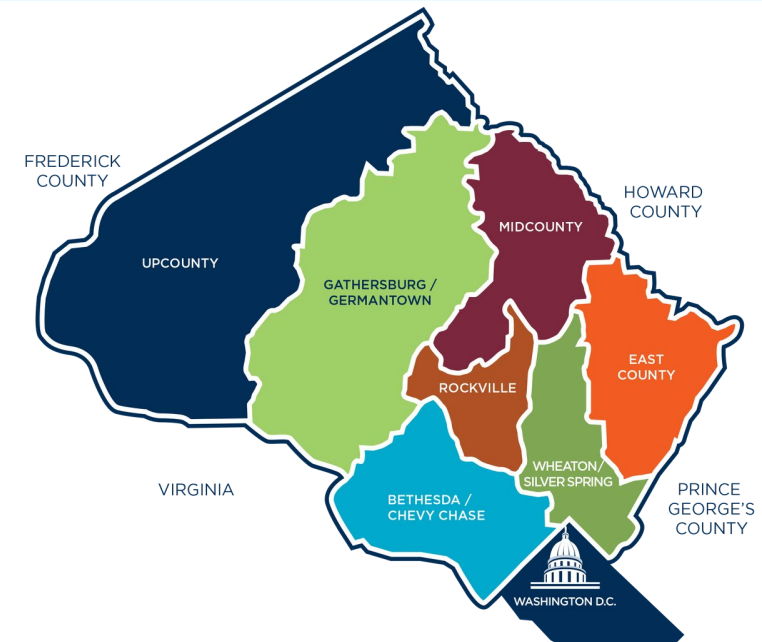




March 14, 2022

# Building Energy Performance Standards (Bill 16-21): BEPS Technical Report *Standard Setting Research to Inform Regulations*



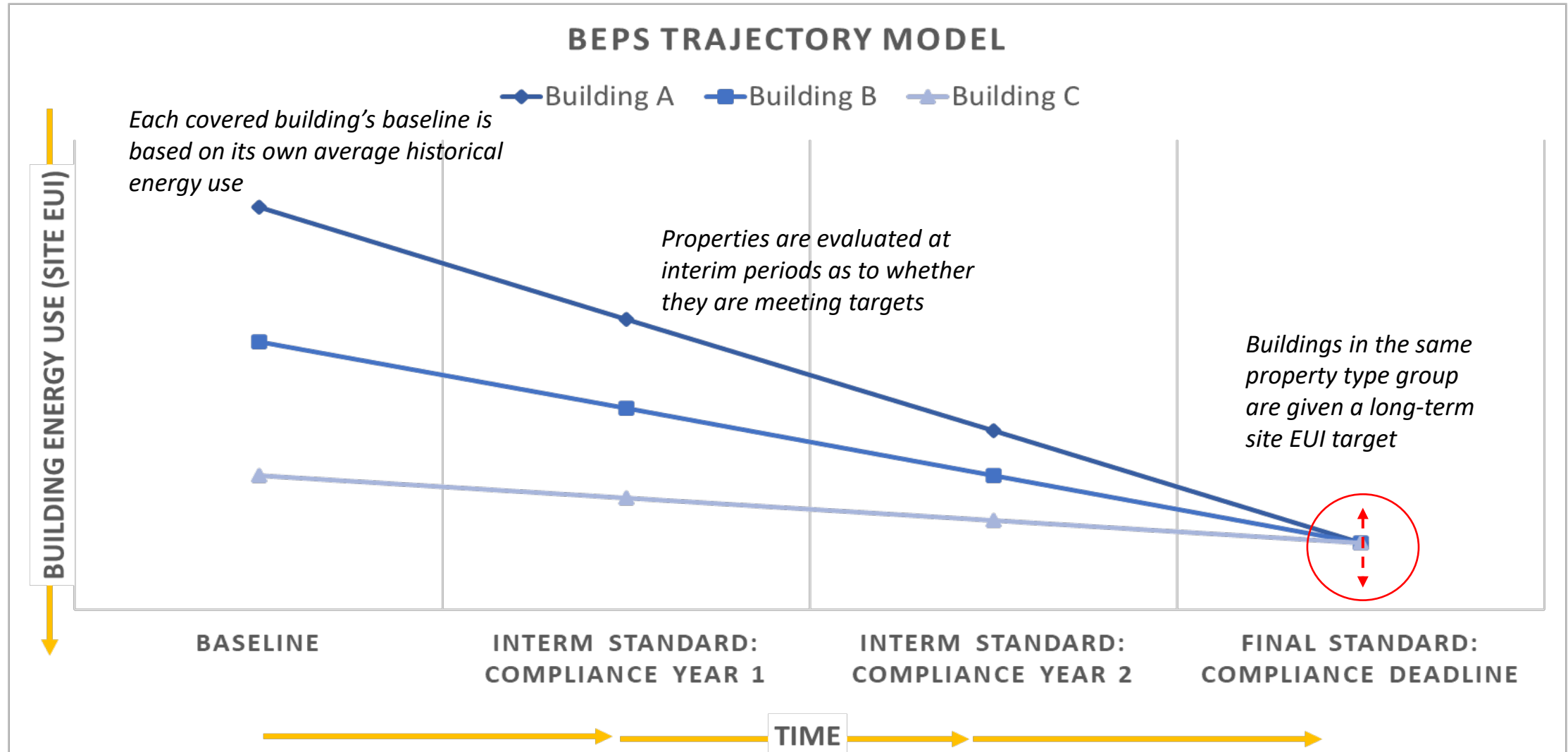
Learn more at <https://www.montgomerycountymd.gov/green/energy/beps.html>

# Briefing Agenda

- Methodology for BEPS Technical Report Analyses
- Site EUI Target Calculation Approach
- Site EUI Options
- Building Inventory Analysis
- Impacts of BEPS Target Options:
  - County-wide Energy and GHG Benefits
  - Cumulative GHG Emissions Impacts
  - Financial Costs and Savings
- Case Studies
- Concluding Takeaways

# BEPS Policy Overview

- Final standard (to be defined by regulation) will dictate scale of investments and emissions reductions



# High-Level Methodology of BEPS Technical Analysis

## Covered Buildings

- Develop an approximate covered buildings list
- Group covered buildings into building types to evaluate a range of technically feasible site EUI targets

## Standard Setting Options

- Establish a recommended method for setting building performance standards
  - Use typical energy use profiles in building types representative of buildings in Montgomery County
  - Assume retrofits using commercially available technology

## County-Wide Impacts

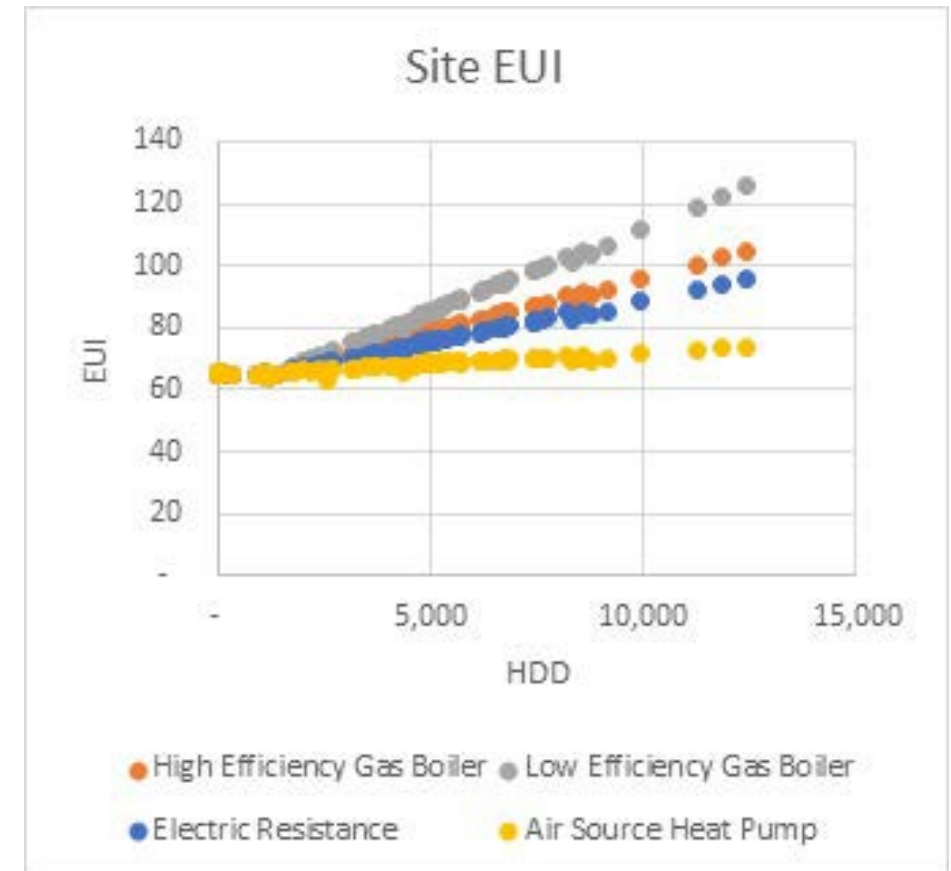
- Model county-wide impacts of potential BEPS targets to estimate:
  - Energy savings
  - GHG reductions
  - Cost savings
  - Cost impacts

