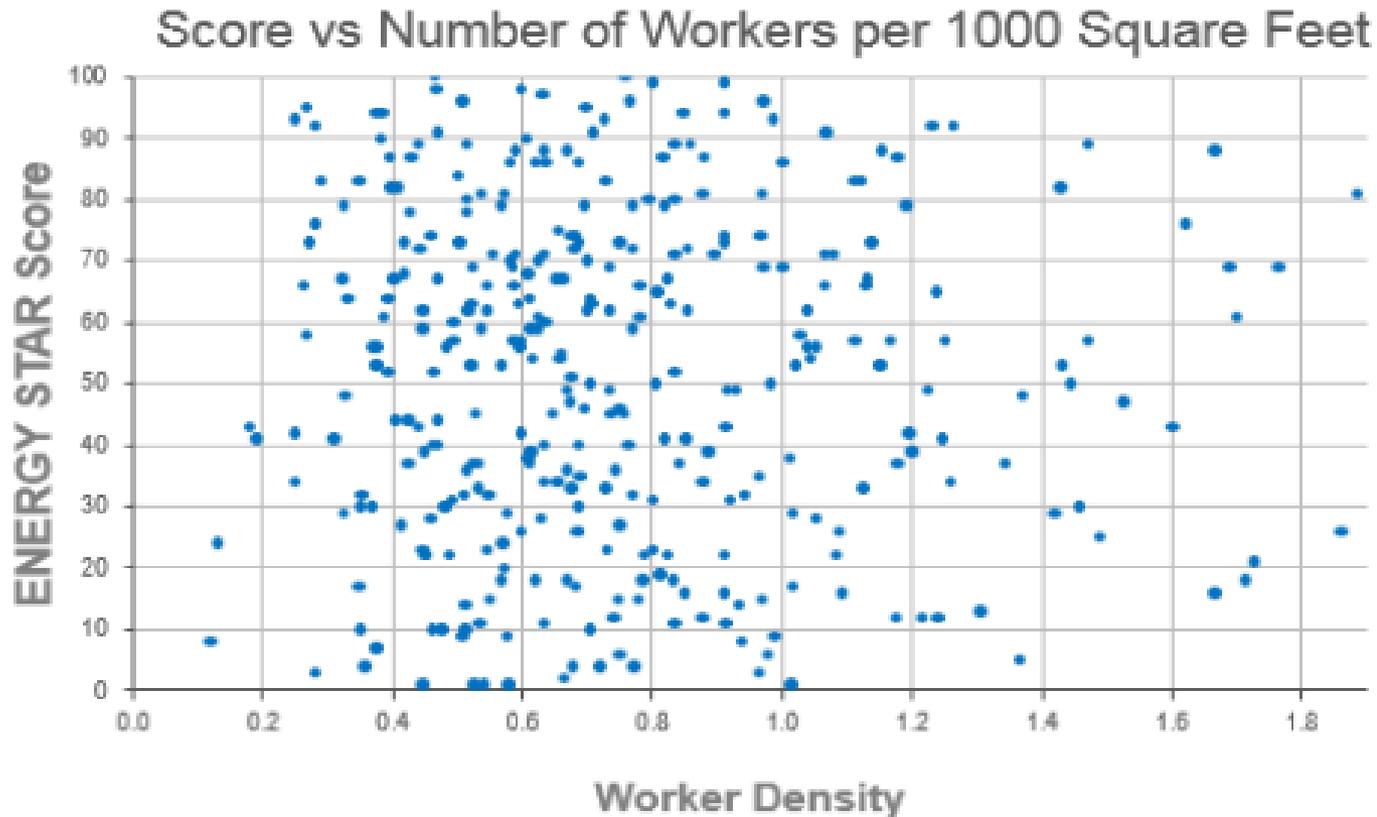
- Buildings score equitably over all values of computer density.





# Score and Worker Density

- Buildings score equitably over all values of worker density.

