

# 2009/2012 IECC Cost-Effectiveness Analysis Webinar

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**Pacific Northwest National Laboratory**  
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# Topics

- ▶ **Overview of the analysis**
- ▶ **Overview of changes to the IECC from 2006 to 2012**
- ▶ **National energy analysis results**
- ▶ **Results from an example state analysis**
- ▶ **Energy simulation methodology**
- ▶ **Economic analysis methodology**



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# Overview of the Analysis

**The 2009 and particularly the 2012 version of the International Energy Conservation Code (IECC) have substantial energy efficiency improvements over the 2006 version.**

**Many states currently use either the 2006 or 2009 version of the IECC. Some states make varying degrees of modifications to the IECC**

- **States with major modifications that are accounted for in this analysis: Georgia, Michigan, Minnesota, Montana, Oklahoma, Vermont, Virginia, Washington D.C., Wisconsin.**

**This analysis examined the cost effectiveness of moving from the current state code to the 2009 and/or 2012-IECC for residential buildings**

- **This will assist states in assessing whether they should update their residential energy codes to the recent versions of the IECC**



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# How the IECC Has Improved from 2006 to 2012

Climate Zone	IECC	Ceiling (R-value)	Skylight (U-factor)	Fenestration (Windows and Doors)		Wood Wall (R-value)	Floor (R-value)	Basement Wall (R-value)	Tested Air Leakage Rate (ACH)	Slab (R-value /depth)
				U-factor	SHGC					
1	2006				0.4				NR	
	2009	30	0.75	NR	0.3	13	13	NR	NR	NR
	2012				0.25				5	
2	2006	30	0.75	0.75	0.4				NR	
	2009	30	0.75	0.65	0.3	13	13	NR	NR	NR
	2012	38	0.65	0.4	0.25				5	
3	2006	30	0.65	0.65	0.4	13		0	NR	
	2009	30	0.65	0.5	0.3	13	19	5/13	NR	NR
	2012	38	0.55	0.35	0.25	20		5/13	3	
4	2006	38	0.6	0.4	NR	13			NR	
	2009	38	0.6	0.35	NR	13	19	10/13	NR	10, 2 ft
	2012	49	0.55	0.35	0.4	20			3	
5	2006	38	0.6	0.35		19		10/13	NR	
	2009	38	0.6	0.35	NR	20	30	10/13	NR	10, 2 ft
	2012	49	0.55	0.32		20		15/19	3	
6	2006		0.6	0.35		19		10/13	NR	
	2009	49	0.6	0.35	NR	20	30	15/19	NR	10, 4 ft
	2012		0.55	0.32		20+5		15/19	3	
7 and 8	2006		0.6	0.35		21	30	10/13	NR	
	2009	49	0.6	0.35	NR	21	38	15/19	NR	10, 4 ft
	2012		0.55	0.32		20+5	38	15/19	3	



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# How the IECC Has Improved from 2006 to 2012 (continued)

## Envelope Sealing

- ▶ Only visual inspection of envelope sealing required in 2006 IECC
- ▶ More sealing details and alternative testing path added in 2009 IECC
- ▶ Testing is mandatory with stringent leakage limits in 2012 IECC

## Duct sealing

- ▶ Testing with leakage rate limits added in 2009 IECC
- ▶ Allowable leakage rates reduced in 2012 IECC

## Lighting

- ▶ No high efficacy lighting requirements in 2006 IECC
- ▶ 50% efficient light bulbs per home in 2009 IECC
- ▶ 75% efficient light bulbs or fixtures per home in 2012 IECC



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# How the IECC Has Improved from 2006 to 2012 (continued)

- ▶ **Insulation required on hot water pipes in 2012 IECC**
  - **Exemption allowed if pipes runs are short enough and/or have a small diameter**
  
- ▶ **2009 and 2012 IECC do not credit improved equipment trade-offs in performance path**
  - **Does not impact this analysis because**
    - **This analysis considers prescriptive requirements**
    - **Equipment trade-offs are energy neutral on paper**
  
- ▶ **There are additional minor changes that have little or no impact on costs and benefits in most cases**



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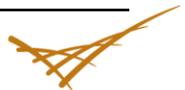
# Economic Metrics for Determining Cost Effectiveness

- ▶ **DOE calculated three metrics for evaluating the cost effectiveness:**
  - **Life Cycle Cost is the primary metric DOE uses to evaluate cost effectiveness**
  - **Simple payback provides additional information that is easy to understand and may be of interest**
  - **Cash flow presents net annual impacts (mainly energy cost savings vs. mortgage cost increase) and also years to net positive cash flow accounting for down payment**