## Case Studies

- Select buildings representative of primary building types that would have to meet a BEPS target
- Create retrofit packages via desk audits to:
  - Test technical feasibility of potential site EUI targets,
  - Estimate the total capital costs,
  - Estimate energy cost savings of meeting targets

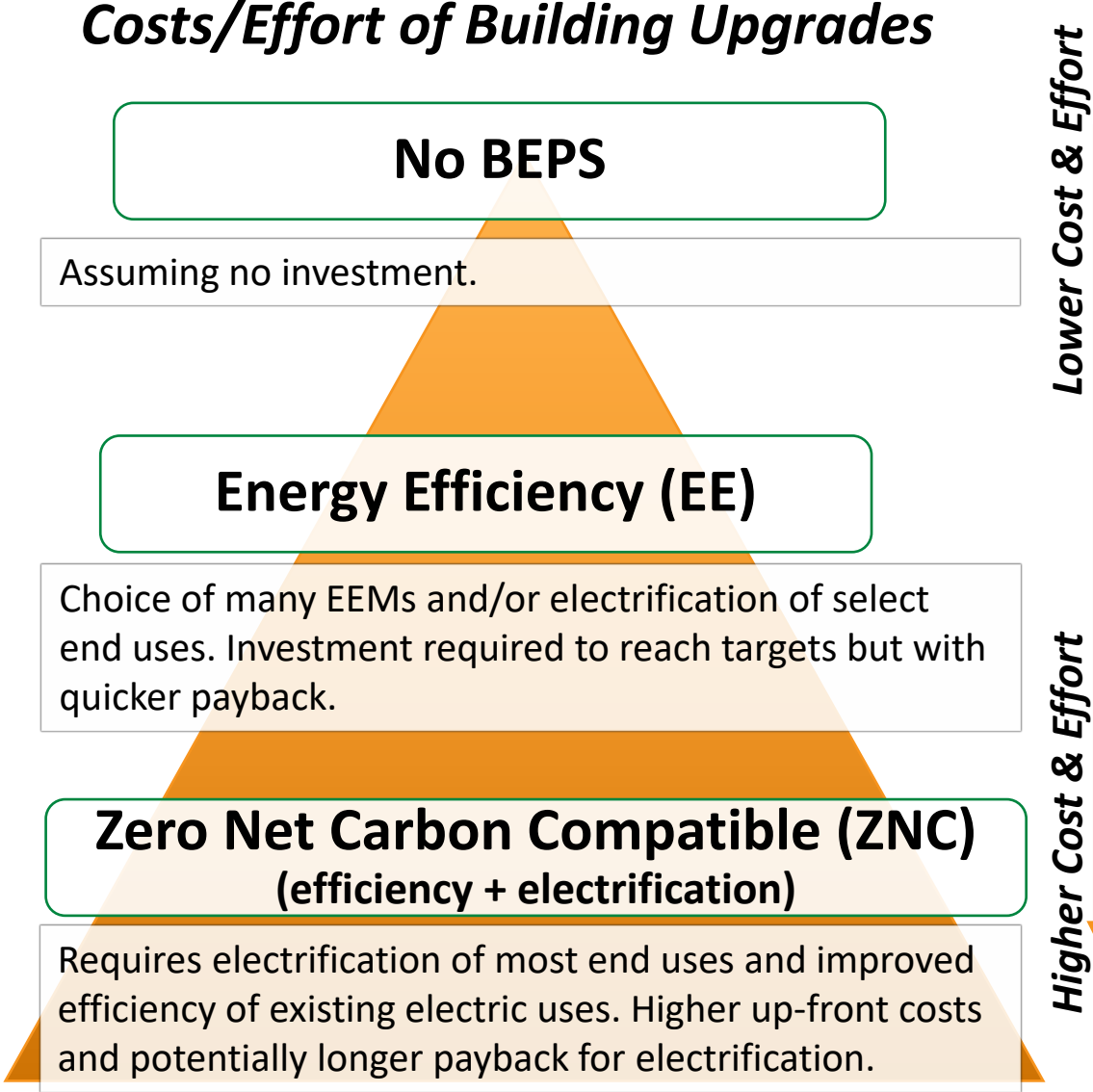
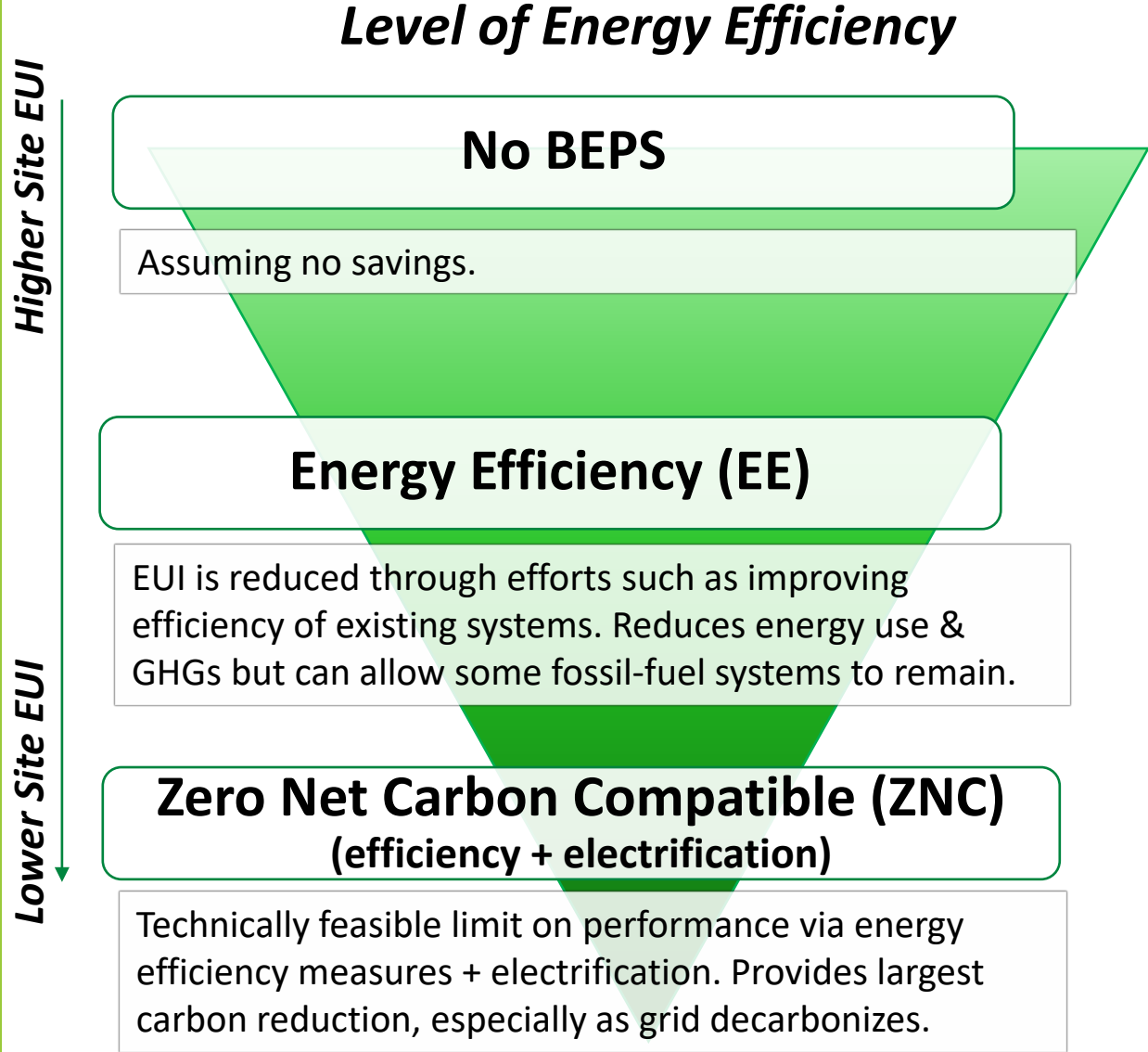
# Electrification and Site Energy Use Intensity (site EUI)

- Site EUI measures energy use per square foot per year.
- The Site EUI metric in Bill 16-21 favors electrification regardless of the efficiency of the electric technology.
- **Electrification is one of the deepest forms of energy efficiency because electric equipment operates at higher efficiency than fuel-fired equipment.**
- Setting a low BEPS site EUI target would require buildings to electrify end uses efficiently over time *and* improve electric efficiency.