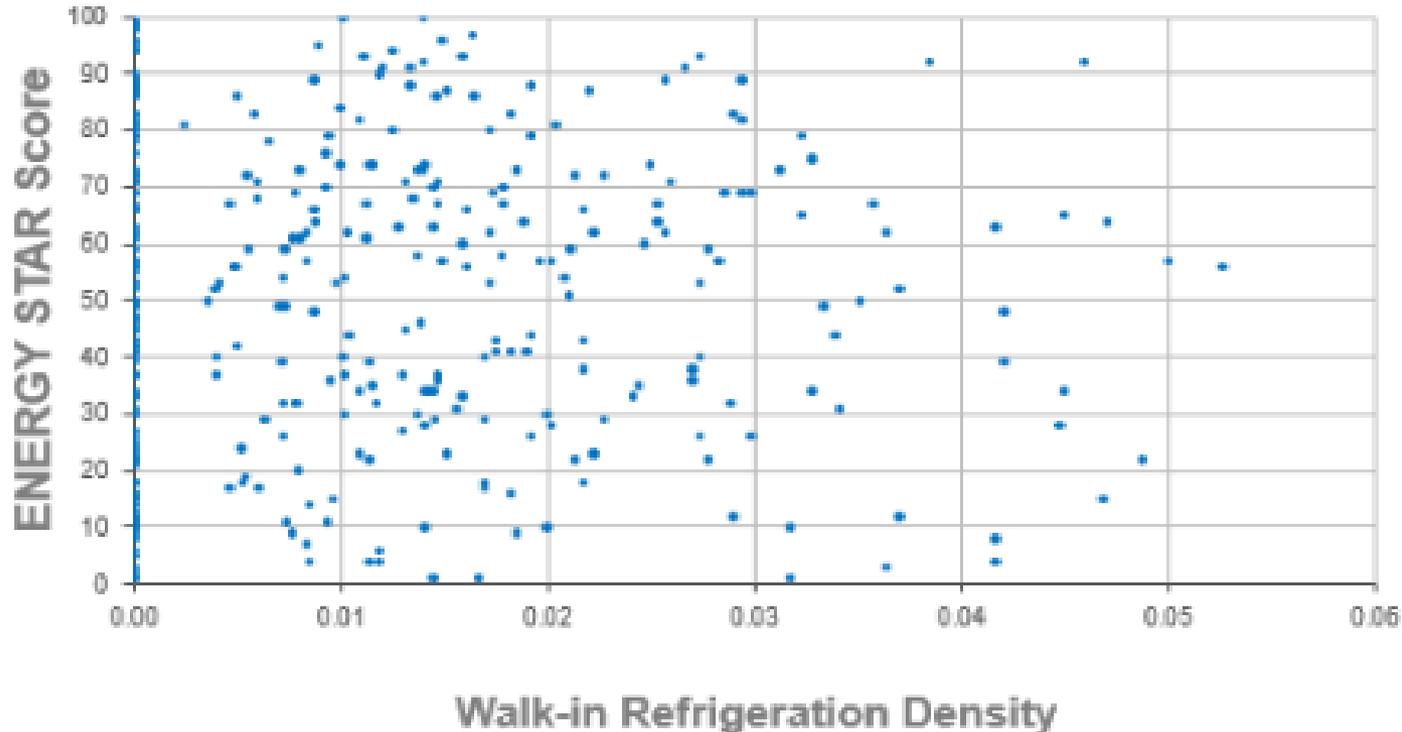




# Score and Refrigeration Density

- The updated model without refrigeration adjustment scores buildings equitably over all values of refrigeration density.