# Economic Parameters for Life-Cycle Cost Analysis

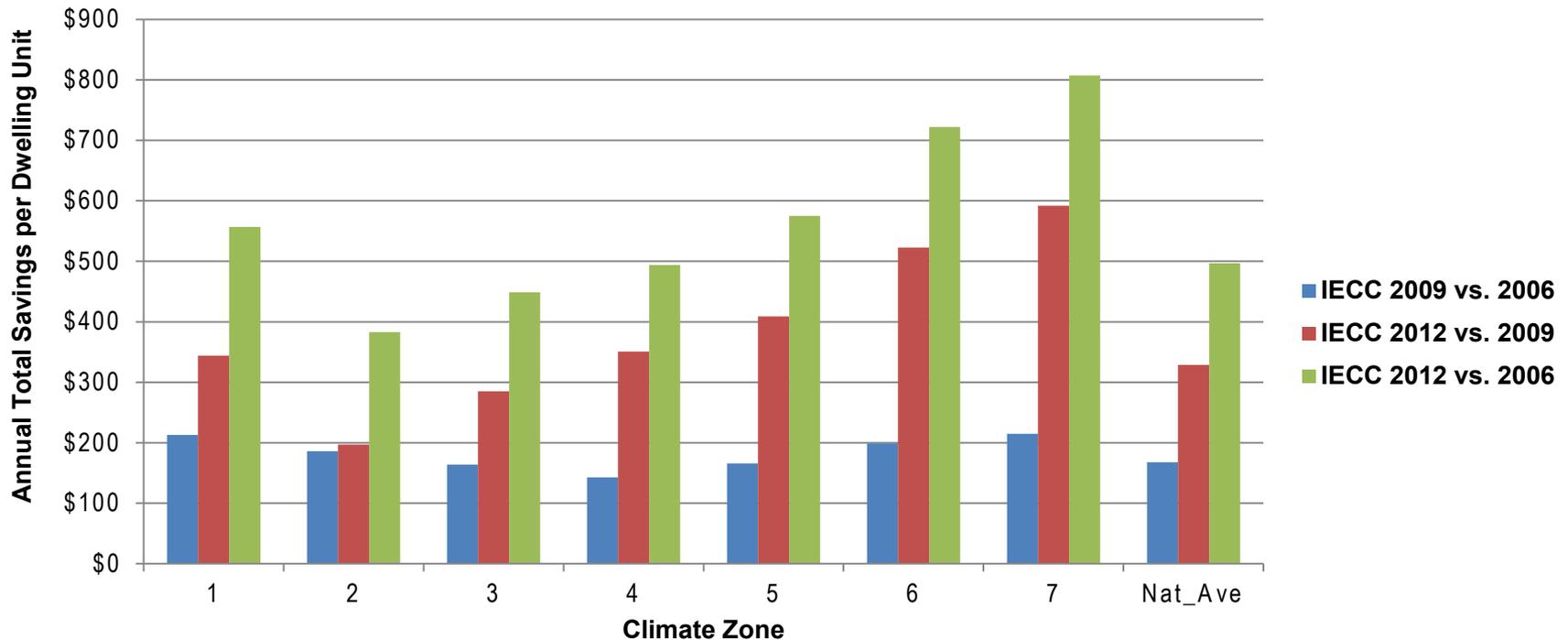
Parameter	Value Used in Analysis
<b>Mortgage Term</b> <b>Interest rate</b> <b>Down payment</b> <b>Points and fees</b>	<b>30 years</b> <b>5% interest</b> <b>10% down payment</b> <b>0.7% points/fees</b>
<b>Discount rate</b>	<b>5% (nominal)</b>
<b>Income tax deduction on mortgage interest</b>	<b>25% plus state rate</b>
<b>General inflation</b>	<b>1.6%</b>
<b>Fuel price inflation (nominal)</b>	<b>2.2%</b>
<b>Period of Analysis</b>	<b>30 years</b>
<b>Measure Lives</b>	<b>60 years for insulation. 30 years for windows and duct/envelope sealing, 6 years for efficient lighting</b>
<b>Residual values at end of period of analysis</b>	<b>Linear depreciation on measure values. No future energy cost savings after 30 years.</b>



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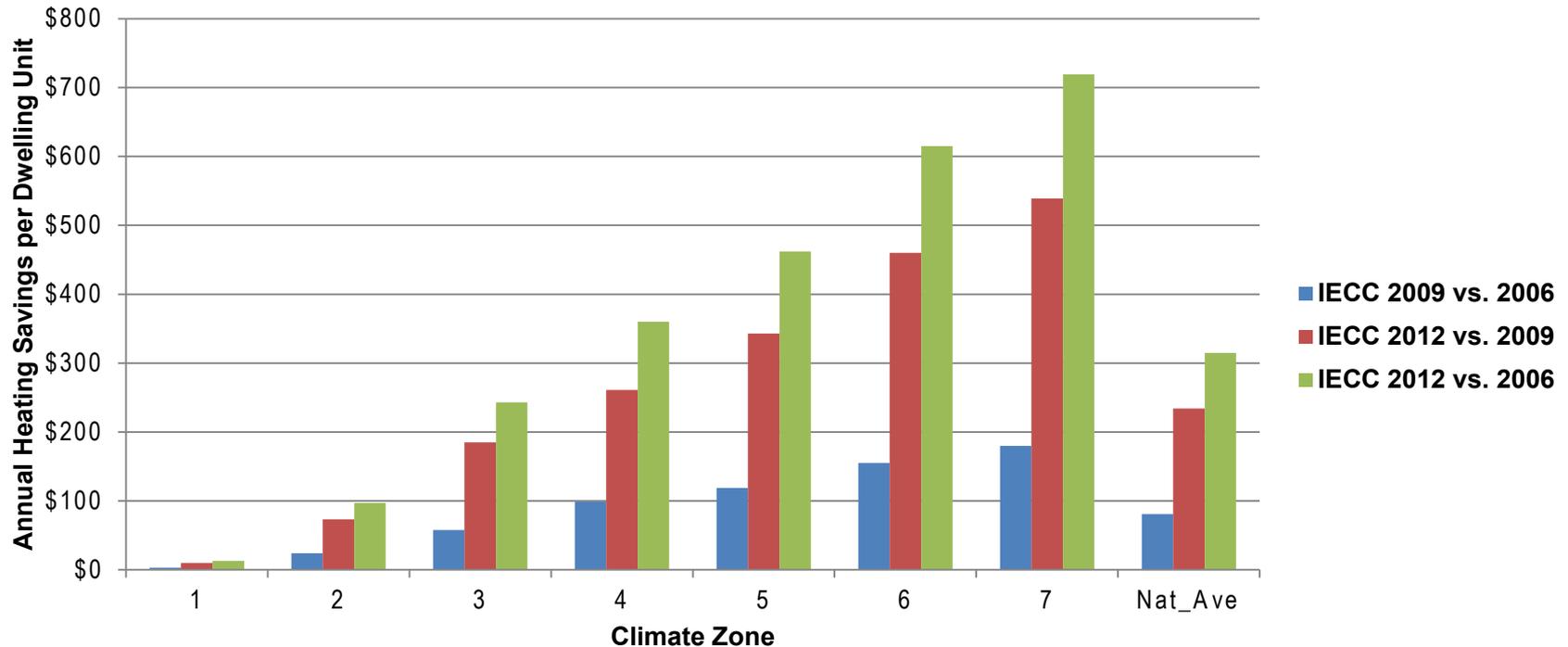
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# Annual Energy Cost Savings