Source: US EPA, *Understanding and Choosing Metrics for Building Performance Standards and Zero-Carbon Recognition*, May 2021

# Overview of BEPS Standard-Setting Approach Options



# Target Method 1: Energy Efficiency (EE) Target

- Achievable through energy efficiency measures for the typical building.
  - Most buildings should be able to achieve these reductions through efficiency and equipment optimization of electric and fossil fuel-based systems.
  - For some buildings, the easiest pathway may be electrifying some systems. Electrification is a very effective site EUI energy efficiency measure.
- Calculated by applying a moderate reduction of energy use to the typical building in each building type:

| End Use           | Percent reduction from the localized median EUI for EE target |
|-------------------|---------------------------------------------------------------|
| Electricity       | 15%                                                           |
| Gas Space Heating | 20%                                                           |
| Gas Water Heating | 10%                                                           |
| Gas Cooking       | 0%                                                            |
| Gas Laundry/Other | 0%                                                            |

## Target Method 2: Zero-Net Carbon Compatible (ZNC) Target

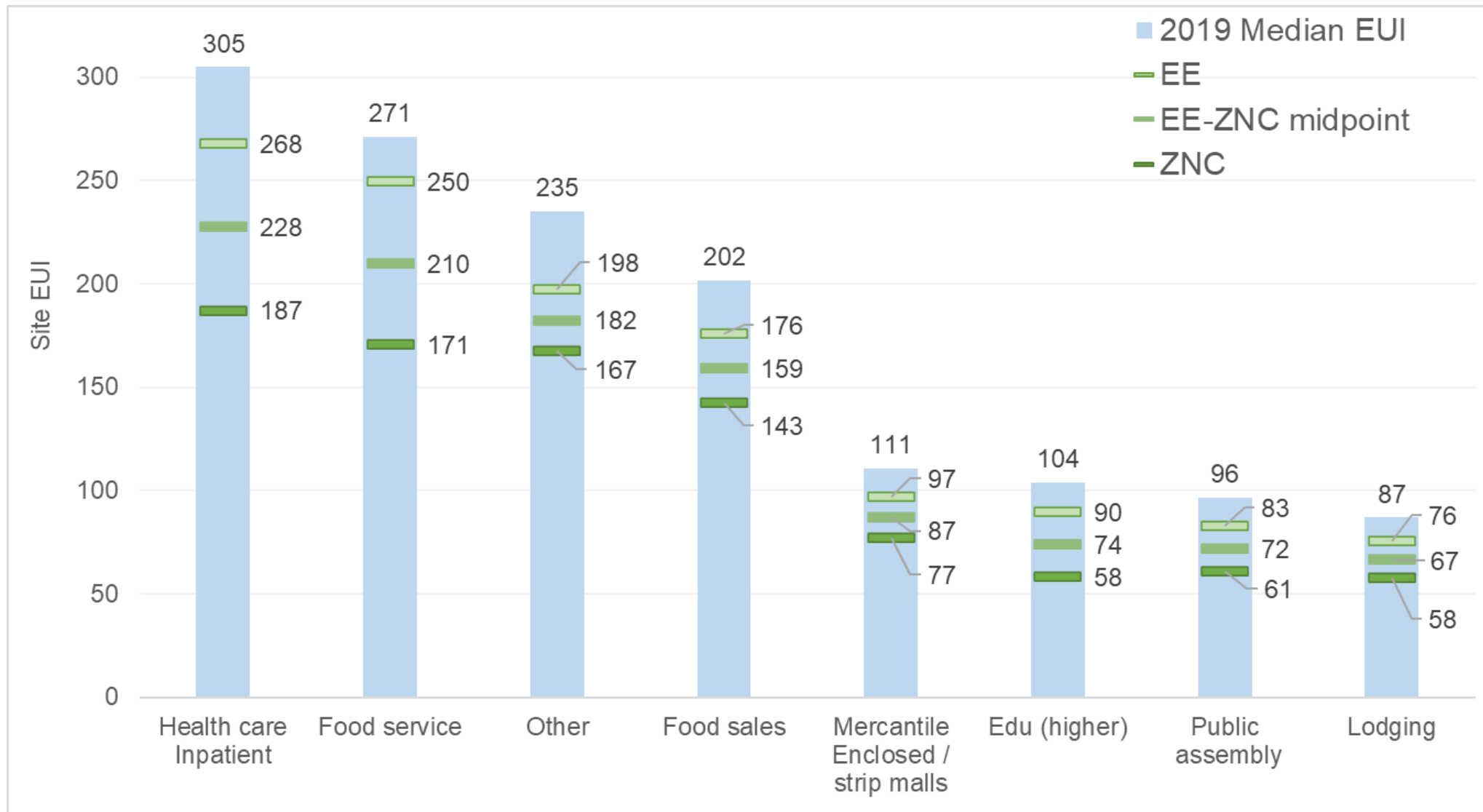
- An EUI level simulating the electrification of all fossil fuel end uses using market-ready technology in an energy efficient building.
- The ZNC targets are a technically feasible limit on building energy performance for each group

| End Use           | Percent reduction from the localized median EUI for EE target | Additional percent reduction starting from the EE target for ZNC target |
|-------------------|---------------------------------------------------------------|-------------------------------------------------------------------------|
| Electricity       | 15%                                                           | 0% (no further change)                                                  |
| Gas Space Heating | 20%                                                           | 68%, all electric (COP* 0.80 → 2.50)                                    |
| Gas Water Heating | 10%                                                           | 59%, all electric (COP 0.90 → 2.20)                                     |
| Gas Cooking       | 0%                                                            | 39%, all electric (COP 0.45 → 0.74)                                     |
| Gas Laundry/Other | 0%                                                            | 11%, all electric (COP 0.90 → 1.00)                                     |

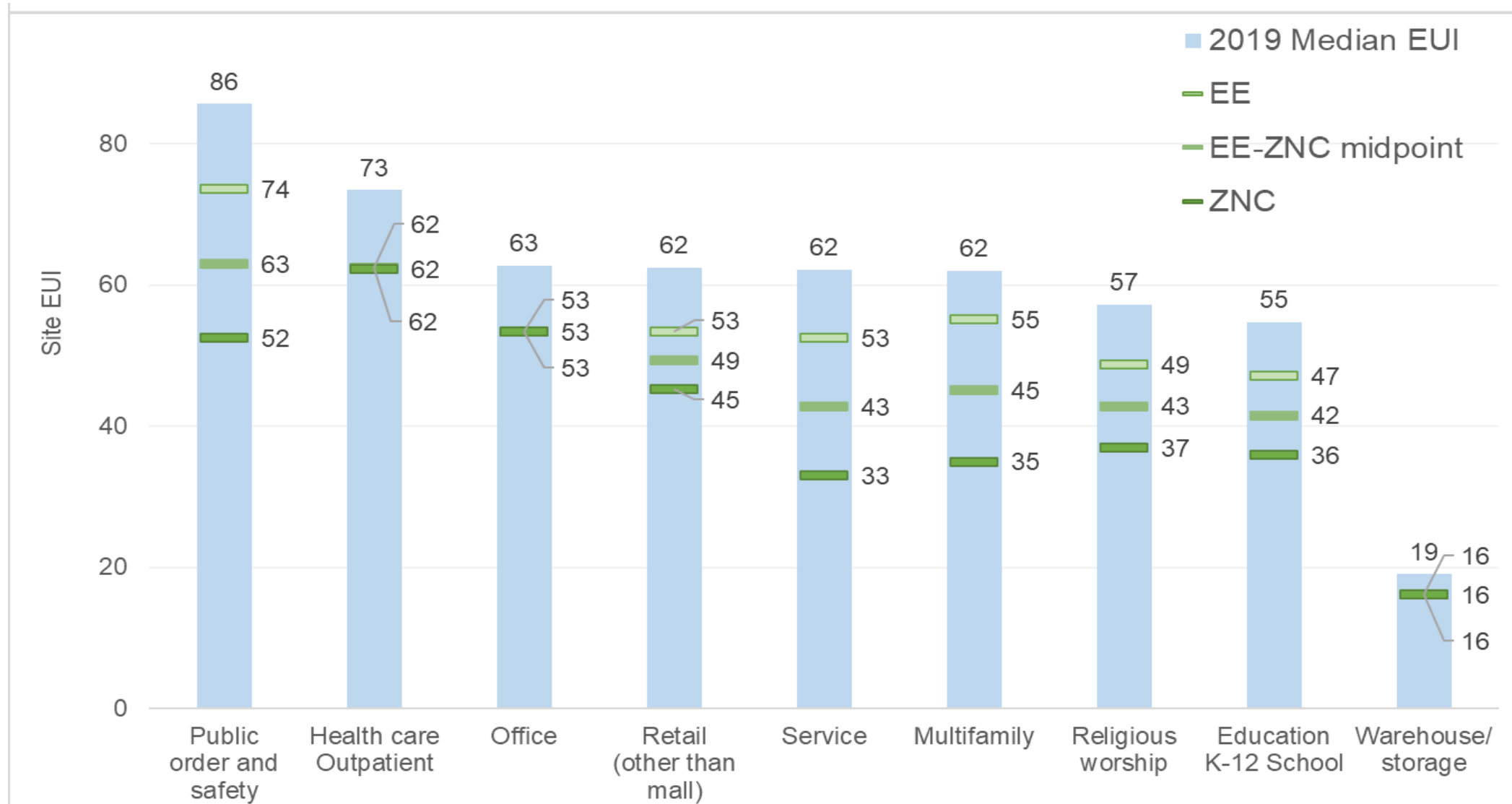
*\*COP is the Coefficient of Performance of the equipment, defined as energy output (heat) divided by purchased energy input (gas or electricity). A COP of 0.8 is an annual efficiency of 80%. A heat pump can operate at average efficiencies of 250% (COP of 2.50) by extracting heat from the outside air.*



