Hearing Docket No.: 2019-R-CCE-0020

Exhibit No.: 6

MEMORANDUM

Pacific Northwest NATIONAL LABORATORY

Date: **10/2/2019**

To: **Jessica Quinn**

From: **Matthew Tyler**

Information Release # **PNNL-SA-147982**

Subject: **Preliminary Cost-Effectiveness of ASHRAE Standard 90.1-2016 for the State of Delaware**

Moving to the ASHRAE Standard 90.1-2016 edition from Standard 90.1-2013 is expected to be cost-effective for the State of Delaware. This assessment of cost-effectiveness is based on expected changes in construction cost and estimated energy savings from building energy simulations.

The cost-effectiveness analysis uses six building types represented by six prototype building energy models: small office, large office, standalone retail, primary school, small hotel, and mid-rise apartment.[1]

Climate zones are defined in ASHRAE Standard 169, with the hottest being climate zone 0 and the coldest being climate zone 8. Letters A, B, and C are applied in some cases to denote the level of moisture, with A indicating moist or humid, B indicating dry, and C indicating marine. Delaware contains just one climate zone—Climate Zone 4A.

Life Cycle Cost (LCC) savings is the primary measure DOE uses to assess the economic impact of building energy codes. Net LCC savings is the calculation of the present value of energy savings minus the present value of non-energy incremental costs over a 30-year period. The costs include initial equipment and construction costs, maintenance and replacement costs, less the residual value of components at the end of the 30-year period. When net LCC is positive, the updated code edition is considered cost-effective.

Two LCC scenarios[2] are analyzed with the inputs shown in Table 1 and the differences are outlined here:

- Scenario 1: represents publicly-owned buildings, considers initial costs, energy costs, maintenance costs, and replacement costs without borrowing or taxes. These LCC results per square foot are shown in Table 2 by building type and climate zone.
- Scenario 2: represents privately-owned buildings, adds borrowing costs (financing of the incremental first costs) and tax impacts (such as mortgage interest and depreciation deductions using corporate tax rates). These LCC results per square foot are shown in Table 3 by building type and climate zone.

[1] https://www.energycodes.gov/development/commercial/prototype_models
[2] https://www.energycodes.gov/commercial-energy-and-cost-analysis-methodology

The energy prices used in the analysis are:

- Electricity price: $0.0971/kWh
- Natural gas price: $1.0507/therm

These prices are the state average commercial energy costs for January 2018 through December 2018. This is a weighted average by monthly retail sales of electricity and natural gas for commercial buildings in Delaware. The prices and sales data are from the United States Energy Information Administration (EIA) *Electricity Power Monthly* and *Natural Gas Monthly*.[3,4]

Table 4 below shows the economic impact of upgrading to Standard 90.1-2016 by building type and climate zone in terms of the annual energy cost savings in dollars per square foot. Table 5 shows the additional construction cost per square foot required by the additional energy code requirements.

The added construction cost is negative for some building types, which represents a reduction in first costs and a savings that is included in the net LCC savings. This is due to the following:

- Fewer light fixtures are required when the allowed lighting power is reduced. Also changes from fluorescent to LED technology results in reduced lighting costs in many cases and longer lamp lives, requiring fewer lamp replacements.
- Smaller heating, ventilating, and air-conditioning (HVAC) equipment sizes can result from the lowering of heating and cooling loads due to other efficiency measures, such as better envelope. For example, Standard 90.1-2016 has more stringent fenestration U-factors for Climate Zone 4A. This results in smaller equipment and distribution systems, resulting in a smaller first cost and in some cases a negative first cost.

Table 1. Economic Analysis Parameters

Economic Parameter	Scenario 1	Scenario 2
Study Period – Years	30	30
Nominal Discount Rate	3.10%	6.00%
Real Discount Rate	3.00%	4.05%
Inflation	-0.20%	1.87%
Electricity Price, per kWh	$0.0971	$0.0971
Natural Gas Price, per therm	$1.0507	$1.0507
Electricity and Natural Gas Price Escalation	Uniform present value factors Electric 21.94, Gas 23.69	Uniform present value factors Electric 16.16, Gas 17.45
Loan Interest Rate	NA	6.00%
Federal Corporate Tax Rate	NA	21.00%
State Corporate Tax Rate	NA	8.70%

[3] https://www.eia.gov/electricity/monthly/
[4] https://www.eia.gov/naturalgas/monthly/

Table 2. Net LCC Savings, Scenario 1 ($/ft^2)

Climate Zone	Small Office	Large Office	Stand-Alone Retail	Primary School	Small Hotel	Mid-Rise Apartment
4A	$1.99	$1.50	$12.81	$4.23	$6.00	$2.44

Table 3. Net LCC Savings, Scenario 2 ($/ft^2)

Climate Zone	Small Office	Large Office	Stand-Alone Retail	Primary School	Small Hotel	Mid-Rise Apartment
4A	$1.45	$1.06	$10.83	$3.26	$4.74	$1.96

Table 4. Annual Energy Cost Savings ($/ft^2)

Climate Zone	Small Office	Large Office	Stand-Alone Retail	Primary School	Small Hotel	Mid-Rise Apartment
4A	$0.095	$0.084	$0.140	$0.144	$0.156	$0.049

Table 5. Incremental Construction Cost ($/ft^2)

Climate Zone	Small Office	Large Office	Stand-Alone Retail	Primary School	Small Hotel	Mid-Rise Apartment
4A	$0.266	$0.218	$0.888	($1.584)	($2.463)	($0.660)

Note: The large reduction in construction cost in primary schools and small hotels is mostly due to the extended life of LED lamps vs. fluorescent lamps in the baseline.