U.S. DEPARTMENT OF ENERGY

PNNL-18552

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Cost-Effectiveness and Impact Analysis of Adoption of Standard 90.1-2007 for New York State

K Gowri
M Halverson
R Bartlett

June 2009

Pacific Northwest NATIONAL LABORATORY

Proudly Operated by Battelle Since 1965

DISCLAIMER

PACIFIC NORTHWEST NATIONAL LABORATORY
operated by
BATTELLE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC05-76RL01830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information,
P.O. Box 62, Oak Ridge, TN 37831-0062;
ph: (865) 576-8401
fax: (865) 576-5728
email: reports@adonis.osti.gov

Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161
ph: (800) 553-6847
fax: (703) 605-6900
email: orders@ntis.fedworld.gov
online ordering: http://www.ntis.gov/ordering.htm

This document was printed on recycled paper.
(9/2003)

PNNL-18552

Cost-Effectiveness and Impact Analysis of Adoption of Standard 90.1-2007 for New York State

K Gowri
M Halverson
R Bartlett

June 2009

Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory
Richland, Washington 99352

Cost-Effectiveness and Impact Analysis of Adoption of Standard 90.1-2007 for New York State

Krishnan Gowri, Mark Halverson, and Rosemarie Bartlett

Pacific Northwest National Laboratory

June 25, 2009

Summary:

This analysis indicates that the adoption of Standard 90.1-2007 is cost-effective under New York's requirements for all buildings in New York.

New York State Calculated Paybacks

Building Prototype	***Climate Zone 4A – New York City***	***Climate Zone 5A – Albany***	***Climate Zone 6A - Binghamton***
Nonresidential	8	4	4
Residential	10	8	8
Semiheated	0 (no change)	0 (no change)	0 (no change)

Background:

New York State has requested that BECP provide an analysis of the impacts of adoption of ANSI/ASHRAE/IESNA Standard 90.1-2007. New York State is unique among states in requiring a ten-year payback for energy code measures. BECP has based this analysis on the results of a nationwide, state-by-state code comparison for DOE. The baseline assumptions for the state-by-state code comparison include:

1) The analysis will be based on three building types:
    a. medium office (representative of nonresidential construction)
    b. mid-rise apartment (representative of residential construction)
    c. warehouse (representative of semiheated construction)
2) The analysis will be conducted in one location in each climate zone found in the state (using climate zones defined in Standard 90.1-2007).
3) If a state adopts a version of the IECC, DOE will use the commercial requirements of the IECC version as the baseline requirements for nonresidential and high-rise residential construction.
4) If a state adopts a version of the IECC, DOE will use the semiheated requirements of the ASHRAE reference standard for the IECC version. Thus, for states that adopt the 2003 IECC, DOE will assume the semiheated building is built to the requirements of ANSI/ASHRAE/IESNA Standard 90.1-2001.

The implications for New York State are as follows:

1) The New York State Energy Conservation Code (NYSECC) is currently based on the 2003 IECC.
2) New York has also updated the ASHRAE reference standard to the 2003 IECC to ANSI/ASHRAE/IESNA Standard 90.1-2004.
3) DOE will use the requirements found in the 2003 IECC for nonresidential and residential construction.
4) DOE will use the requirements found in Standard 90.1-2004 for semiheated construction.

Energy Impact Analysis

New York State includes three climate zones – 4A, 5A, and 6A. DOE has selected the following cities to represent each zone:

Zone 4A	New York City
Zone 5A	Albany
Zone 6A	Binghamton

The primary difference between current IECC 2003[1] requirements and 90.1-2007 requirements for New York, represented in the analysis are:

(i) Opaque envelope requirements for exterior walls, roof, slab (as shown in Table 1, representing steel frame wall and insulation entirely above deck roof requirements for residential and nonresidential buildings, metal building walls and roof in semiheated buildings)

(ii) Fenestration requirements (as shown in Table 1)

(iii) HVAC equipment efficiencies effective as of 1/23/2006 (includes NAECA covered equipment)

[1] For the semiheated portion of the warehouse, the semiheated requirements in ASHRAE Standard 90.1-2001, the reference standard to the 2003 IECC, were utilized as it is believed that this is how a building of this type would typically comply with the 2003 IECC.