# Site EUI Options from BEPS Technical Report (1 of 2)



# Site EUI Options from BEPS Technical Report (2 of 2)

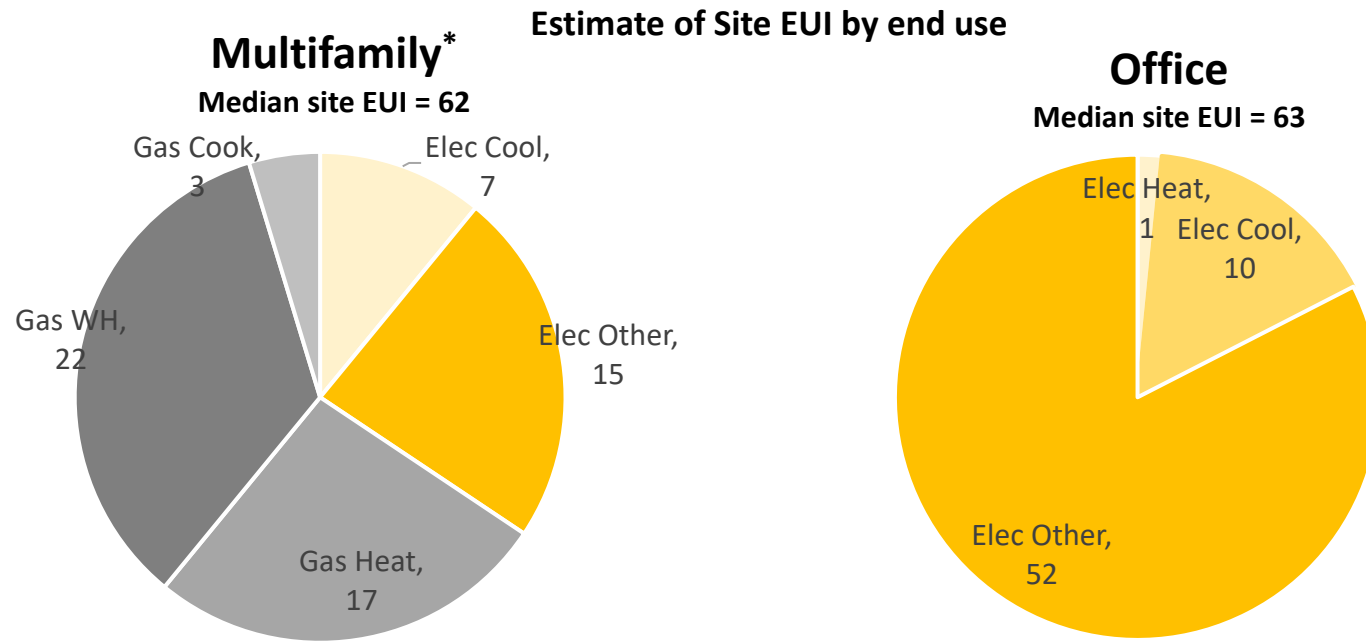


# Site EUI Options from BEPS Technical Report

| Building Type          | 2019 Median | EE  | EE-ZNC Mid-Point | ZNC | % of covered area | % reduction from median needed for ZNC |
|------------------------|-------------|-----|------------------|-----|-------------------|----------------------------------------|
| Multifamily            | 62          | 55  | 45               | 35  | 34%               | 44%                                    |
| Office                 | 63          | 53  | 53               | 53  | 31%               | 16%                                    |
| Enclosed/Strip Mall    | 111         | 97  | 87               | 77  | 7%                | 31%                                    |
| Health Care Inpatient  | 305         | 268 | 228              | 187 | 4%                | 39%                                    |
| Lodging                | 87          | 76  | 67               | 58  | 4%                | 33%                                    |
| Warehouse/storage      | 19          | 16  | 16               | 16  | 4%                | 16%                                    |
| Other                  | 235         | 198 | 182              | 167 | 3.5%              | 29%                                    |
| Retail                 | 62          | 53  | 49               | 45  | 3.1%              | 27%                                    |
| Food Sales             | 202         | 176 | 159              | 143 | 2.5%              | 29%                                    |
| Public Assembly        | 96          | 83  | 72               | 61  | 2.1%              | 36%                                    |
| K-12 School            | 55          | 47  | 42               | 36  | 1.8%              | 35%                                    |
| Religious worship      | 57          | 49  | 43               | 37  | 1.5%              | 35%                                    |
| Health Care Outpatient | 73          | 62  | 62               | 62  | 1.3%              | 15%                                    |
| Higher Education       | 104         | 90  | 74               | 58  | 0.2%              | 44%                                    |
| Public Order/Safety    | 86          | 74  | 63               | 52  | 0.2%              | 40%                                    |
| Food Service           | 271         | 250 | 210              | 171 | 0.01%             | 37%                                    |

# Example Building Types – Achievable Savings

- Different buildings types use energy differently to meet their occupancy needs, and source that energy in different ways
- Some building types are already substantially electric (e.g., offices)
- Building types with large gas uses have more potential for reductions in site EUI (e.g., multifamily)



| Site EUI           | 2019 Median | EE<br>% reduction from median | Mid-Point<br>% reduction from median | ZNC<br>% reduction from median |
|--------------------|-------------|-------------------------------|--------------------------------------|--------------------------------|
| <b>Multifamily</b> | 62          | 11%                           | 27%                                  | <b>44%</b>                     |
| <b>Office</b>      | 63          | 16%                           | 16%                                  | <b>16%</b>                     |

\* MF, Old, Tall typology from DC benchmarking data

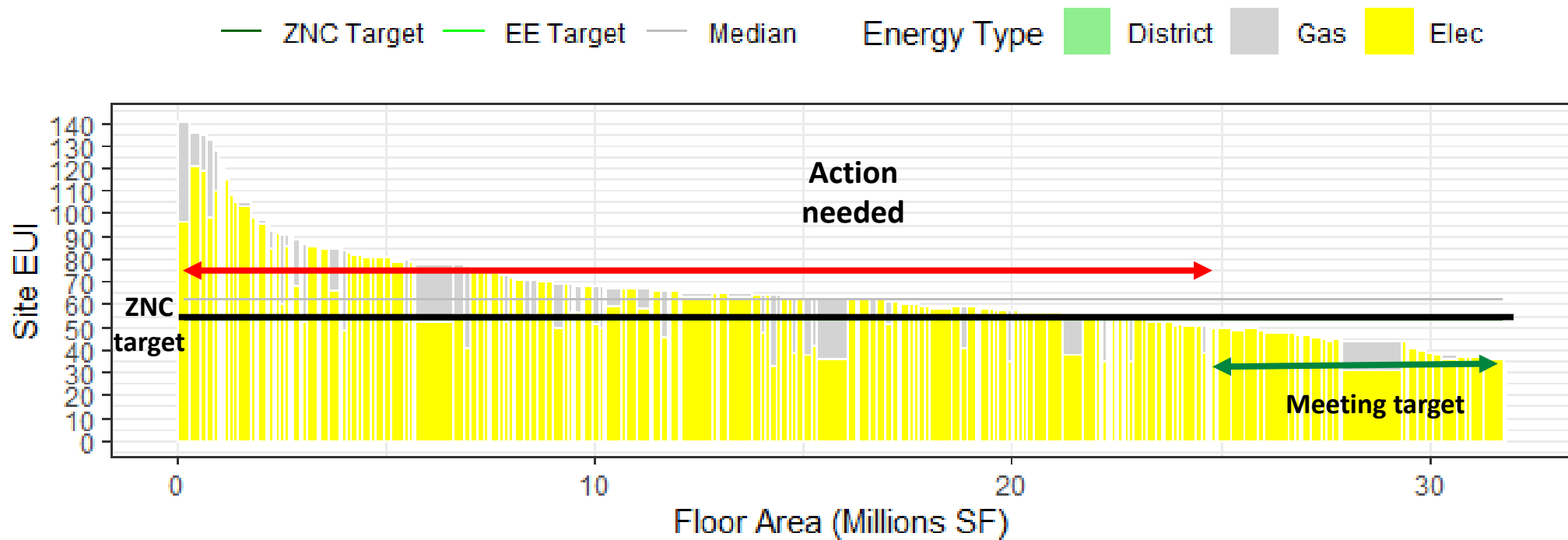
# % of Buildings Needing to Reduce Site EUI to Reach Target