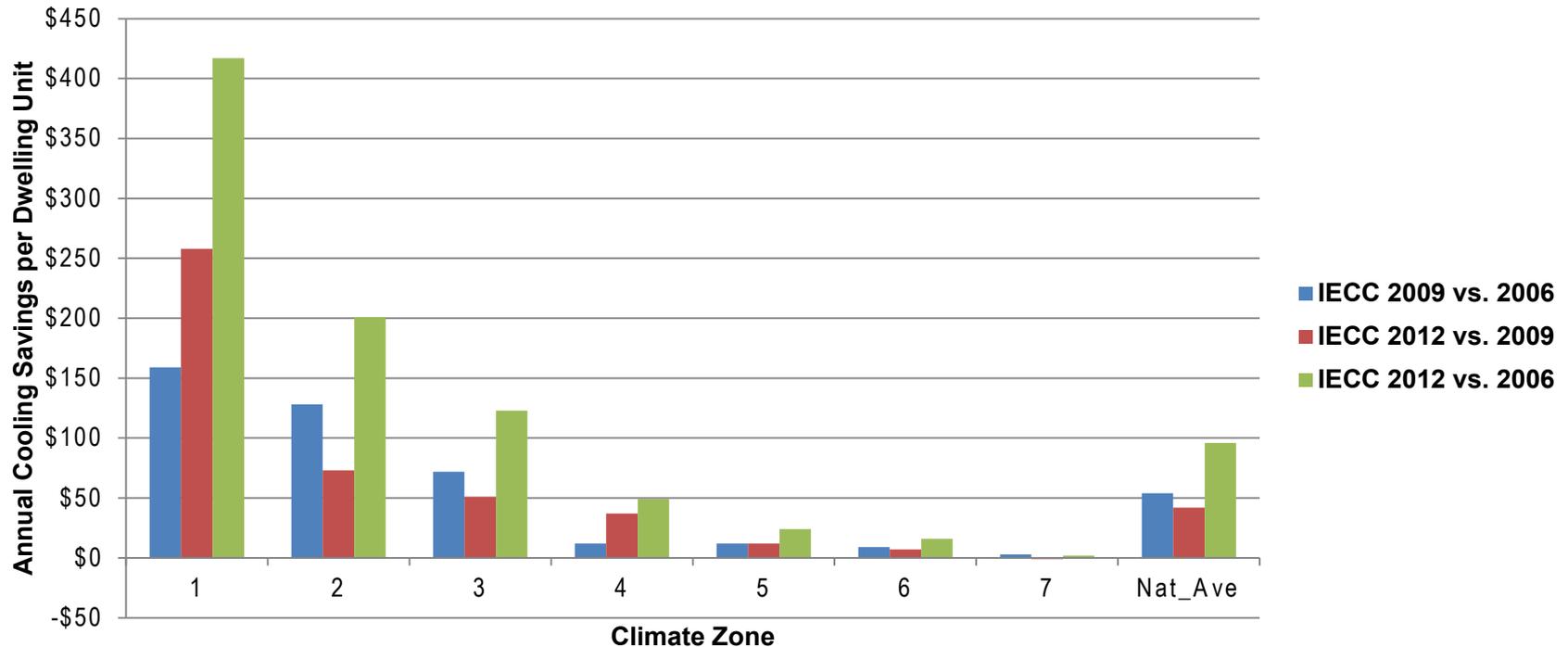
***Annual energy cost savings for the 2009 and 2012 IECC range from about \$150 to \$800.***

# Annual Energy Cost Savings – Heating



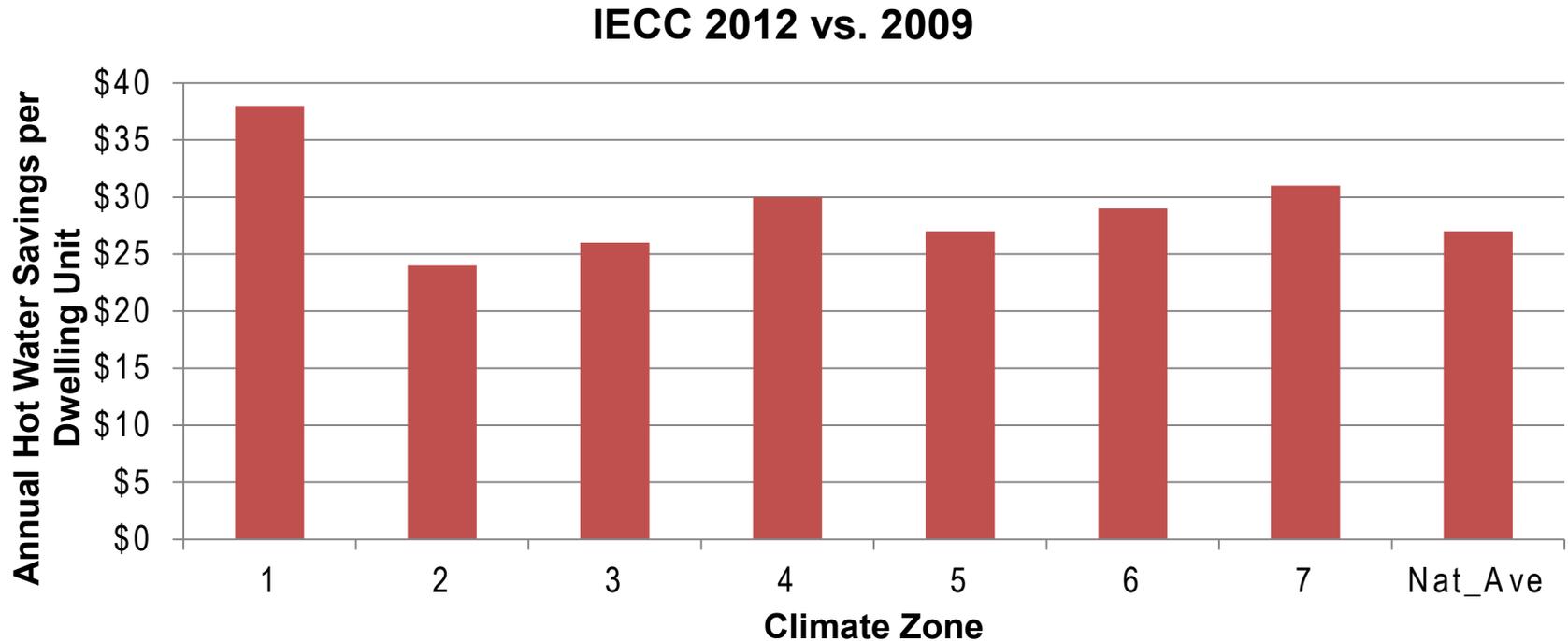
***Annual heating cost savings for the 2009 and 2012 IECC range from near zero to \$700.***