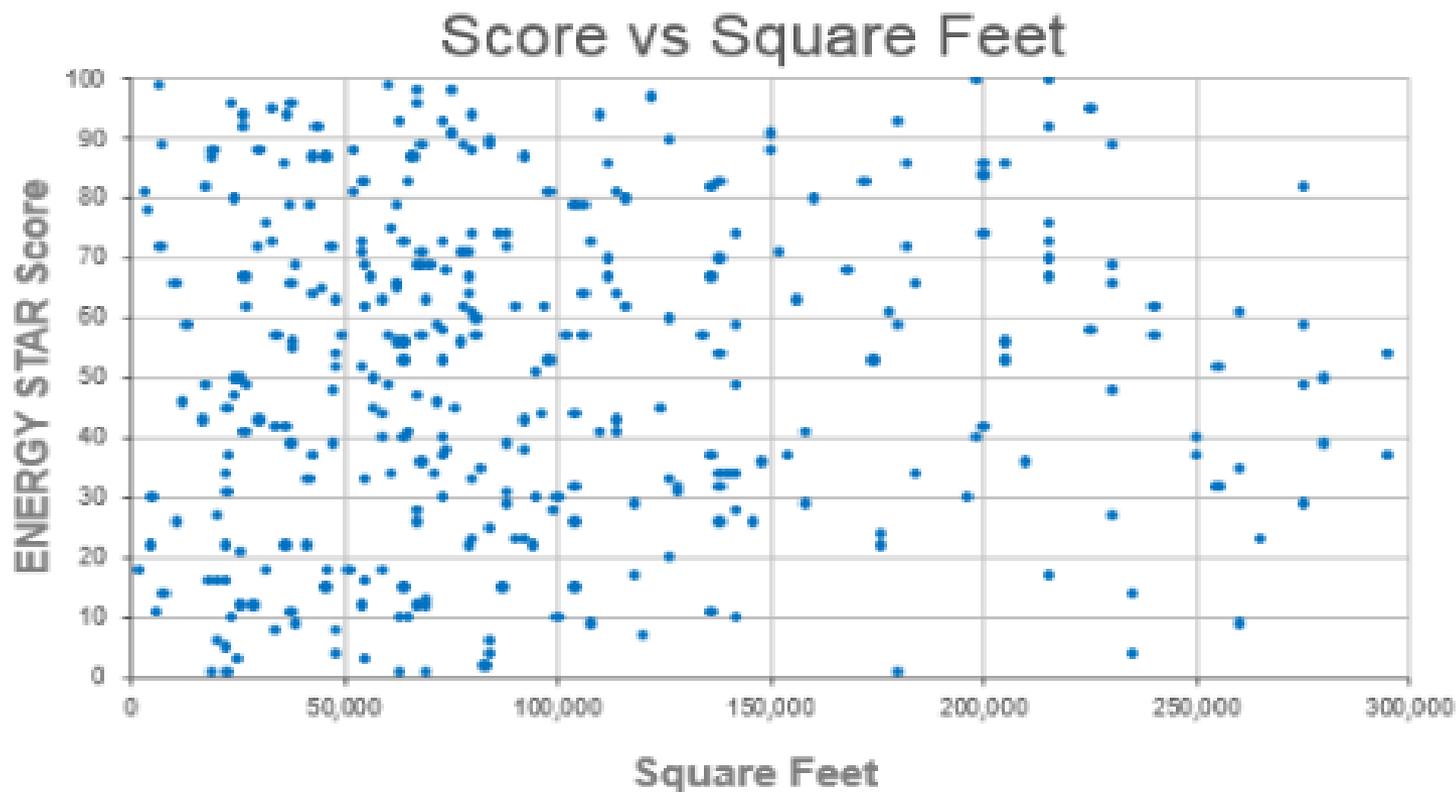
Score vs Number of Walk-in Refrigerators per 1000 Square Feet





# Score and Building Size

- The updated model without size adjustment scores buildings equitably for buildings of all sizes.





# What should you expect?

- **Expect some changes**
  - The median energy use for K-12 Schools has decreased
  - Correlations between energy use and key activities (hours, workers, computers)
  - Variables included in EPA's model
  - ***The scores of your properties!***
- **EPA's basic approach is not changing**
  - Provide a national level benchmark
  - Use source energy to provide equitable scores for all fuel mixes
  - Leverage ordinary least squares (OLS) regressions to assess factors that impact energy consumption
  - Incorporate variables that capture weather and business activity
  - Exclude technology terms from regression, in order to reward technology that saves energy