|                                                                        | Total covered | EE         | EE-ZNC midpoint | ZNC        |
|------------------------------------------------------------------------|---------------|------------|-----------------|------------|
| Office                                                                 | 391           | 81%        | 81%             | 81%        |
| MF-New-Tall <i>(built after 1980, 4 stories and up)</i>                | 145           | 38%        | 59%             | 79%        |
| Warehouse and storage                                                  | 144           | 51%        | 51%             | 51%        |
| MF-Short <i>(3 stories and shorter)</i>                                | 101           | 56%        | 67%             | 89%        |
| MF-Old-Tall <i>(built before 1980, 4 stories and up)</i>               | 90            | 70%        | 80%             | 90%        |
| Mercantile Retail (other than mall)                                    | 82            | 71%        | 71%             | 71%        |
| Other                                                                  | 76            | 66%        | 74%             | 74%        |
| Lodging                                                                | 73            | 60%        | 84%             | 93%        |
| Religious Worship                                                      | 71            | 61%        | 70%             | 70%        |
| Food Sales                                                             | 55            | 76%        | 76%             | 89%        |
| Public Assembly                                                        | 53            | 53%        | 53%             | 64%        |
| Mercantile Enclosed and strip malls                                    | 45            | 64%        | 64%             | 69%        |
| Education - K-12 School                                                | 40            | 83%        | 88%             | 98%        |
| Health care Outpatient                                                 | 38            | 87%        | 87%             | 87%        |
| Public order and safety                                                | 11            | 100%       | 100%            | 100%       |
| Health care Inpatient                                                  | 10            | 100%       | 100%            | 100%       |
| Education                                                              | 3             | 33%        | 33%             | 33%        |
| Food Service                                                           | 1             | 100%       | 100%            | 100%       |
| <b>Total % of Buildings Needing To Reduce Site EUI to Reach Target</b> | 1429          | <b>66%</b> | <b>72%</b>      | <b>78%</b> |

# Energy Use & BEPS Targets, Sample Building Typologies

| % of Buildings Needing to Reduce Site EUI to Reach Target | Total covered | EE  | EE-ZNC midpoint | ZNC        |
|-----------------------------------------------------------|---------------|-----|-----------------|------------|
| Office                                                    | 391           | 81% | 81%             | <b>81%</b> |

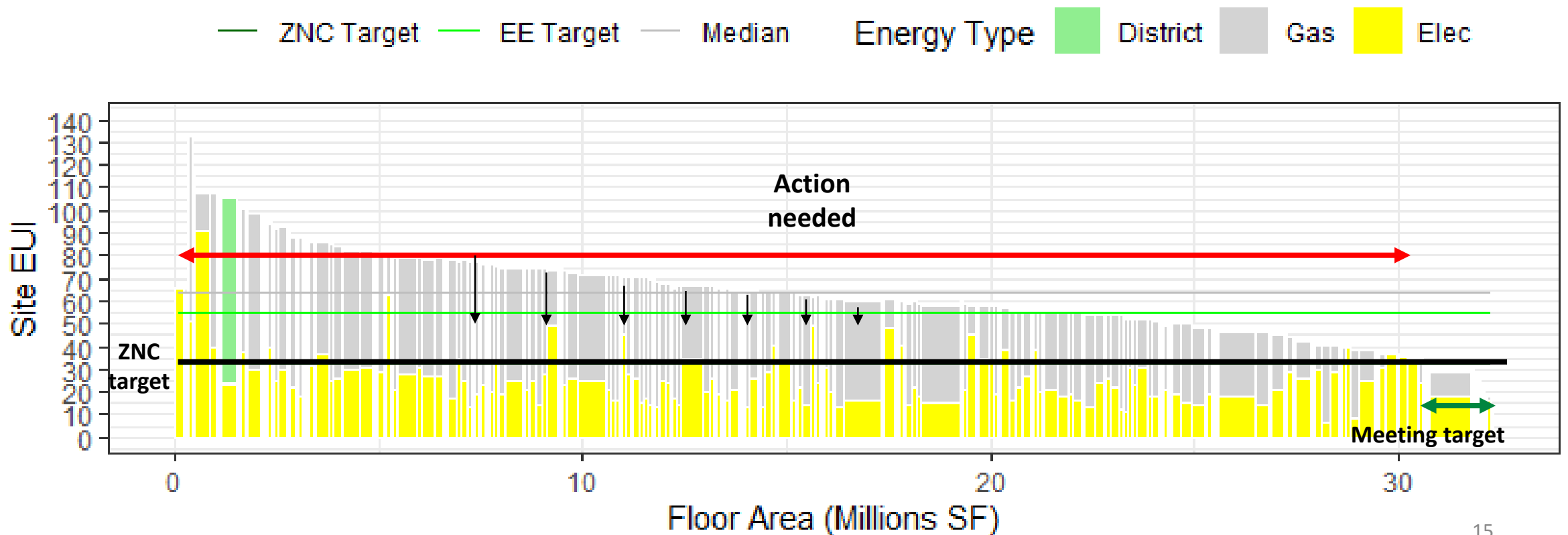
## Office Energy Use Distribution



# Energy Use & BEPS Targets, Sample Building Typologies

| % of Buildings Needing to Reduce Site EUI to Reach Target  | Total covered | EE  | EE-ZNC midpoint | ZNC        |
|------------------------------------------------------------|---------------|-----|-----------------|------------|
| MF-Old-Tall ( <i>built before 1980, 4 stories and up</i> ) | 90            | 70% | 80%             | <b>90%</b> |

## MF-Old-Tall Energy Use Distribution



# Impact: County-Wide Energy and Emissions Reductions

Selecting an EE target would allow new fossil-fuel equipment to be installed, locking buildings into a long period of fossil fuel use until the next replacement cycle, e.g., 15-20 years.