# Annual Energy Cost Savings – Cooling



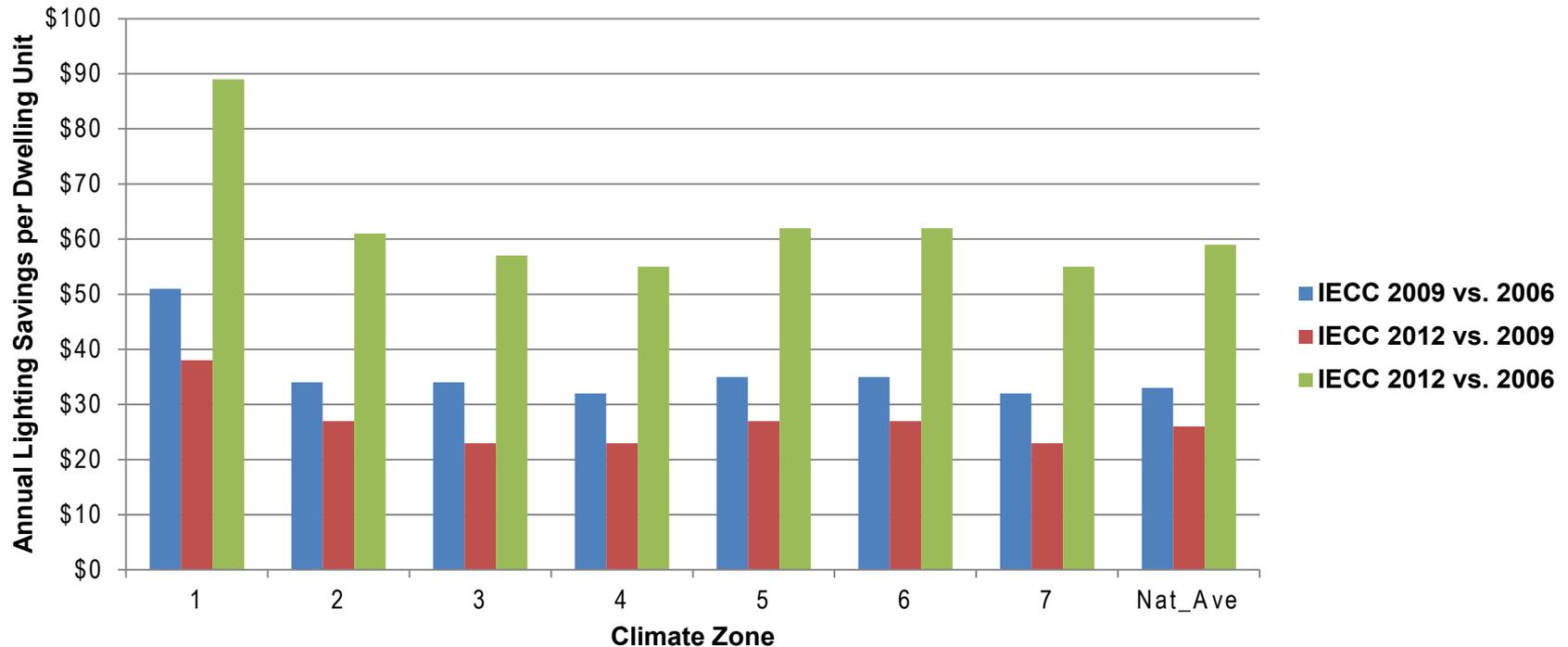
***Annual cooling cost savings for the 2009 and 2012 IECC range from near zero to \$400.***

# Annual Energy Cost Savings – Water Heating



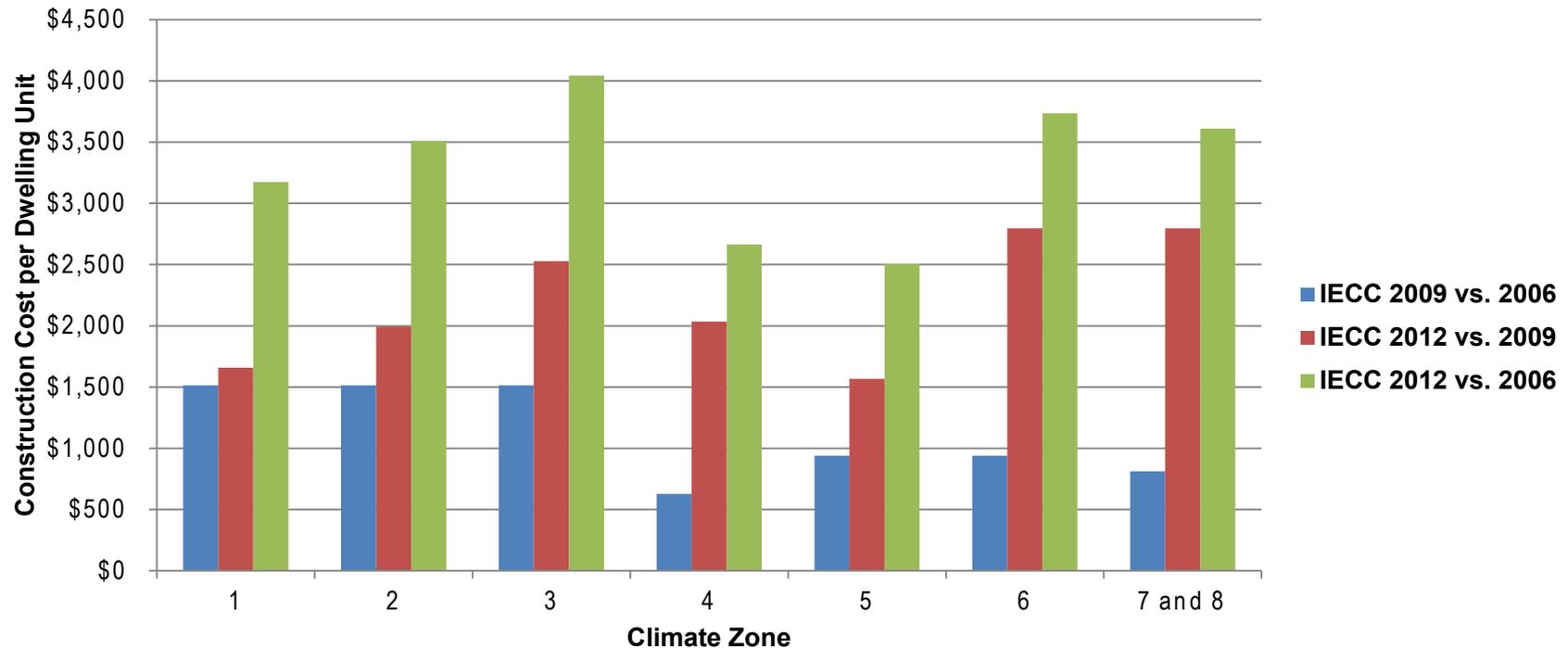
***Annual water heating cost savings for the 2012 IECC range from \$25 to \$40 and are a 10% reduction in water heating costs.***

