MEMORANDUM

Pacific Northwest NATIONAL LABORATORY

Date:	**7/18/2024**		
To:	**City of Alexandria, Virginia; Office of Climate Action, City Manager Office**	Information Release #	**PNNL-SA-200796**
From:	**Kim Cheslak**		
Subject:	**Data and Analysis for Alexandria Target Setting**		

The City of Alexandria, Virginia (Alexandria) is in the process of updating their Green Building Policy to increase energy efficiency amongst other items. Currently Alexandria is enforcing the Virginia Commercial Energy Code, based on ASHRAE Standard 90.1-2019 and the International Energy Conservation Code (IECC) 2021. The Office of Climate Action in the City Manager's Office requested a review of existing building data to understand how to set more stringent energy use intensity (EUI) targets that would still be achievable, with a focus on commercial office and multifamily buildings. Because Alexandria has limited benchmarking data, Pacific Northwest National Laboratory (PNNL) pulled data from comparable sources to serve as a reasonable proxy for what would be achievable within Alexandria.

In coordination with the City, PNNL reviewed the following datasets to inform Alexandria staff in their decision making:

1. Existing building data for the Commonwealth of Virginia from EnergyStar Portfolio Manager Data Explorer.[1]
2. Local benchmarking data from Washington, DC and Montgomery County, MD.[2,3]
3. Simulation based building energy results for ASHRAE Standard 90.1-2022 that illustrate the range of EUIs that would be expected from buildings complying with the prescriptive path (variability study) and the EUI for the "standard prototype" for each building type. The "standard prototype" for each building prototype is a configuration, as selected by the ASHRAE 90.1 committee, intended to represent good, standard design options.
4. EUIs for the standard prototypes for the current and previous VA commercial energy codes based on 90.1-2019/IECC 2021 and 90.1-2016/IECC 2018 respectively.[4]

[1] Downloaded from EnergyStar Portfolio Data Explorer https://www.energystar.gov/buildings/resources-topic/portfolio-manager-data-explorer on May 15, 2024. Use of this dataset is not to be confused with EnergyStar Certification. An overview of the dataset and technical explanation for the tool can be found online. https://www.energystar.gov/sites/default/files/tools/Data%20Explorer%20Technical%20Reference%20Final%2010202023_508.pdf

[2] Data from Washington DC was downloaded from OpenData DC https://opendata.dc.gov/ on May 15, 2024.

[3] Data from Montgomery County, MD was received from MoCo DEP on May 8, 2024.

[4] Virginia updated to ASHRAE 90.1-2019/IECC 2021 with an effective date of Jan. 18, 2024.

This memo serves as a written record of the review of the energy data (presented as site EUI) and high-level estimated cost impacts.

Review of Data Sets

The Office of Climate Action in the City Manager's Office requested a focus on commercial office and multifamily buildings. As part of the U.S. Department of Energy established methodology, prototype buildings are established to simulate energy savings associated with changes in energy codes and standards. This methodology is used to evaluate published versions of the code, as well as in developing proposed code changes.[5,6] Three prototype buildings and their associated data and analysis are used in this analysis: Medium Office, Midrise Multifamily, and Highrise Multifamily building.

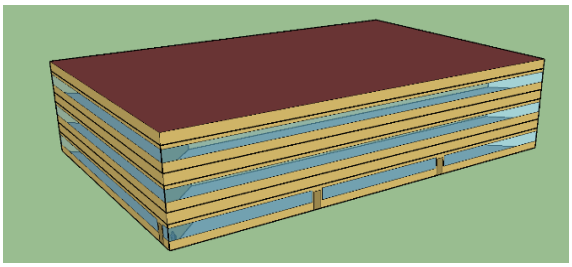

Figure 1. PNNL Medium Office Prototype

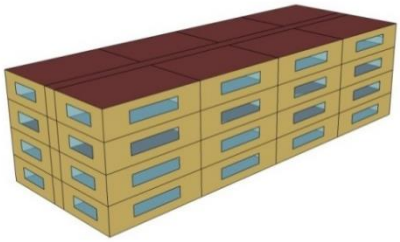

Figure 2. PNNL Midrise Multifamily Prototype

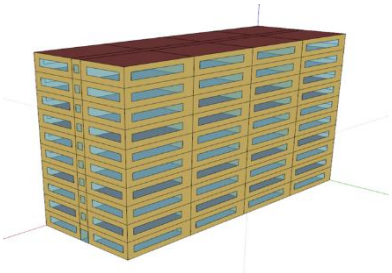

Figure 3. PNNL Highrise Multifamily Prototype

[5] https://www.energycodes.gov/prototype-building-models
[6] https://www.energycodes.gov/methodology