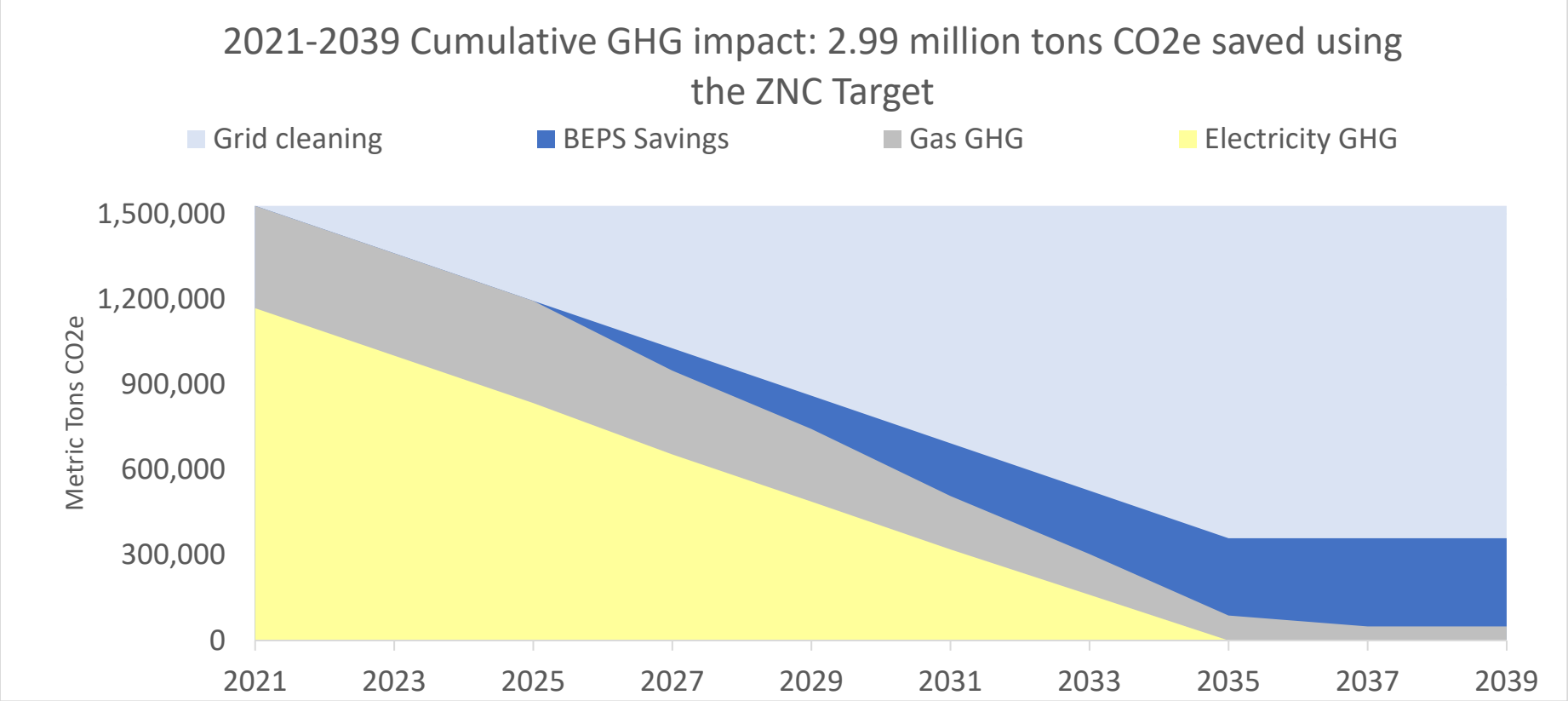
Selecting a ZNC target, if implemented along with the realization of a 100% carbon-free electricity supply, would result in the deepest emissions reductions.

|                                                                             | EE  | EE-ZNC midpoint | ZNC |
|-----------------------------------------------------------------------------|-----|-----------------|-----|
| Reduction in Site EUI vs baseline                                           | 23% | 28%             | 35% |
| Reduction in On-site Fossil Fuel Emissions                                  | 46% | 66%             | 86% |
| Reduction in emissions vs baseline<br>( <b>NO</b> change from today's grid) | 19% | 22%             | 26% |
| Reduction in emissions<br>(carbon free electric supply)                     | 87% | 92%             | 97% |



# Impact: County's Cumulative GHG Emissions

- The transition to a carbon-free electricity supply will provide the most carbon emissions savings in buildings.
- BEPS enables further emissions reductions by:
  - Reducing on-site emissions through fossil fuel efficiency and/or electrification
  - Improving electric energy efficiency and easing the burden on the supply side to provide electricity from carbon-free sources



# Impact: County-Wide Estimated Financial Costs and Savings

Costs = full cost of new system, not incremental cost above standard replacement.

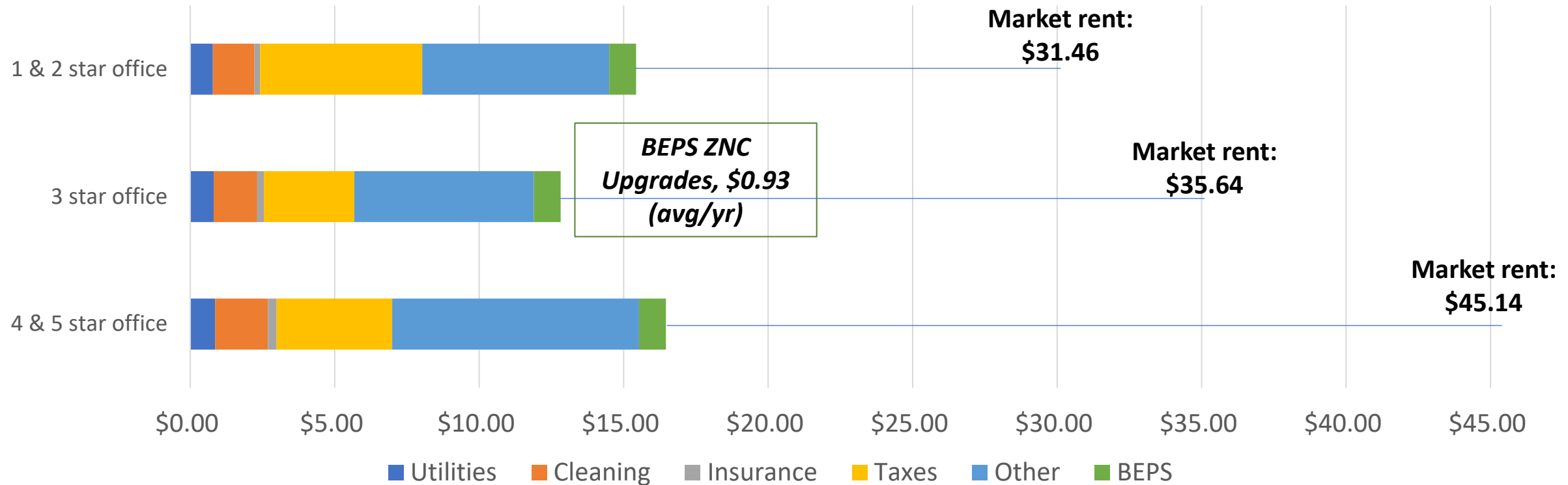
|                                                                                 | No BEPS | EE     | EE-ZNC midpoint | ZNC    |                              |
|---------------------------------------------------------------------------------|---------|--------|-----------------|--------|------------------------------|
| <b>Energy Costs</b><br>(annual, post-BEPS)                                      | \$543   | \$458  | \$451           | \$437  | <i>Million</i>               |
| <b>Energy Cost Savings</b><br>(annual, post-BEPS vs baseline)                   | \$0     | \$85   | \$92            | \$106  | <i>Million</i>               |
| <b>% Energy Cost Savings</b><br>(annual, post-BEPS vs baseline)                 | 0%      | 16%    | 17%             | 19%    | <i>% lower than baseline</i> |
| <b>Total BEPS Related Capital Cost*</b><br>(annual average over 15 years)       | \$0     | \$111  | \$160           | \$216  | <i>Million</i>               |
| <b>BEPS Related Capital Cost* / SF / year</b><br>(annual average over 15 years) | \$0     | \$0.48 | \$0.69          | \$0.93 | <i>\$/SF/year</i>            |

Most major in-building equipment (i.e., mechanical equipment) is likely to be replaced prior to 2035. This capital cost can be redirected toward deeper retrofit projects. This creates a lower “effective” cost of compliance, but baseline capital costs are highly building dependent on factors outside of the study. Baseline capital cost outlay, financial incentives, and financing were too building-specific to determine, and thus, are not included in this report.

# BEPS Related Capital Costs / SF in Context

- Costar market reports show annual expenses per square foot as well as rental income per square foot
- Report shows total average rental income for Bethesda/Chevy Chase offices: \$41.26 per square foot
- Operating expenses per square foot are ~\$11-15 per square foot