# Annual Energy Cost Savings – Lighting



***Annual lighting cost savings for the 2009 and 2012 IECC range from \$20 to \$90.***

# National Impacts – Construction Cost Increase: Single-Family



***Construction cost increases for the 2009 and 2012 IECC vary from about \$500 to about \$4000 for a average single-family home.***

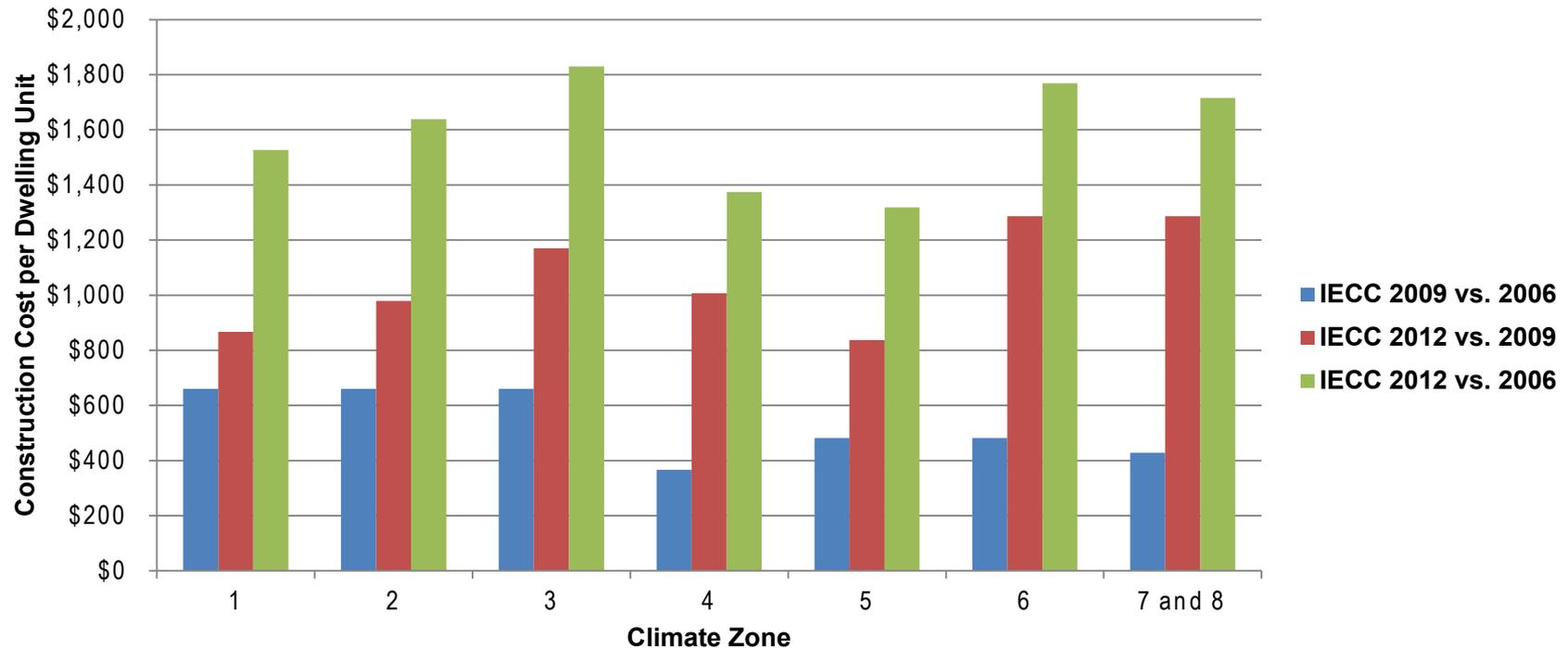
National Energy and Cost Savings for New Single and Multifamily Homes: A Comparison of the 2006, 2009, and 2012 Editions of the IECC, April 2012 PNNL-21329



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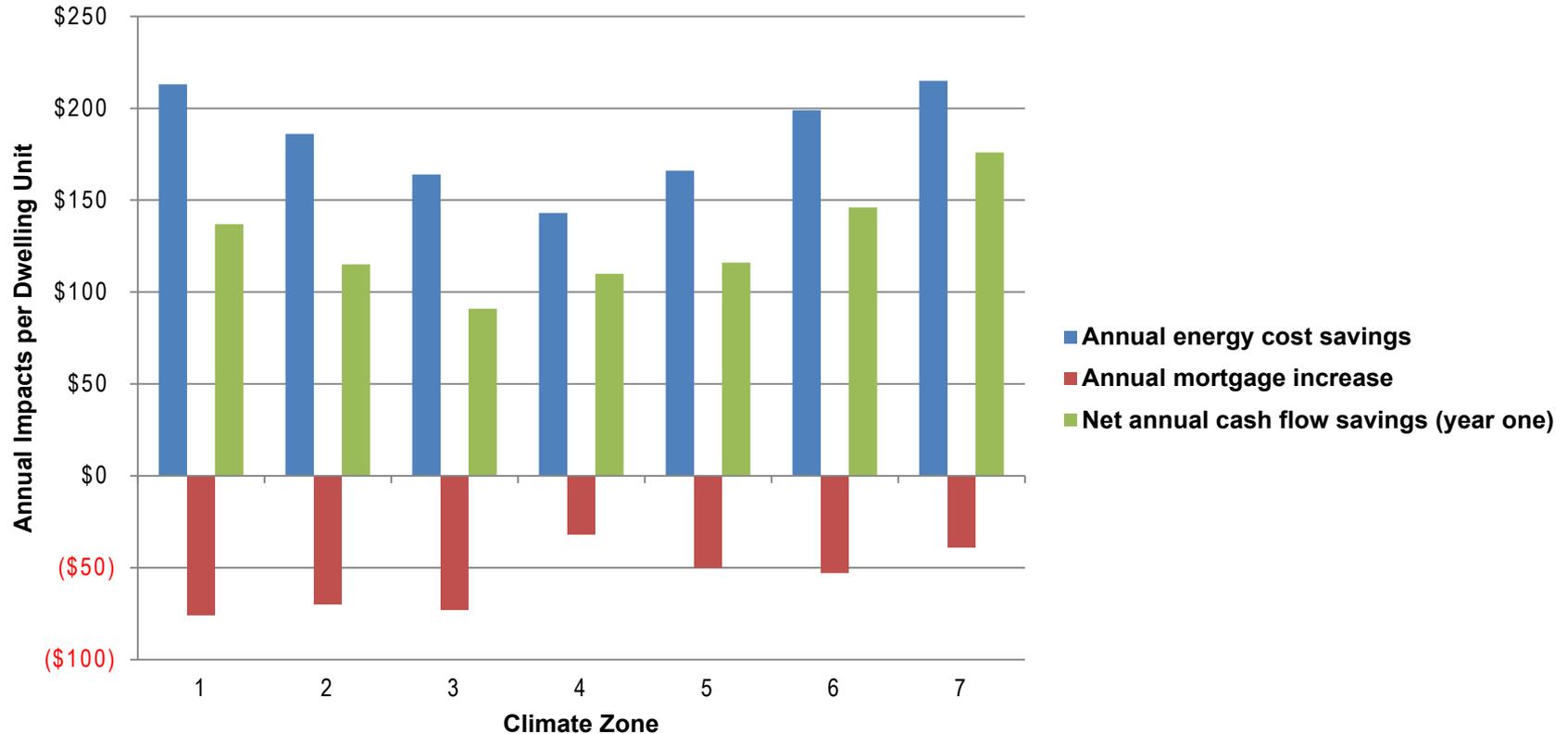
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# National Impacts – Construction Cost Increase: Multifamily