EnergyStar Data Explorer
The EnergyStar dataset is retrieved for data year 2022 to review buildings in the Commonwealth of Virginia using EnergyStar Portfolio Manager's Data Explorer tool. Data is reviewed by property type, year of construction and percentile of performance, focusing on the top 25% and median property performance values using Site EUI as the basis. The exact size of this dataset is unknown, as Data Explorer provides a range for the "Property Count". Where property counts in any category are less than five, Data Explorer does not provide EUIs.

To approximate a medium office building for comparison, the office building type is limited to gross floor area of 25,000 to 199,999 sq.ft. and are further limited to exclude veterinary offices (an EnergyStar defined sub-type in the office category). Office buildings are not limited by hours of operation. Table 1 presents the Data Explorer data for "medium office" as described.

Table 1. Medium Office Dataset (Site EUI)

Type	Year Built	25%	Median	Property Count
Office	All Years	46.8	57.6	250-500
Office	Before 1946	51.3	70.3	6-29
Office	1946-1959	-	-	<5
Office	1960-1979	49.4	62.9	30-49
Office	1980-1999	47.0	56.8	100-249
Office	2000-2009	46.9	56.8	50-99
Office	2010 and after	41.1	60.0	6-29

To approximate a midrise multifamily building for comparison, the multifamily buildings are pulled from the Lodging/residential property type by selecting the inclusion of only the multifamily subtype. Gross floor area is limited to 5,000 to 199,999 sq.ft. Table 2 presents the Data Explorer data for "midrise multifamily" as described.

Table 2. Midrise Multifamily Dataset (Site EUI)

Type	Year Built	25%	Median	Property Count
Multifamily MR	All Years	27.6	32.6	100-249
Multifamily MR	Before 1946	-	-	<5
Multifamily MR	1946-1959	-	-	<5
Multifamily MR	1960-1979	34.2	38.3	6-29
Multifamily MR	1980-1999	29.1	33.1	6-29
Multifamily MR	2000-2009	27.6	32.2	30-49
Multifamily MR	2010 and after	26.2	31.5	6-29

To approximate a highrise multifamily building for comparison highrise multifamily buildings are pulled from the lodging/residential property type by selecting the inclusion of only the multifamily

subtype. Gross floor area is limited to >200,000 sqft. Table 3 presents the Data Explorer data for “highrise multifamily” as described.

Table 3. Highrise Multifamily Dataset (Site EUI)

Type	Year Built	25%	Median	Property Count
Multifamily HR	All Years	23.3	31.8	100-249
Multifamily HR	Before 1946	-	-	<5
Multifamily HR	1946-1959	-	-	<5
Multifamily HR	1960-1979	41.5	55.7	50-99
Multifamily HR	1980-1999	24.3	34.0	50-99
Multifamily HR	2000-2009	24.6	31.4	30-49
Multifamily HR	2010 and after	21.2	25.1	50-99

Local Benchmarking

Benchmarking data from Washington, DC and Montgomery County, MD are combined to review the metered energy performance of buildings in the Alexandria region. This data set is considered a reasonable proxy due to the geographic proximity to Alexandria, as well as a large overlap in construction practices and professionals. Data is sorted into categories by building type and year of construction, using the same parameters applied to the EnergyStar data set. Building type selection focuses on primary property type and does not account for additional property types in the buildings. Table 4 presents the local benchmarking data for “medium office,” “midrise multifamily,” and “highrise multifamily” as previously described.

