B-21: Resubmitted on 12/12/23 for consideration with formatted review aid requested by the Rules Review Commission of the NC Office of Administrative Hearings.

NORTH CAROLINA BUILDING CODE COUNCIL

N.C. Gen. Stat. § 143-138(a1)(2) COST-BENEFIT ANALYSIS

FOR

Request from NC Building Code Council Energy Standing Committee to adopt the 2024 edition of the North Carolina Energy Conservation Code as presented by the Committee.

(Item B-6, Approved March 14, 2023)

Proposed Amendment: https://www.ncosfm.gov/b-6-2024-ncecc-0/open

2021 International Energy Conservation Code:
https://codes.iccsafe.org/content/IECC2021P2

Pursuant to N.C. Gen. Stat. § 143-138(a1)(2), the following cost-benefit analyses were conducted by the U.S. Department of Energy, Pacific Northwest National Laboratory at the request of the North Carolina Building Code Council to determine the cost-effectiveness of the adoption of the proposed 2024 edition of the North Carolina Energy Conservation Code compared to the present 2018 edition of the North Carolina Energy Conservation Code.

Appendix A:
Cost-Effectiveness of Proposed 2024 North Carolina Energy Conservation Code, Matthew Tyler
U.S. Department of Energy, Pacific Northwest National Laboratory
March 22, 2023

Appendix B:
Cost-Effectiveness Analysis of the 2024 North Carolina Energy Conservation Code, Vrushali Mendon, Rob Salcido, and YuLong Xie
U.S. Department of Energy, Pacific Northwest National Laboratory
March 24, 2023

APPENDIX A

Cost-Effectiveness of Proposed 2024 North Carolina Energy Conservation Code

Prepared by Matthew Tyler

U.S. Department of Energy
Pacific Northwest National Laboratory
902 Batelle Boulevard
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March 22, 2023

MEMORANDUM

Pacific Northwest NATIONAL LABORATORY

Date:	**3/22/2023**		
To:	**North Carolina Building Code Council**	Information Release #	**PNNL-SA-180329**
From:	**Matthew Tyler**		
Subject:	**Cost-Effectiveness of Proposed 2024 North Carolina Energy Conservation Code**		

Moving to the proposed 2024 North Carolina Energy Conservation Code from the 2018 North Carolina Energy Conservation Code is expected to be cost-effective for North Carolina. This assessment of cost-effectiveness is based on expected changes in construction cost relative to energy cost savings. The analysis is based on six building prototypes[1] and three of the 16 climate zones in the United States.

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. Most of North Carolina is in climate zone 3A, the Blue Ridge Mountains are in climate zone 4A, and a few counties in the northwest corner are in climate zone 5A.

The analysis included the following six building prototypes: small office, large office, standalone retail, primary school, small hotel, and mid-rise apartment.

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, which is the case here.

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.

[1] https://www.energycodes.gov/prototype-building-models#Commercial
[2] https://www.energycodes.gov/methodology

- Scenario 2: represents privately-owned buildings, considers initial costs, energy costs, maintenance costs, replacement costs, 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.

The energy prices used in the analysis are:

- Electricity price: $0.0877/kWh
- Natural gas price: $0.8800/therm

These prices are the state average commercial energy costs. This is a weighted average by monthly retail sales of electricity and natural gas for commercial buildings in North Carolina. 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 the 2024 Energy Conservation Code by building type 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, the 2024 Energy Conservation Code has more stringent envelope and fenestration U-factors. This results in smaller equipment and distribution systems, resulting in a negative first cost.

The state averages by building type and climate zone shown in Table 2 through Table 5 are weighted averages based on weightings shown in Table 6. These weighting factors are based on the floor area of new construction and major renovations for the six analyzed building prototypes.

Again, when net LCC is positive, the updated code edition is considered cost-effective, which is the case for all analyzed building types in Scenarios 1 and 2.