***Construction cost increases for the 2009 and 2012 IECC are lower for a multifamily home because of the smaller size. Net annual savings vary from about \$400 to about \$1800 for a average multifamily dwelling unit.***

# First Year Cash Flow – 2009 IECC vs. 2006 IECC



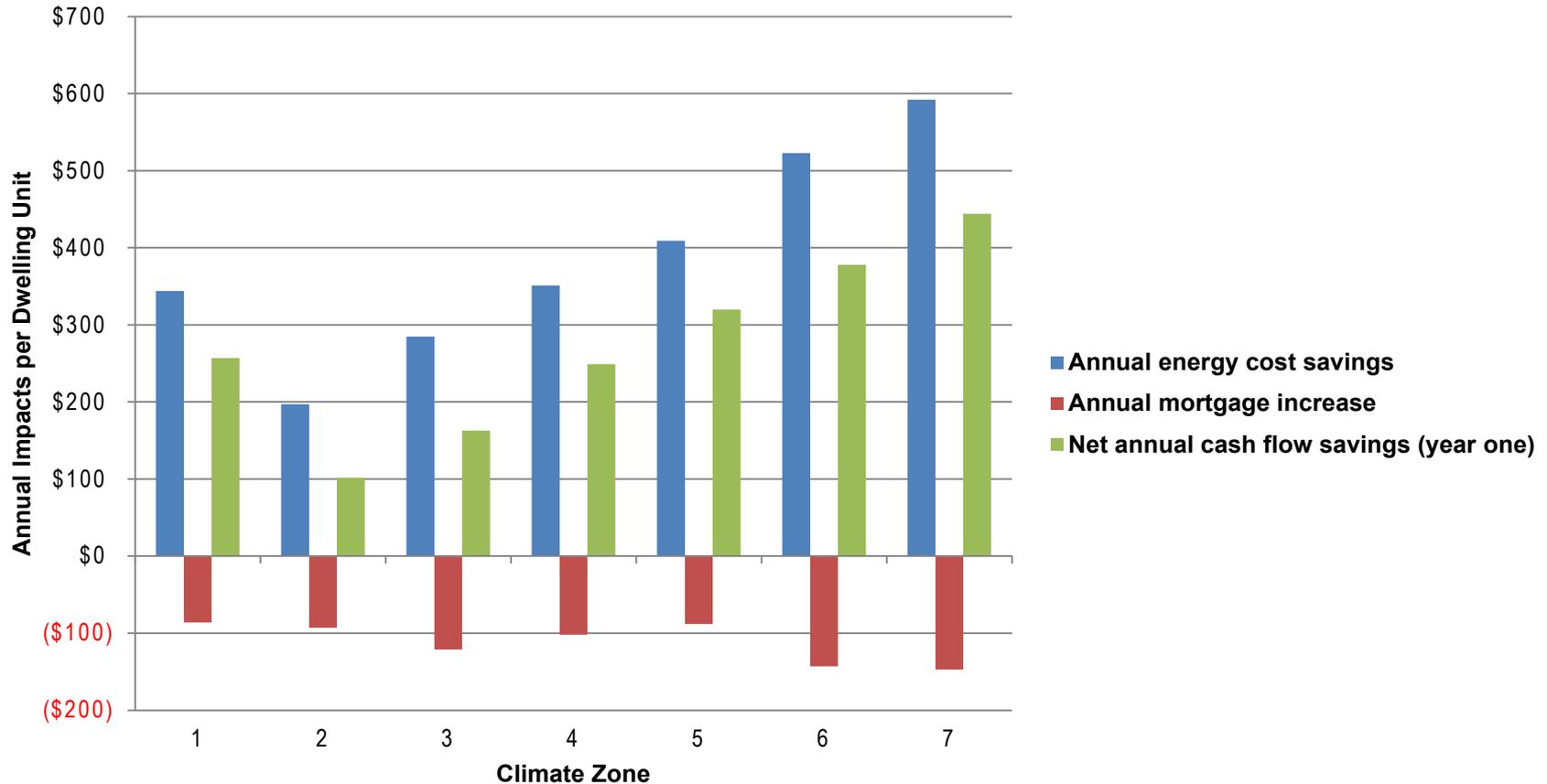
**Cash flow shows the annual energy cost savings, mortgage cost increase, and net savings to the home owner. Net savings vary from about \$90 to \$175.**