Table 1: Comparison of Envelope Requirements (U-factors in Btu/hr.ft^2.°F)

	Climate Zone 4A		Climate Zone 5A		Climate Zone 6A	
	IECC 2003	90.1-2007	IECC 2003	90.1-2007	IECC 2003	90.1-2007
Nonresidential						
Exterior Wall	0.101	0.064	0.079	0.064	0.076	0.064
Roof	0.063	0.048	0.054	0.048	0.053	0.048
Slab	NR	NR	NR	NR	NR	R-10/2ft.
Window*	0.57 (0.39)	0.52 (0.40)	0.57 (0.39)	0.48 (0.40)	0.57 (0.39)	0.48 (0.40)
Residential						
Exterior Wall	0.101	0.064	0.079	0.064	0.076	0.064
Roof	0.063	0.048	0.054	0.048	0.053	0.048
Slab	NR	R-10/2ft.	NR	R-10/2ft.	NR	R-15/2ft.
Window*	0.62 (0.39)	0.52 (0.40)	0.62 (0.39)	0.48 (0.40)	0.62 (0.39)	0.48 (0.40)
Semiheated						
Exterior Wall	0.113	0.113	0.113	0.113	0.113	0.113
Roof	0.065	0.065	0.065	0.065	0.065	0.065
Slab	NR	NR	NR	NR	NR	NR

- Window SHGC shown in parantheses next to the U-factor

New York state-wide average energy savings are estimated based on the requirements for three representative locations for Climate Zones 4A (New York City), 5A (Albany) and 6A (Binghamton). Table 2 shows a summary of average energy use intensities and percentage savings that can be achieved with the adoption of 90.1-2007. Cost savings shown in Table 2 are based on national average fuel prices and not New York State natural gas and electricity prices. New York State fuel prices will be used in the cost-effectiveness portion of this analysis.

Tables A-1 to A-3 in Appendix A present a high level summary of building models used in energy analysis. The energy cost savings are calculated based on a national average fuel price used by the ASHRAE 90.1 Envelope Subcommittee (Electricity: $ 0.0939/kWh; Natural gas: $1.2201/therm).

Based on the analysis, New York State can expect to realize state average energy savings of 6% and cost savings of 4.5% assuming all new building construction is equally represented by the three prototypes and the climate zones used in the analysis.

Table 2: New York Energy End Use and Percentage Savings

Building Prototype	Location	*Energy Use Intensity*				*Savings 90.1-2007 vs. IECC2003*	
		IECC2003		**90.1-2007**			
		Electricity (kWh/sf/yr)	Natural Gas (kBtu/sf/yr)	Electricity (kWh/sf/yr)	Natural Gas (kBtu/sf/yr)	Energy	Cost
Nonresidential	New York City	12.32	5.42	11.85	4.76	4.8%	4.3%
Residential	New York City	9.05	17.04	8.90	13.89	7.7%	5.0%
Semiheated	New York City	4.37	16.53	4.37	16.39	0.5%	0.3%
Nonresidential	Albany	12.21	7.57	11.79	6.38	5.4%	4.4%
Residential	Albany	8.89	21.46	8.85	18.92	5.2%	3.2%
Semiheated	Albany	4.34	21.38	4.33	21.27	0.4%	0.3%
Nonresidential	Binghamton	12.09	7.90	11.65	6.62	5.7%	4.7%
Residential	Binghamton	8.93	22.94	8.88	20.44	4.9%	3.1%
Semiheated	Binghamton	4.40	24.64	4.39	24.51	0.3%	0.2%

Cost Effectiveness Analysis

New York State has a requirement for a ten-year simple payback for new code requirements. At the request of New York, BECP examined the cost effectiveness of Standard 90.1-2007 compared to the NYSECC based on the changes identified for the three building prototypes covered in this analysis. The analysis approach used was a comparison of incremental cost to build the three prototype buildings compared to the incremental savings that would be achieved using Standard 90.1-2007.

The only significant changes identified in these three prototypes were related to envelope measures. Roof insulation, wall insulation, slab insulation, and window performance requirements differed as noted in Table 1.