Table 4. Local Benchmarking Dataset (Site EUI)

Type	Year Built	25%	Median	Property Count
Office	All Years	34.5	53.2	534
Office	Before 1946	27.3	48.2	91
Office	1946-1959	33.2	53.9	56
Office	1960-1979	38.6	56.4	152
Office	1980-1999	33.7	51.9	137
Office	2000-2009	35.4	61.3	47
Office	2010 and after	30.9	47.5	51
Multifamily MR	All Years	30.7	54.1	1,363
Multifamily MR	Before 1946	31.0	54.8	551
Multifamily MR	1946-1959	38.7	63.3	176
Multifamily MR	1960-1979	35.2	60.3	236
Multifamily MR	1980-1999	29.6	47.6	77

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Type	Year Built	25%	Median	Property Count
Multifamily MR	2000-2009	32.8	47.2	141
Multifamily MR	2010 and after	29.4	42.8	169
Multifamily HR	All Years	33.9	52.8	428
Multifamily HR	Before 1946	40.3	56.9	49
Multifamily HR	1946-1959	40.3	56.3	46
Multifamily HR	1960-1979	36.7	61.5	97
Multifamily HR	1980-1999	32.2	42.8	17
Multifamily HR	2000-2009	35.5	51.0	64
Multifamily HR	2010 and after	30.9	46.7	153

Simulation Based Analysis

Alexandria, VA is located in ASHRAE climate zone (CZ) 4A. Simulation based building energy results for ASHRAE Standard 90.1-2022 (the most recent model commercial energy code) and 90.1-2019/IECC 2021 (the current code adopted in Virginia and Alexandria) for CZ 4A are used to understand the expected site energy use of new construction buildings built to code.

Results for both the medium office and midrise multifamily buildings are shown based on the following available simulation analyses:

1. ASHRAE Standard 90.1-2016/IECC 2018 standard prototype simulation result, specific to the previous adopted code in Virginia,
2. ASHRAE Standard 90.1-2019/IECC 2021 standard prototype simulation result, specific to the current adopted code in Virginia,
3. ASHRAE Standard 90.1-2022 standard prototype simulation result for CZ 4A,
4. ASHRAE Standard 90.1-2022 study of expected prescriptive variability for CZ 4A.

Results for highrise multifamily buildings are shown based on the following available simulation analyses:

1. ASHRAE Standard 90.1-2016/IECC 2018 standard prototype simulation result, specific to the previous adopted code in Virginia,
2. ASHRAE Standard 90.1-2019/IECC 2021 standard prototype simulation result, specific to the current adopted code in Virginia,
3. ASHRAE Standard 90.1-2022 standard prototype simulation result for CZ 4A.

Table 5. Simulation Based Analysis (Site EUI)

Type	VA 90.1-2016/ 2018 IECC	VA 90.1-2019/ 2021 IECC	90.1-2022	90.1-2022 Variability
Office	31.2	29.0	25.3	21.0 – 31.0
Multifamily MR	37.7	29.9	34.4	25.0 - 44.0
Multifamily HR	40.3	33.6	40.0[a]	Not Available

a. Current analysis for Multifamily HR is based on national data and is not available for CZ4A only.

The DOE methodology uses whole-building energy simulation to assess energy use impacts of code changes. The DOE methodology is based on 16 representative building types across all U.S. climate zones, as defined by Standard 90.1. Energy use intensities (EUIs) by fuel type and by end-use are developed for each building type and weighted by the relative square footage to estimate the difference between the aggregated national energy use under the previous code version, which serves as the baseline, and the new code or standard.

This methodology is also applied to the state level. The state level analysis uses six building types represented by six prototype building energy models. These models represent the energy impact of five of the eight commercial principal building activities that account for 74% of the new construction by floor area covered by the full suite of 16 prototypes. The prototypes represent common construction practice and include the primary conventional HVAC systems most used in commercial buildings. Each prototype building is analyzed for each climate zone found within a state. Using the U.S. DOE EnergyPlus software, the six building prototypes summarized are simulated with characteristics meeting the requirements of the current code and then modified to meet the requirements of the next edition of the code. The energy use and energy cost are then compared between the two sets of models.

Actual and Expected Performance of Office and Multifamily Buildings

The described datasets are combined to graphically present the data to inform city staff and decision makers in their effort to update the Alexandria Green Building Policy.