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

Table 1. Economic Analysis Parameters

Economic Parameter	Scenario 1	Scenario 2
Study Period – Years	30	30
Nominal Discount Rate	8.98%	8.98%
Real Discount Rate	7.00%	7.00%
Inflation	1.85%	1.85%
Electricity Price, per kWh	$0.0877	$0.0877
Natural Gas Price, per therm	$0.8800	$0.8800
Energy Price Escalation, uniform present value factors	Electric 19.17, Gas 23.45	Electric 19.17, Gas 23.45
Loan Interest Rate	NA	5.25%
Federal Corporate Tax Rate	NA	21.00%
State Corporate Tax Rate	NA	2.50%

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	All Building Types
3A	$3.78	$5.06	$6.32	$6.17	$11.76	$6.70	$6.16
4A	$4.13	$5.57	$5.54	$6.49	$11.54	$5.93	$6.00
5A	$3.59	$6.04	$5.73	$4.83	$11.15	$2.77	$5.18
State Average	$3.80	$5.06	$6.24	$6.18	$11.73	$6.64	**$6.15**

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	All Building Types
3A	$3.95	$4.44	$5.83	$5.11	$12.06	$6.44	$5.76
4A	$4.22	$4.75	$5.07	$5.50	$11.83	$5.89	$5.70
5A	$3.85	$5.16	$5.22	$4.50	$11.43	$2.63	$4.85
State Average	$3.97	$4.44	$5.75	$5.13	$12.02	$6.40	**$5.75**

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

Climate Zone	Small Office	Large Office	Stand-Alone Retail	Primary School	Small Hotel	Mid-Rise Apartment	All Building Types
3A	$0.176	$0.180	$0.242	$0.170	$0.240	$0.267	$0.227
4A	$0.184	$0.180	$0.204	$0.191	$0.227	$0.263	$0.220
5A	$0.181	$0.197	$0.215	$0.208	$0.231	$0.080	$0.189
State Average	$0.177	$0.180	$0.238	$0.172	$0.238	$0.266	**$0.226**

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

Climate Zone	Small Office	Large Office	Stand-Alone Retail	Primary School	Small Hotel	Mid-Rise Apartment	All Building Types
3A	$0.342	($1.275)	($0.993)	($2.137)	$0.603	($0.695)	($0.878)
4A	$0.183	($1.669)	($0.957)	($1.999)	$0.610	($0.255)	($0.651)
5A	$0.539	($1.805)	($1.037)	($0.670)	$0.572	($0.468)	($0.719)
State Average	$0.333	($1.276)	($0.991)	($2.117)	$0.604	($0.670)	**($0.863)**

Table 6. Construction Weights by Building Type

Climate Zone	Small Office	Large Office	Stand-Alone Retail	Primary School	Small Hotel	Mid-Rise Apartment	All Building Types
3A	10.0%	11.1%	24.3%	11.9%	2.6%	33.2%	93.1%
4A	0.7%	0.0%	2.3%	0.8%	0.4%	2.0%	6.2%
5A	0.0%	0.0%	0.4%	0.1%	0.0%	0.1%	0.7%
State Average	10.7%	11.1%	27.1%	12.8%	3.0%	35.3%	100.0%

APPENDIX B

Cost-Effectiveness Analysis of the 2024 North Carolina Energy Conservation Code

Prepared by Vrushali Mendon, Rob Salcido, and YuLong Xie

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March 24, 2023

MEMORANDUM

Pacific Northwest NATIONAL LABORATORY

Date:	**3/24/2023**		
To:	**Bridget Herring, North Carolina Building Code Council**	Information Release #	**PNNL-180509 Rev-1**
From:	**Vrushali Mendon, Rob Salcido, and YuLong Xie**		
Subject:	**Cost-Effectiveness Analysis of the 2024 North Carolina Energy Conservation Code**		

The State of North Carolina is in the process of updating their current residential energy code, the 2018 North Carolina Energy Conservation Code (NCECC) which is an amended version of the 2015 International Energy Conservation Code (IECC), to the 2024 NCECC, which is an amended version of the 2021 IECC. The Building Code Council of North Carolina requested an analysis on the energy, environmental, and economic impacts of the proposed code. To assess these impacts, PNNL analyzed the cost-effectiveness of adopting the 2024 NCECC compared to the 2018 NCECC.