Rents & Expenses/SF, Bethesda Chevy Chase



# Case Studies

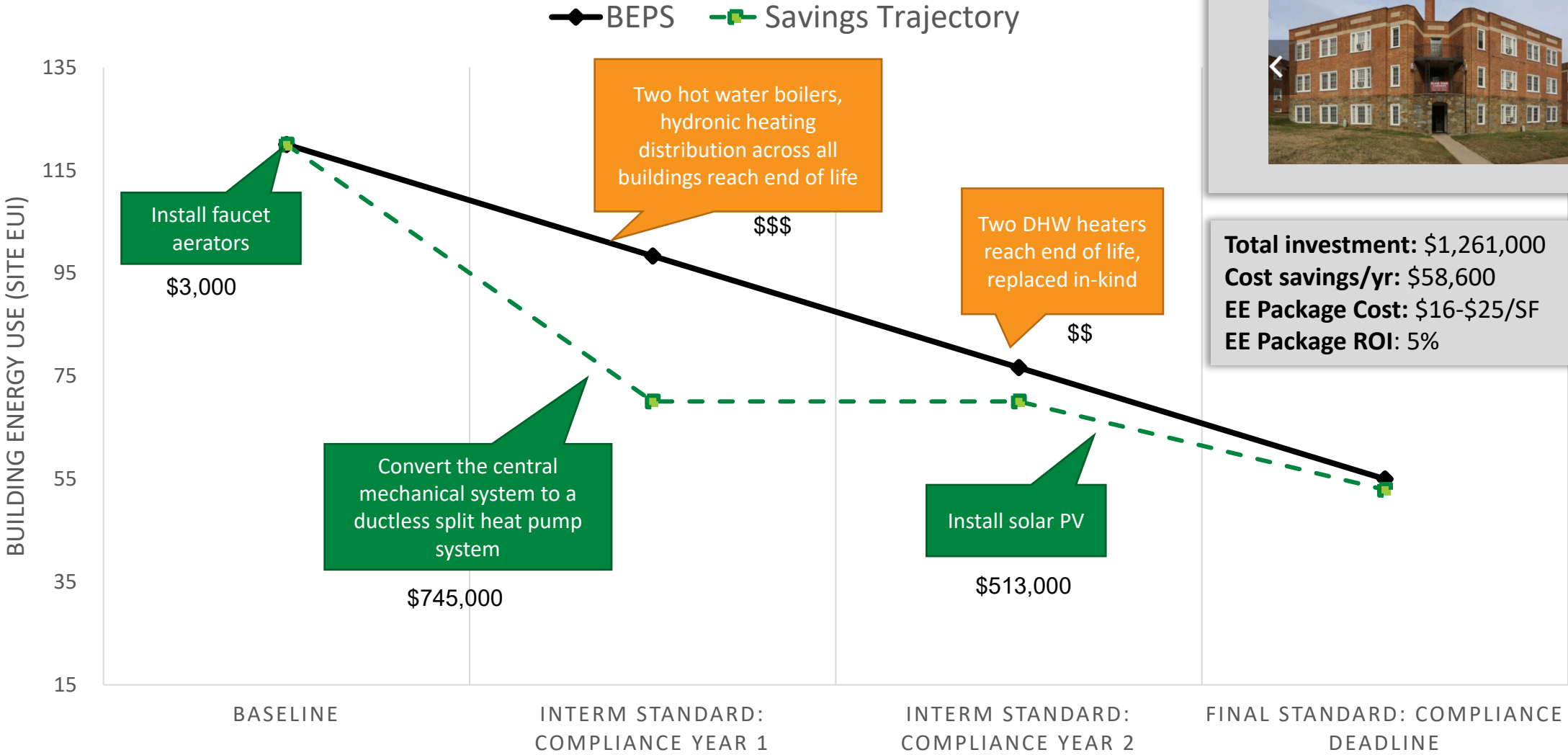
- **Case studies evaluated 9 buildings:**
  - 3 offices (class A, older mixed-fuel, older all-electric)
  - 3 multifamily buildings (new high-rise, old affordable high-rise, affordable garden-style)
  - 2 lodging (hotel with conference, standard hotel)
  - 1 worship facility
- **Desktop audits were performed to develop energy efficiency measure (EEM) packages:**
  - EE Target Package
  - ZNC Target Package
  - Less-than-Five-Year Payback Package
- **Each measure and package summarize total costs and savings to estimate:**
  - Site EUI and GHG reduction
  - Cost savings
  - Capital cost
  - Simple payback (in years)
  - Return on investment

# Case Study Example: Garden Style Multifamily, EE

**Building Information**  
 Square Footage: 50,000 – 75,000 SF  
 Year Built: 1950 – 1955  
 2019 Site EUI (kBtu/SF): 120



**Total investment: \$1,261,000**  
**Cost savings/yr: \$58,600**  
**EE Package Cost: \$16-\$25/SF**  
**EE Package ROI: 5%**

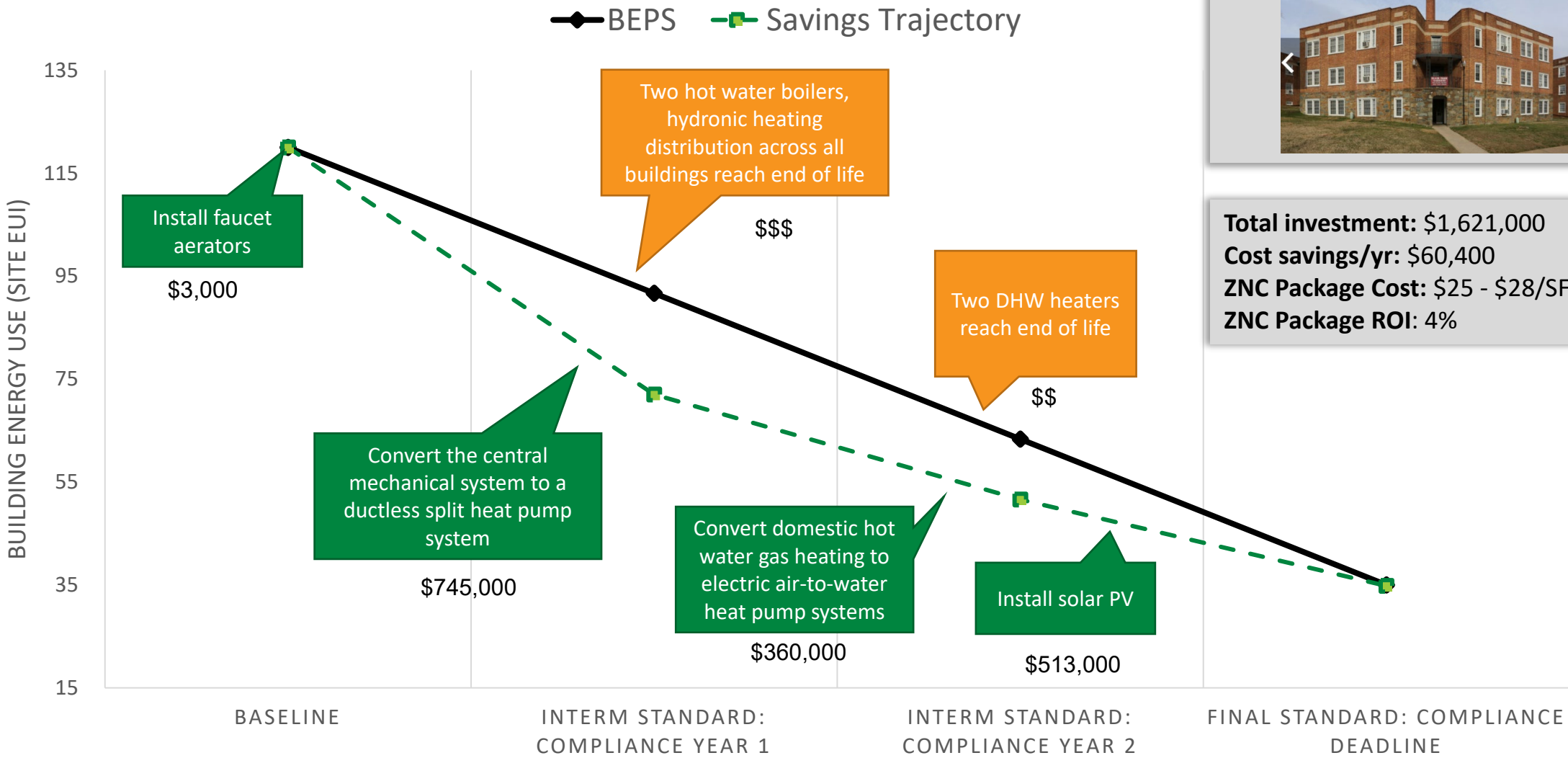


# Case Study Example: Garden Style Multifamily, ZNC

**Building Information**  
 Square Footage: 50,000 – 75,000 SF  
 Year Built: 1950 – 1955  
 2019 Site EUI (kBtu/SF): 120