The envelope requirements generation spreadsheet used by the ASHRAE SSPC 90.1 envelope subcommittee to generate the requirements for Standards 90.1-2004, 2007, and proposed requirements for 90.1-2010 was used. Specifically, the latest available cost information taken from the "2010 Opaque Constr" tab and the "FenestrationData 2010" tab of the" 901EnvOpt_VBA(2009-01-24).xls" spreadsheet was used to generate costs for this analysis. Where opaque constructions identified in the 2003 IECC were not explicitly identified in the tables in this spreadsheet, value were interpolated to provide cost estimates for opaque constructions. For glazing performance, the lowest cost option for meeting the requirements of

either Standard 90.1-2007 or the 2003 IECC was identified, even if that option might provide better performance than was required to meet the code requirements. (For example, a low cost metal framed, double paned low-e argon filled window with a U-factor of 0.47 and an SHGC of 0.24 was used as the cost basis for windows that need to meet U/SHGC requirements of 0.50/.40, 0.48/.40, and 0.47/.40 because this window was clearly the lowest cost option in this range.) A first cost adjustment factor of 1.2 for New York City (Zone 4A) was used at the suggestion of Mark Eggers of NYSERDA. Estimated first cost impacts are shown in Table 3 for each building prototype in each climate zone. First cost impacts range from $0 for semiheated warehouses to a high of $34,530 for the nonresidential office building in New York City.

Table 3: New York State Calculated Incremental First Cost Impacts

Building Prototype	***Climate Zone 4A – New York City***	***Climate Zone 5A – Albany***	***Climate Zone 6A - Binghamton***
Nonresidential	$34,530	$17,773	$18,142
Residential	$21,083	$10,423	$9,525
Semiheated	$0	$0	$0

Gas and electricity savings were taken directly from the analysis spreadsheets that led to Table 2. The values of the savings may be derived by taking the difference in energy use intensity values for gas and electricity in Table 2 and multiplying the difference by the square footage of the building. Estimated energy cost savings are shown in Table 4 for each building prototype in each climate zone. Energy cost savings range from a low of around $100 for semiheated warehouses to a high of $4,597 for the nonresidential office building in Binghamton.

Table 4: New York State Calculated Incremental Energy Cost Savings

Building Prototype	***Climate Zone 4A – New York City***	***Climate Zone 5A – Albany***	***Climate Zone 6A - Binghamton***
Nonresidential	$4,464	$4,349	$4,597
Residential	$2,050	$1,234	$1,185
Semiheated	$94	$115	$89

The resulting kWh/yr and kBtu/yr values were then multiplied by the New York State Fuel Costs for 2007 taken from http://www.nyserda.org/energy_information/energy_prices_supplies.asp. No adjustment for fuel costs in 2008 was made. No adjustment for increased fuel costs in New York City was made. The resulting payback periods calculated in this analysis are shown in Table 5.

Table 5: New York State Calculated Paybacks

Building Prototype	***Climate Zone 4A – New York City***	***Climate Zone 5A – Albany***	***Climate Zone 6A - Binghamton***
Nonresidential	8	4	4
Residential	10	8	8
Semiheated	0 (no change)	0 (no change)	0 (no change)

Note – the values above are rounded to the nearest integer values for clarity

This analysis indicates that the adoption of Standard 90.1-2007 is, on average, cost-effective under New York's requirements for buildings in New York State. The requirement in the New York State Energy Law (Energy Law Article 11-103.2) is that the overall code update be cost effective on average for the state. The average value for the code would depend on the weighting factors provided for each prototype, but the average is clearly between 0 and 10, as shown in Table 5.