Medium office building site EUI data is shown in Figure 3 from these previously described data sources:

1. **EnergyStar Portfolio Manager Data Explorer**. For Data Explorer existing building data, the year groupings are limited by the way data is presented making the most recent group data including 2010-2022. This group is used as a proxy for new construction because it is the most recent year grouping that is provided in Data Explorer. The single value shown is the average EUI of the top 25% of performers in the Commonwealth of Virginia. Shown as a vertical dashed red line.
2. **Local benchmarking data:** For local benchmarking data (from Washington, DC and Montgomery County, MD), the single value shown is the average EUI of the top 25% of performers for buildings constructed after 2010. The year 2010 was used in order to align with the vintage of the Data Explorer data. Shown as a vertical dashed red line.
3. **90.1-2022 prescriptive variability data**: Simulation based building energy results for ASHRAE Standard 90.1-2022 that illustrate the range of EUIs that would be expected from buildings complying with the prescriptive path. This analysis limited to climate zone 4A, the only CZ in the Commonwealth of Virginia. Shown as a histogram (orange bars) illustrating model counts by site EUI bins from PNNL analysis of the Medium Office prototype in climate zone 4A for all model design variants. Each model design variant is minimally compliant with the prescriptive requirements of AHSHRAE Standard 90.1-2022.

4. **90.1-2022 CZ4A standard prototype**: This reference EUI value is the prototype building with typical HVAC systems. Shown as a vertical dashed red line.
5. **Analysis of the Virginia specific adoption of 90.1-2016/IECC 2018 and 90.1-2019/IECC 2021**: These reference EUI values represent the Virginia specific adoption of 90.1-2016/IECC 2018 and 90.1-2019/IECC 2021. This analysis is specific to Virginia only and only considers at the standard prototype application of the adopted code versions. Shown as a vertical dashed red line.