Moving to the 2024 NCECC is cost-effective for both single-family and low-rise multifamily residential buildings when compared to the 2018 NCECC in North Carolina. The new code will provide energy cost savings of 18.7%. This equates to $399 of annual utility bill savings for the average North Carolina household as detailed in Table 1. Adopting the 2024 NCECC will also result in societal benefits such as cost savings and reduced greenhouse gas emissions. During the first year alone, North Carolina residents could expect to save over $15,372,000in energy costs and reduce CO_2 emissions by 130,700 metric tons, equivalent to the annual CO_2 emissions of nearly 29,000 cars on the road. Adopting the 2024 NCECC in North Carolina is expected to result in homes that are energy efficient, more affordable to own and operate, and based on newer industry standards for health, comfort, and resilience.

Table 1. Individual Consumer Impact[1]

Metric	Compared to the 2018 NCECC
Life-cycle cost savings of the 2024 NCECC	$2,319
Net annual consumer cash flow in year 1 of the 2024 NCECC [2]	$144
Annual (year 0) energy cost savings of the 2024 NCECC ($)[3]	$399
Annual energy cost savings of the 2024 NCECC (%)[4]	18.7%

Table 2. Societal Benefits

Statewide Impact	First Year	30 Years Cumulative
Energy cost savings, $	15,372,000	5,331,440,000
CO_2 emission reduction, Metric tons	130,700	65,815,000
CH_4 emissions reductions, Metric tons	9.4	4,700
N_2O emissions reductions, Metric tons	1.310	660
NOx emissions reductions, Metric tons	78.5	39,500
SOx emissions reductions, Metric tons	50.3	25,300

Table 3. Statewide Jobs Impact

Statewide Impact	First Year	30 Years Cumulative
Jobs Created Reduction in Utility Bills	755	22,500
Jobs Created Construction Related Activities	1,270	37,900
Total Jobs Created	2,025	60,400

Methodology

DOE's cost-effectiveness methodology evaluates 32 residential prototypes comprising two building types, four foundation types, and four HVAC types. The entire set is simulated with TMY3 weather data representing climate zone 3A, 3AWH, 4A and 5A in this analysis.

Construction cost differences between the 2024 NCECC and the 2018 NCECC were taken directly from DOE/PNNL reports on the cost-effectiveness of new code editions. National cost

[1] A weighted average is calculated across building configurations and climate zones.
[2] The annual cash flow is defined as the net difference between annual energy savings and annual cash outlays (mortgage payments, etc.), including all tax effects but excluding up-front costs (mortgage down payment, loan fees, etc.). First-year net cash flow is reported; subsequent years' cash flow will differ due to the effects of inflation and fuel price escalation, changing income tax effects as the mortgage interest payments decline, etc.
[3] Annual energy savings is reported at time zero, before any inflation or price escalations are considered.
[4] Annual energy savings is reported as a percentage of whole building energy use.

estimates were adjusted by a North Carolina-specific construction cost multiplier[5] and appropriate Consumer Price Index (CPI) multipliers[6] to bring costs into 2022 dollars.

Life Cycle Cost (LCC) savings is the primary measure DOE uses to assess the economic impact of building energy codes. LCC is the calculation of the present value of costs over a 30-year period including initial equipment and construction costs, energy savings, maintenance and replacement costs, and residual value of components at the end of the 30-year period. When the LCC of the updated code (e.g., the 2024 NCECC) is lower than that of the previous code (the 2018 NCECC), the updated code is considered cost-effective.

The energy savings from the simulation analysis are converted to energy cost savings using fuel prices found in Table 3. Fuel prices are escalated over the analysis period based on an escalation factor of 1.6% for all fuel types.

Table 3. Fuel Prices used in the Analysis

Electricity ($/kWh)	Gas ($/Therm)	Fuel Oil ($/MBtu)
0.116	1.253	2.422

The financial and economic parameters used in calculating the LCC and annual consumer cash flow are based on the latest DOE cost-effectiveness methodology.[7] The real discount rate is assumed to be 7.0% as requested by the State of North Carolina. The parameters are summarized in Table 4 for reference.