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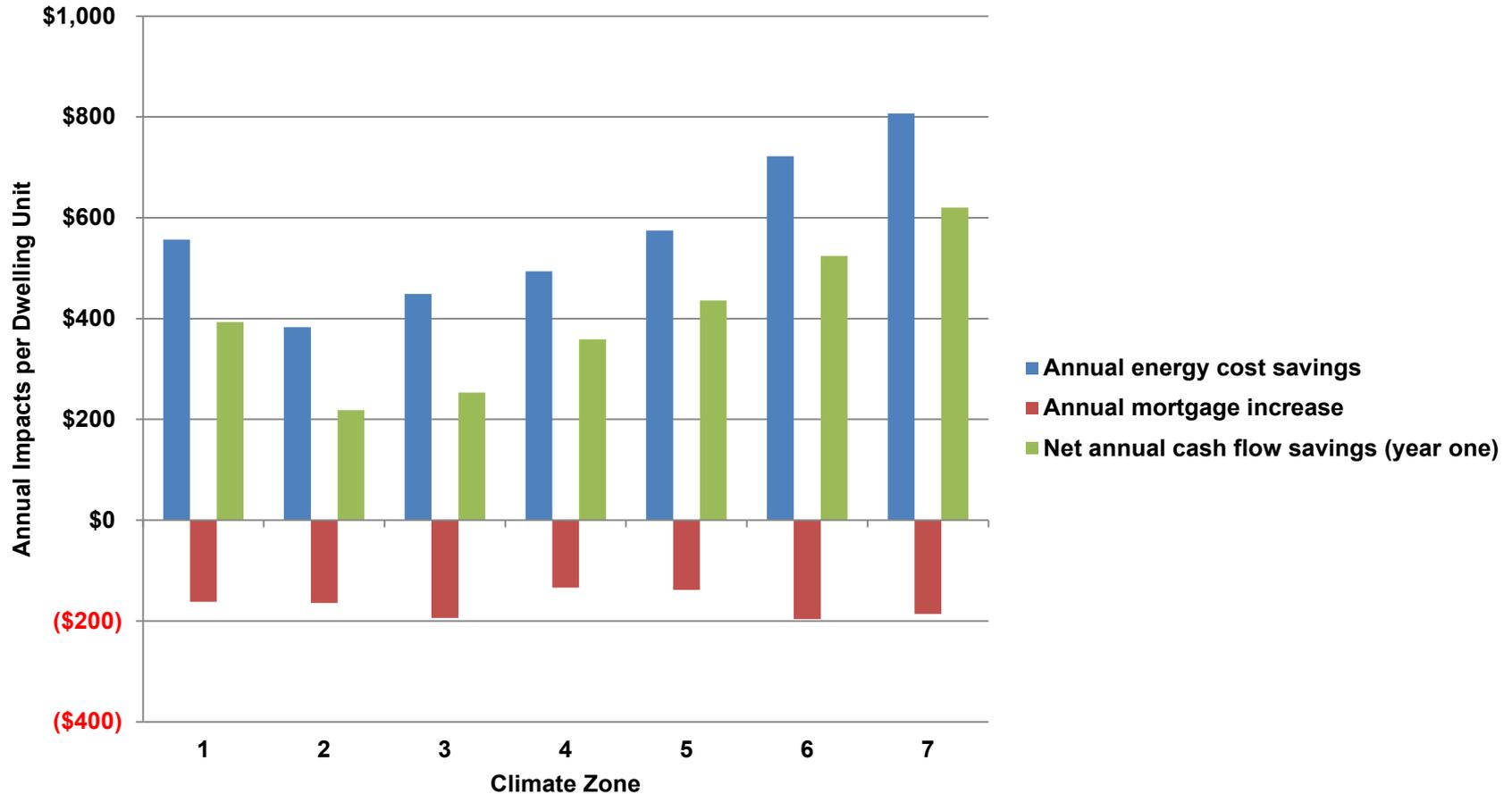
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# First Year Cash Flow – 2012 IECC vs. 2009 IECC



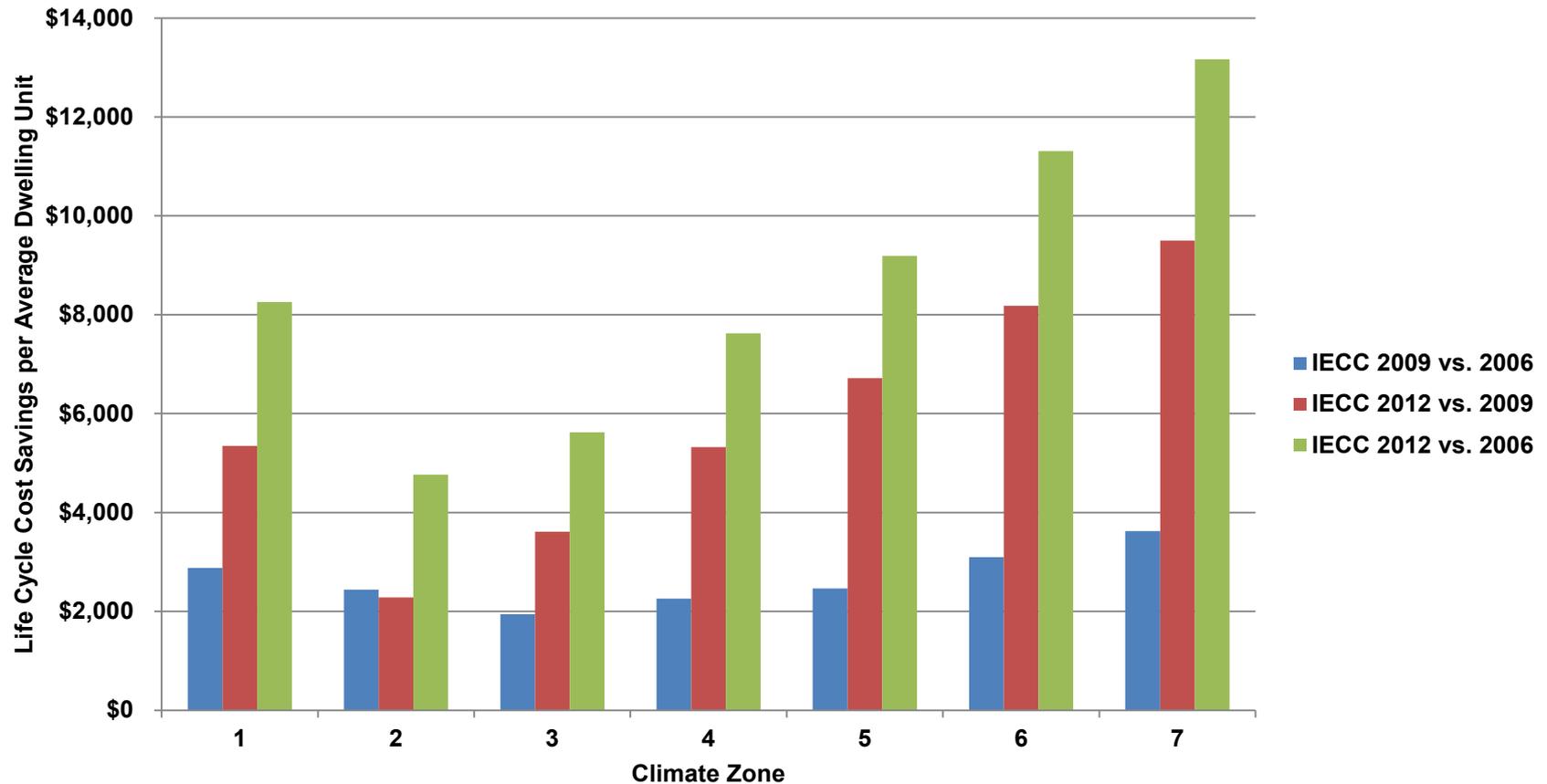
**Net annual savings vary from about \$100 to \$450 for the 2012 IECC vs. 2009 IECC.**