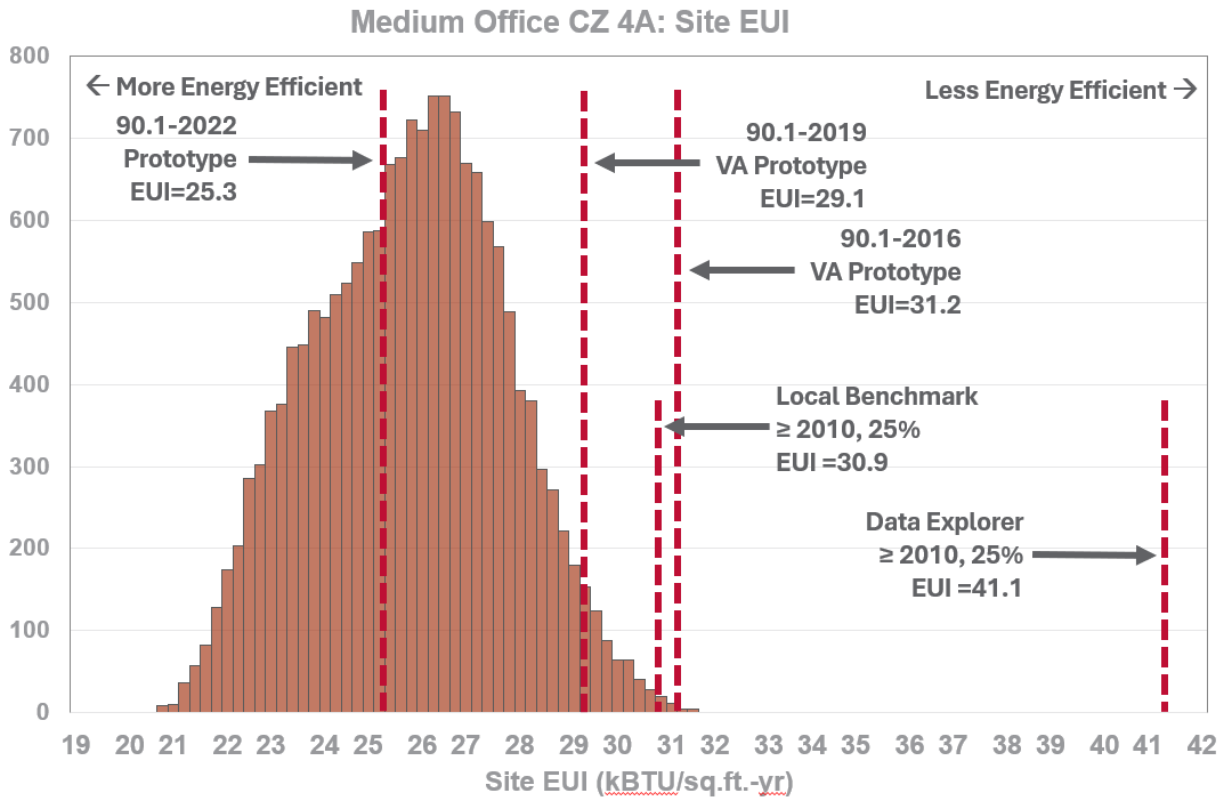

Figure 4. Medium Office Site EUI (kBtu/sq.ft.-yr) from Various Data Sources.

Comparing the local benchmarking data for recently constructed local office buildings with simulated performance data for the Standard 90.1-2022 Medium Office prototype:

- 7.8% of the benchmarked buildings report energy performance that is better than the 90.1-2022 standard prototype for Medium Office.
- 11.8% of the benchmarked buildings report energy performance that falls within the predicted range of energy performance for Medium Office buildings compliant with the prescriptive path of 90.1-2022.

The Midrise multifamily building site EUI data is shown in Figure 5 from the previously described data sets. The Virginia 90.1-2016/IECC 2018 Mid-rise Apartment standard prototype shows the highest site EUI at 37.7, stepping down to data from Data Explorer showing the lowest EUI at 27.3.

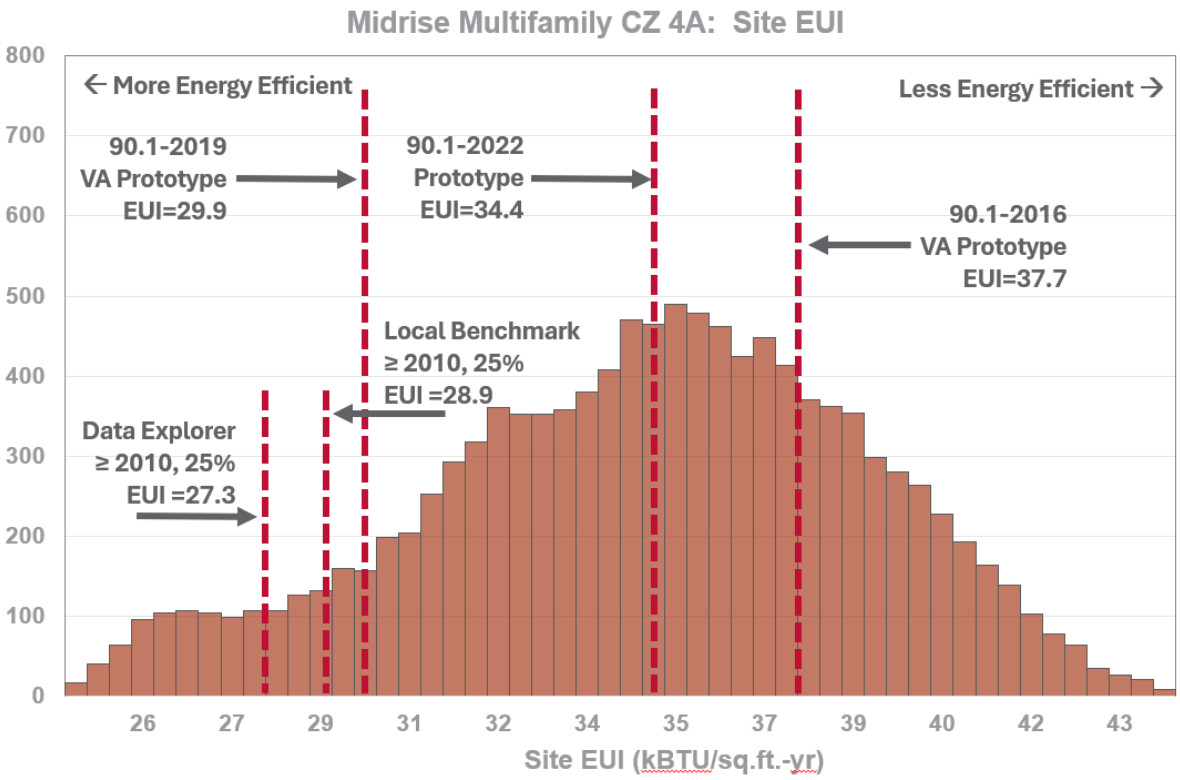

Figure 5. Midrise Multifamily Site EUI (kBtu/sq.ft.-yr) from Various Data Sources