[5] https://www.energycodes.gov/sites/default/files/2021-11/Location_Factors_Report.pdf
[6] https://www.usinflationcalculator.com/inflation/consumer-price-index-and-annual-percent-changes-from-1913-to-2008/
[7] https://www.energycodes.gov/sites/default/files/2021-07/residential_methodology_2015.pdf

Table 4. Economic Parameters Used in the Analysis

Parameter	Value
Mortgage interest rate (fixed rate)	5%
Loan fees	0.6% of mortgage amount
Loan term	30 years
Down payment	10% of home value
Real discount rate[8]	7.0%
Inflation rate	1.6%
Marginal federal income tax	15%
Marginal state income tax	5.25%
Property tax	1.1%

Consumer Impacts

Moving to the 2024 NCECC is cost-effective for households living in single-family and low-rise multifamily units in North Carolina. Based on a 30-year life-cycle cost analysis, the average consumer can expect to save nearly $4,347 and see a positive cashflow in 3 years.

Table 5 through Table 7 display typical cost-effectiveness metrics analyzed in DOE national and state energy code analyses. These metrics include climate zone specific life-cycle cost savings, consumer cash flow timeframe,[9] and annual energy cost savings. Tables 8 and 9 show the climate zone specific incremental construction costs when updating to the 2018 IECC based on the single-family and multifamily prototypes used in this analysis.

[8] Assuming a rate of inflation of 1.6%, this works out to a nominal discount rate of 8.71% using this conversion: $(1 + R\text{nominal}) = (1 + R\text{real}) \times (1 + R\text{inflation})$

[9] Consumer Cash Flow: Net annual cost outlay (i.e., difference between annual energy cost savings and increased annual costs for mortgage payments, etc.)

Table 5. Life-Cycle Cost Savings of the 2024 NCECC compared to the 2018 NCECC

Climate Zone	Life-Cycle Cost Savings ($)
3A	2,063
3AWH	1,858
4A	4,530
5A	3,256

Table 6. Consumer Cash Flow from Compliance with the 2024 NCECC compared to the 2018 NCECC

	Cost/Benefit	3A	3AWH	4A	5A
A	Incremental down payment and other first costs	$429	$429	$421	$534
B	Annual energy savings (year one) [10]	$395	$381	$545	$523
C	Annual mortgage increase	$236	$236	$231	$294
D	Net annual cost of mortgage interest deductions, mortgage insurance, and property taxes (year one)	$31	$31	$30	$38
E = [B-(C+D)]	Net annual cash flow savings (year one)	$129	$114	$283	$191
F = [A/E]	Years to positive savings, including up-front cost impacts	4	4	2	3

[10] Annual energy savings as reported at year 1, after considering inflation and price escalations.

Table 7. Simple Payback Period for the 2024 NCECC Compared to the 2018 NCECC

Climate Zone	Simple Payback (Years)
3A	11
3AWH	11
4A	8
5A	10

Table 8. Total Single-Family Construction Cost Increase for the 2024 NCECC Compared to the 2018 NCECC

Single-family Prototype House			
Climate Zone	**Crawlspace**	**Slab**	**Unheated Basement**
3A	$4,763	$5,194	$4,763
3AWH	$4,763	$5,194	$4,763
4A	$4,755	$5,186	$4,755
5A	$6,057	$6,487	$6,057

Table 9. Multifamily Construction Cost Increase for the 2024 NCECC Compared to the 2018 NCECC per Dwelling Unit[11]

Multifamily Prototype Apartment/Condo			
Climate Zone	**Crawlspace**	**Slab**	**Unheated Basement**
3A	$1,803	$1,867	$1,803
3AWH	$1,803	$1,867	$1,803
4A	$1,552	$1,616	$1,552
5A	$2,029	$2,092	$2,029

[11] In the multifamily prototype model, the heated basement is added to the building, and not to the individual apartments. The incremental cost associated with heated basements is divided among all apartments equally.

For a more detailed description of the approach PNNL uses to evaluate residential energy code cost-effectiveness, including building prototypes, energy and economic assumptions, and other considerations, please review the latest DOE Residential Cost-Effectiveness Methodology.[12]

[12] https://www.energycodes.gov/sites/default/files/2021-07/residential_methodology_2015.pdf