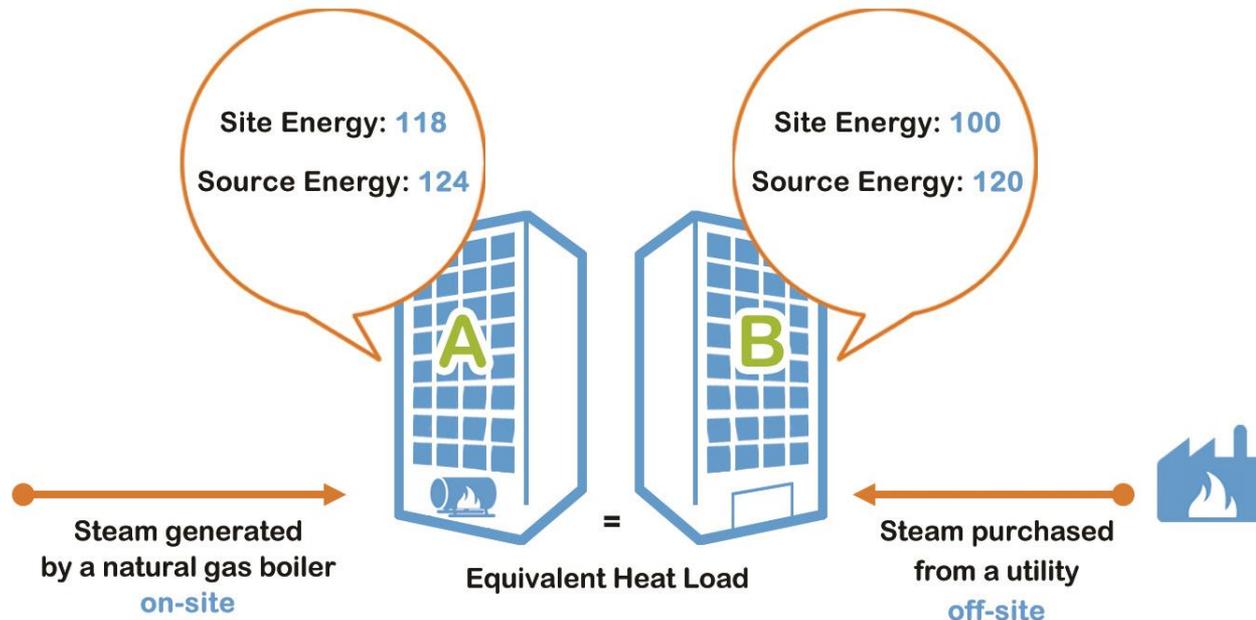
# Moving Forward: Continue Benchmarking

- **There is time**
  - Changes are not anticipated until 2018.
- **We will keep you informed**
  - We will give ample notice of an exact date.
- **We will not rescind prior certifications**
  - All of your certified properties will still be on our registry.
  - If you have top performers that are not certified, now is a good time to pursue certification.
- **We will coordinate with cities and other partners**
  - We will review the implications of changes.
  - We will prepare organizations that use Portfolio Manager for implications of changes to the scores.

# Source Energy

- Ensure that no individual building receives a credit (or penalty) based on the efficiency of its provider.
- Places primary and secondary energy on an equal footing.

Site Energy results in **Building B** appearing more efficient.  
Source Energy provides an **equitable** comparison.





# Update to Source Factor

- **EPA will still use one national electric factor**
- **The electric factor will be lower**
  - This new lower factor will be incorporated into our CBECS regression analysis and National Median calculation.
  - This new lower factor will be applied to your buildings in Portfolio Manager.
- **Medians for 2012 will be lower**
  - Compared to the numbers you see in Portfolio Manager today, both your actual energy use and the national median will be lower.
- **Portfolio Manager will not change until 2018**
  - These changes will be implemented in 2018.
  - All models will be re-estimated (including property types that do not use CBECS).
  - The changes to the factors affect both the underlying algorithm and the source energy calculation for your property.



# Summary

- EPA will continue to perform extensive analysis of the CBECS 2012 data.
- We anticipate releasing the K-12 school update to Portfolio Manager in 2018.
  - This will coincide with the release date for all property types included in the CBECS update.
- Score changes to existing properties in Portfolio Manager are likely.
- You will have plenty of notice of the exact date before anything changes in Portfolio Manager.
- You are invited to participate in regular webinars to offer feedback.



# Next Steps

- Be on the lookout for our next webinar for the latest updates pertinent to all sectors.
  - Updates approximately every 6 months until Portfolio Manager launch
  - Next Session: Mid 2017 (date TBD)
    - <https://esbuildings.webex.com/>
- If you see something, say something
  - Feel free to reach out with suggestions or questions at any time: [www.energystar.gov/BuildingsHelp](http://www.energystar.gov/BuildingsHelp)
- EPA will be hard at work with regression analysis for the next year 😊



## Questions & Discussion