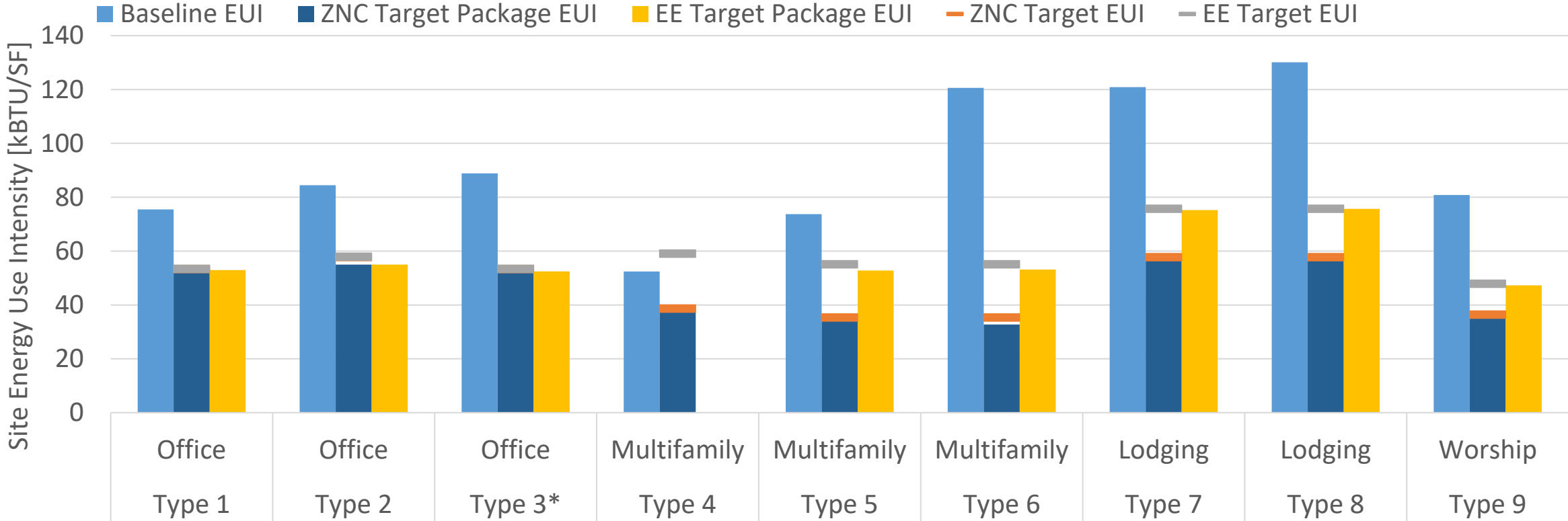
**Total investment: \$1,621,000**  
**Cost savings/yr: \$60,400**  
**ZNC Package Cost: \$25 - \$28/SF**  
**ZNC Package ROI: 4%**



# Impact: Case Study Buildings – Technical Feasibility

- In all case studies, the ZNC target was technically achievable with existing technology and systems through a combination of energy efficiency, electrification, and on-site solar PV
- Targets are technically achievable using today’s technology

Case Study Energy Use Intensity (EUI) Targets and Impact of Packages



# Case Study Buildings – Costs/Benefit Terminology

- **Cost per square foot** = total cost of all efficiency measures in the target package over the course of the BEPS compliance period divided by gross floor area
  - Costs = full cost of new system, not incremental cost above standard replacement.
  - Most major in-building equipment (i.e., mechanical equipment) is likely to be replaced prior to 2035. This creates a lower “effective” cost of compliance, but baseline capital costs are highly building dependent. Baseline capital cost outlay, financial incentives, and financing are not included in this report.
- **Savings per square foot** = total **annual** savings from all efficiency measures in the target package divided by gross floor area
- **Simple payback** = total project cost divided by the energy cost savings per year
  - Equates to the number of years until the annual cost savings “pay back” the up-front investment
- **Return on Investment (ROI)** = energy cost savings per year divided by the total cost, converted to a percentage
  - Equates to the percentage return of a particular investment.

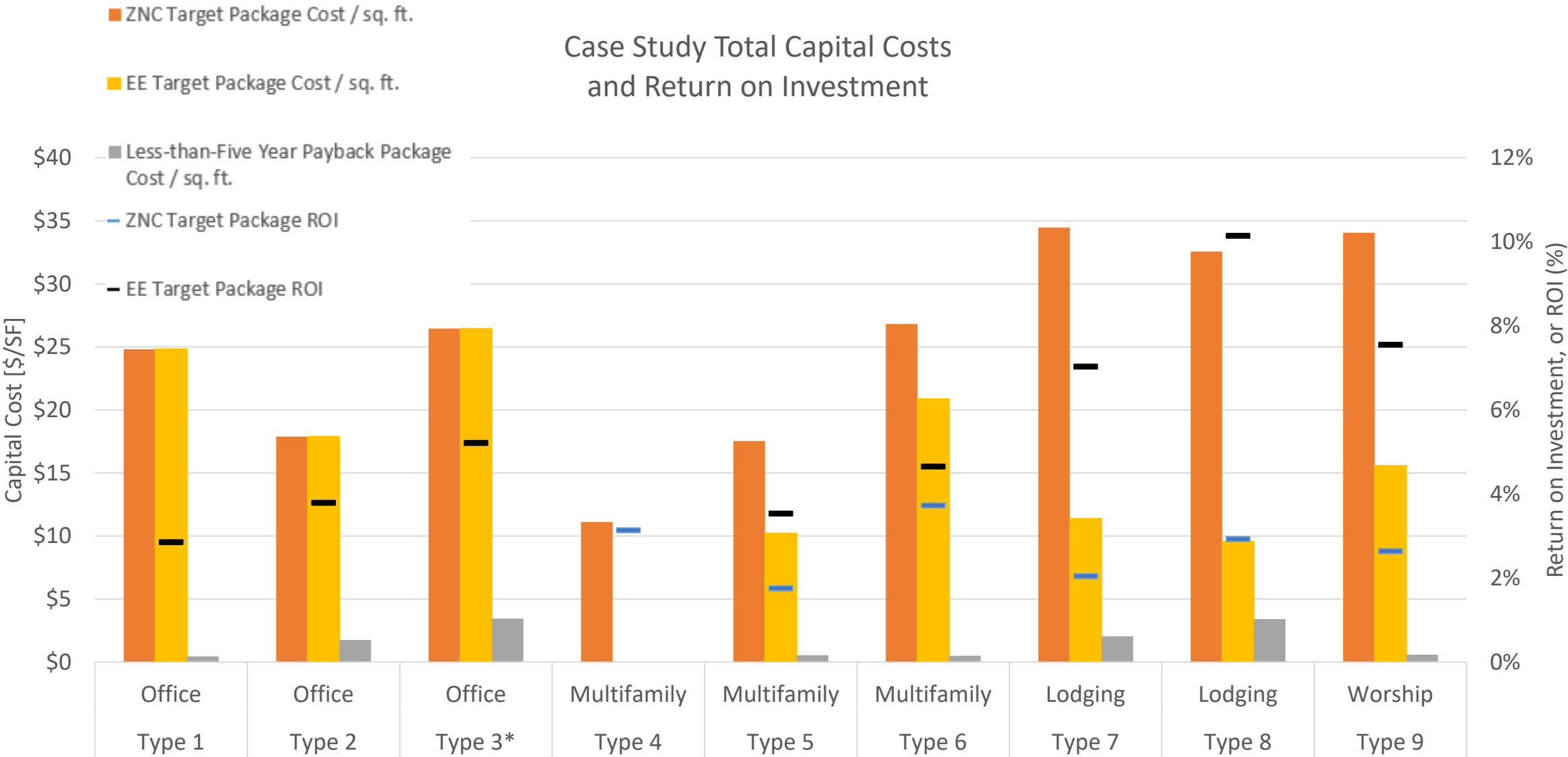


# Impact: Case Study Buildings – Costs/Benefits

- The ZNC target packages delivered a positive return on investment for all case-study buildings
- The EE target packages generally offered a stronger ROI compared to the ZNC target packages due to the less intensive energy savings required.
- Costs = full cost of new systems over whole BEPS period, not incremental cost above standard replacement.

|                                | EE                                        | ZNC                                       |
|--------------------------------|-------------------------------------------|-------------------------------------------|
| Cost* per square foot          | \$10 - \$26<br><b>Average: \$17</b>       | \$11 - \$34<br><b>Average: \$25</b>       |
| Annual savings per square foot | \$0.30 - \$1.40<br><b>Average: \$0.90</b> | \$0.30 - \$1.50<br><b>Average: \$0.77</b> |
| Simple Payback                 | 13 – 35 years<br><b>Average: 24 years</b> | 19 – 57 years<br><b>Average: 32 years</b> |
| Return on Investment           | 3% – 10%<br><b>Average: 6%</b>            | 2% – 5%<br><b>Average: 3%</b>             |

# Impact: Case Study Buildings – Costs/Benefits by Building



# BEPS Technical Analysis Conclusions

- The most aggressive BEPS standard (**ZNC**) is **technically achievable with market-available technology**
- **Any BEPS target is better than no target:** Both EE and ZNC target approaches will produce GHG emission reductions compared to a business-as-usual scenario
- As BEPS targets become more stringent, ways for buildings to reach BEPS standards become more limited and increasingly expensive:
  - **EE targets** permit some fossil-fuel uses to remain, delaying deepest GHG emissions reductions, but can be achieved via a wider range efficiency measures and/or electrification of select end uses
  - **ZNC targets** requires fuel-switching/electrification in most building types with fossil-fuel based systems, which yields higher up-front costs and potentially longer payback, but gets the County closer to its 2035 climate goals
- Choosing where to set the targets should consider the impact to highly fossil-fuel-dependent buildings
  - EE and ZNC targets for some building types where the typical building is already all-electric
  - The difference between targets is large for building types that have greater use of fossil-fuel systems, such as multifamily and lodging (e.g., hotels, motels).