Appendix A – Prototype Building Descriptions

Table A-1: Nonresidential Prototype Building Characteristics

Characteristic	Prototype Building Model Description
GENERAL	
Building Type	Medium Office
Gross Floor Area	53,600 ft²
Building Shape	Rectangle
Aspect Ratio	1.5 (164 ft x 109 ft)
Number of Floors	3
Window to Wall Ratio	33% (modeled as strip windows of 5 ft. high)
Floor Height	13 ft
Floor-to-Ceiling Height	9 ft
Exterior Wall	Steel-framed wall
Roof	Insulation entirely above deck, metal deck roof
Floor	8” Slab-on-grade
INTERNAL LOADS	
Occupancy	
Number of People	5 persons / 1000 sf
Lighting	
Power Density	1.0 w/sf
Plug Load	
Average Power Density	0.75 w/sf
HVAC	
Heating Type	Gas furnace
Cooling Type	Packaged DX Unit
Fan Control	Variable air volume
Distribution/Terminal Units	VAV terminal box with electric reheating coil
Cooling T-stat	75°F (80°F setback)
Heating T-stat	70°F (60°F setback)
SERVICE WATER HEATER	
Water Heater Type	Electric storage water heater
Tank Capacity, gallon	260
Supply Temperature, °F	120

Table A-2: Residential Prototype Building Characteristics

Characteristic	Prototype Building Model Description
GENERAL	
Building Type	Multi-family residential building
Gross Floor Area	33,700 ft²
Building Shape	Rectangle
Aspect Ratio	2.75 (152 ft x 56 ft)
Number of Floors	4
Activity Area	Each floor has 8 (25'x38') apartments, except ground floor which has 7 apartments and one lobby/office
Window to Wall Ratio	15% (4ft high view windows)
Floor Height	10 ft
Floor-to-Ceiling Height	10 ft (for the office area only)
Exterior Wall	Steel-framed wall
Roof	Insulation entirely above deck, metal deck roof
Floor	8" Slab-on-grade
INTERNAL LOADS	
Occupancy	
Number of People	78 persons total (average 2.5 persons per apartment unit)
Lighting	
Average Power Density	• Apartment units: 0.36 w/sf • Corridors: 0.5 w/sf • Office area: 1.1 w/sf
Plug Load	
Average Power Density	0.62 w/sf
HVAC	
Heating Type	Gas furnace
Cooling Type	Split system DX (one per apartment)
Fan Control	Constant volume
Distribution/Terminal Units	Single zone/Direct air
Cooling T-stat	75°F (no setback assumed)
Heating T-stat	70°F (no setback assumed)
SERVICE WATER HEATER	
Water Heater Type	Individual residential electric storage water heater
Tank Capacity, gallon	20 (per apartment unit)
Supply Temperature, °F	120

Table A-3: Semiheated Prototype Building Characteristics

Characteristic	Prototype Building Model Description
GENERAL	
Building Type	Non-refrigerated warehouse
Gross Floor Area	49,500 ft²
Building Shape	Wide rectangle
Aspect Ratio	2.2 (330 ft x 150 ft)
Number of Floors	1
Activity Area (percentage of gross floor area)	• Bulk storage area: 34,500 ft² (70%) • Fine storage area: 12,450 ft² (25%) • Office area: 2,550 ft² (5%)
Window to Wall Ratio	• Storage area: no windows • Office area: 12% view windows
Floor Height	28 ft
Floor-to-Ceiling Height	14 ft (for the office area only)
Exterior Wall	Metal building wall
Roof	Metal building roof
Floor	6” Slab-on-grade
Door	7 opaque doors (3’x7’), 7 roll-up dock doors (8’x10’)
INTERNAL LOADS	
Occupancy	
Number of People	5 (in the office area)
Lighting	
Average Power Density	• Bulk storage area: 0.8 w/sf • Fine storage area: 0.8 w/sf • Office area: 1.0 w/sf
Plug Load	
Average Power Density	Office: 0.75 w/sf Bulk storage: 0.24 w/sf
HVAC	
Heating Type	• Bulk storage area: unit heater • Fine storage area: Gas furnace • Office area: Gas furnace
Cooling Type	• Bulk storage area: no cooling • Fine storage area: Direct expansion • Office area: Direct expansion
Fan Control	Constant volume
Distribution/Terminal Units	Single zone/Direct air
Cooling T-stat	• Fine storage area: 80°F • Office area: 75°F (85°F setback)
Heating T-stat	• Bulk storage area: 50°F • Fine storage area: 60°F • Office area: 70°F (60°F setback)
SERVICE WATER HEATER	
Water Heater Type	Electric storage water heater
Tank Capacity, gallon	20
Supply Temperature, °F	120