Comparing the local benchmarking data for recently constructed local multifamily buildings with simulated performance data for the Standard 90.1-2022 midrise apartment prototype:

- 29.6% of the benchmarked buildings report energy performance that is better than the 90.1-2022 standard prototype for midrise apartment.
- 67.3% of the benchmarked buildings report energy performance that falls within the predicted range of energy performance for midrise apartment buildings compliant with the prescriptive path of 90.1-2022.

The highrise multifamily building site EUI data is shown in Figure 6, from the previously described data sources, excluding the prescriptive variability study data (which is not currently available for this building type). The Virginia 90.1-2016/IECC 2018 standard prototype shows the highest site EUI at 40.3, stepping down to data from Data Explorer showing the lowest site EUI at 21.2.

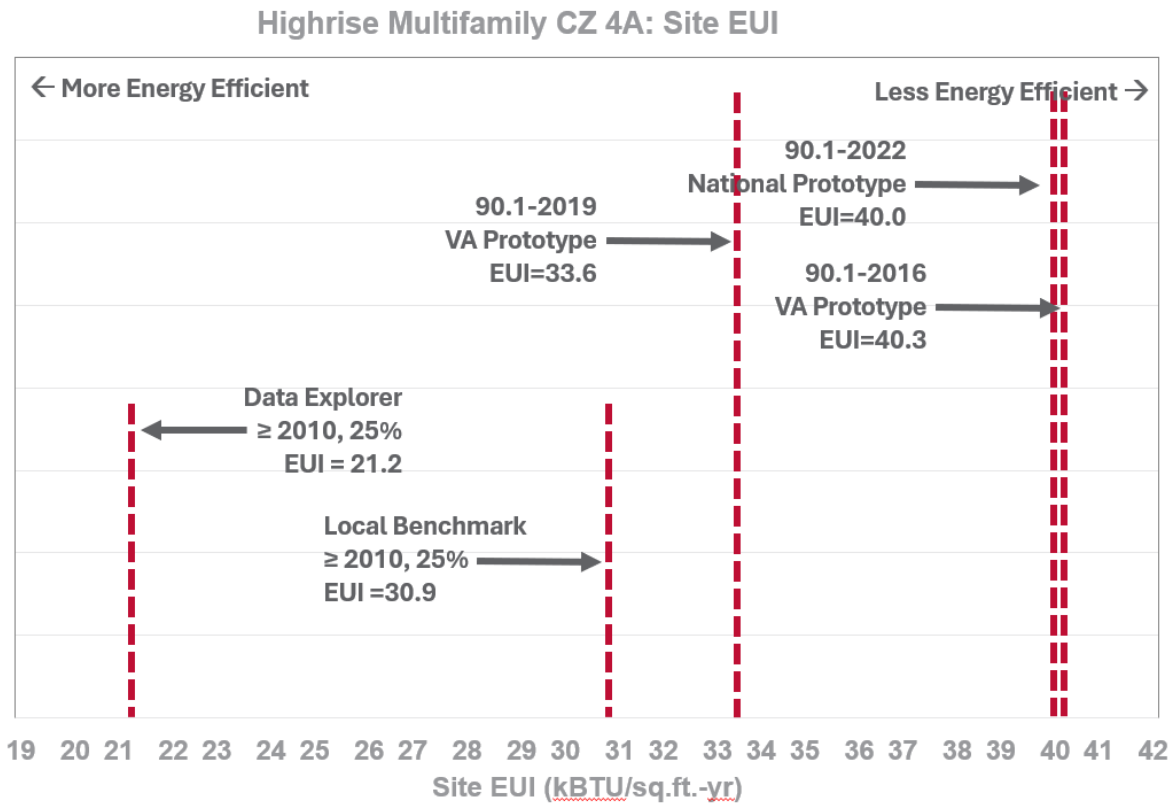

Figure 6. Highrise Multifamily Site EUI (kBtu/sq.ft.-yr) from Various Data Sources

Comparing the local benchmarking data for recently constructed local multifamily buildings with simulated performance data for the Standard 90.1-2022 highrise apartment prototype:

- 33.3% of the benchmarked buildings report energy performance that is better than the 90.1-2022 standard prototype for midrise apartment.

Cost Impacts

Analysis completed for the Commonwealth of Virginia shows that moving from ASHRAE Standard 90.1-2016 to ASHRAE Standard 90.1-2019 is not only cost-effective for Virginia, it also results in lower first costs for new commercial construction.[7] Construction completed in accordance with Standard 90.1-2019 will provide an annual energy cost savings of $0.037 per square foot and reduce first costs by $1.007 per square foot on average across the state.

[7] Cost-Effectiveness of ANSI/ASHRAE/IES Standard 90.1-2019 for Virginia, PNNL-31535. https://www.energycodes.gov/sites/default/files/2021-07/Cost-effectiveness_of_ASHRAE_Standard_90-1-2019-Virginia.pdf

Tables 6 through 8 below show the expected impact of the recent update to Standard 90.1-2019 from a consumer perspective and statewide perspective. The methodology used for this analysis is consistent with the methodology used in the national cost effectiveness analysis.

Table 6. Consumer Impact of 90.1-2019, Commonwealth of Virginia, Statewide

Annual (first year) energy cost savings, $/ft2	$0.037
Added construction cost, $/ft2	-$1.007

Table 7 shows the economic impact of upgrading to Standard 90.1-2019 by building type in Virginia's CZ4A in terms of the annual energy cost savings in dollars per square foot. The annual energy cost savings across CZ4A.

Table 7. Annual Energy Cost Savings for Virginia CZ4A ($/ft^2)

Annual (first year) energy cost savings, $/ft2 (all types)	$0.034
Small Office	$0.032
Large Office	$0.042
Midrise Multifamily	$0.013

Table 8 shows incremental initial cost for individual building types in Virginia's CZ4A and weighted average costs by building type for moving to Standard 90.1- 2019 from Standard 90.1-2016. The incremental construction costs show a negative, or reduction, in first costs across key building types in CZ4A amounting to an immediate payback for building owners.

Table 8. Incremental Construction Cost for Virginia CZ4A ($/ft^2)

Added construction cost, $/ft2	-$1.021
Small Office	-$1.642
Large Office	-$1.926
Midrise Multifamily	-$0.338

Based on the results of the national technical analysis to quantify expected energy savings from Standard 90.1-2022[8], PNNL can estimate that moving from the current energy requirements to updated energy requirements for the Green Building Policy in line with ASHRAE Standard 90.1-2022 would result in an estimated savings of 10.4% for site energy and 9.8% for energy cost in the Commonwealth of Virginia, based on overall savings expected by climate zone.

[8] Details of the analysis, including specific details on amendments with energy impact can be found in the ANSI/ASHRAE/IES Standard 90.1- 2022: Energy Savings Analysis.
https://www.energycodes.gov/sites/default/files/2024-02/Standard_90.1-2022_Final_Determination_TSD.pdf

Additionally, the estimated percent gross energy savings nationally between 2019 and 2022 editions of Standard 90.1 by building type (excluding the impact of on-site energy generation) for the building types presented in this memo are presented in Table 9.

Table 9. Estimated Percent Gross Energy Savings between 2019 and 2022 Editions of Standard 90.1 – for Medium Office, Midrise and Highrise Multifamily

		Savings	
Building Type	***Prototype Building***	***Site EUI***	***Energy Cost Index***
Office	Medium Office	10.7%	11.8%
Apartment	Midrise Multifamily	9.7%	9.0%
	Highrise Multifamily	11.7%	10.3%

PNNL expects that state specific analysis will be complete later in calendar year 2024 that will provide a Virginia specific analysis on the updated standard.

Disclaimer for DOE Technical Analysis

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