# First Year Cash Flow – 2012 IECC vs. 2006 IECC



***Net annual savings vary from about \$200 to \$600 for the 2012 IECC vs. 2006 IECC.***

# National Impacts – Life Cycle Cost Savings



***Life-cycle cost savings vary from about \$2,000 to \$13,000 per home for the 2009 IECC and 2012 IECC. Both the 2009 and 2012 reduce life-cycle cost in all states.***

# Example of State Specific Reports - Massachusetts

**Massachusetts already at the 2009 IECC so improvement from 2009 to 2012 IECC examined**

<b>A</b>	<b>Life-cycle cost savings</b>	<b>\$10,848</b>
<b>B</b>	<b>Annual energy savings (year one)</b>	<b>\$621</b>
<b>C</b>	<b>Construction cost increase</b>	<b>\$1677</b>
<b>D</b>	<b>Simple payback</b>	<b>2.7</b>
<b>E</b>	<b>Down payment and other up-front costs</b>	<b>\$179</b>
<b>F</b>	<b>Annual mortgage increase</b>	<b>\$97</b>
<b>G</b>	<b>Net annual cost of mortgage interest deductions, mortgage insurance, and property taxes (year one)</b>	<b>\$0</b>
<b>H=[B-(F+G)]</b>	<b>Net annual cash flow savings (year one)</b>	<b>\$524</b>
<b>I = [E/H]</b>	<b>Years to positive savings, including up-front cost impacts</b>	<b>1</b>

# Foundation of the Analysis

- ▶ **Methodology for Evaluating Cost-Effectiveness of Residential Energy Code Changes**
  - Published online  
[http://www.energycodes.gov/sites/default/files/documents/residential\\_methodology.pdf](http://www.energycodes.gov/sites/default/files/documents/residential_methodology.pdf)
  - Vetted through a public comment process
  - Forms the basis of this analysis
- ▶ **Building Component Cost Community (BC3) database**
  - Created by PNNL
  - Publicly available repository of building component costs <http://bc3.pnnl.gov>
- ▶ **EnergyPlus software**
  - Powerful whole building energy simulation program
  - Available for free download at  
<http://apps1.eere.energy.gov/buildings/energyplus>



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# EnergyPlus Models and Supporting Documentation

- ▶ **A total number of 11,424 EnergyPlus input files created for this analysis**
  - All energy models and output files available for download at [http://www.energycodes.gov/development/residential/iecc\\_models](http://www.energycodes.gov/development/residential/iecc_models)
- ▶ **Technical Support Document (TSD)**
  - Detailed Supporting document for this cost-effectiveness analysis
  - Details energy modeling assumptions and strategies
  - Contains detailed discussions of energy and cost assumptions and calculations
  - In progress; to be published in September, 2012
- ▶ **Scorecards**
  - Spreadsheets with high level energy modeling assumptions
  - In progress; to be published in September, 2012.

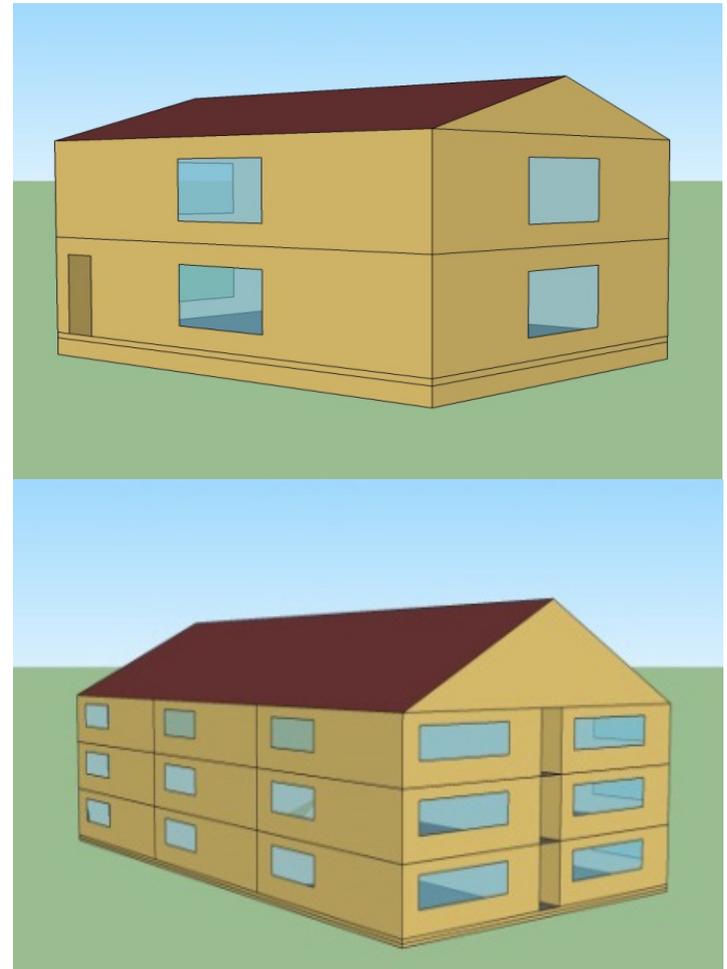


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# Prototype Building Models

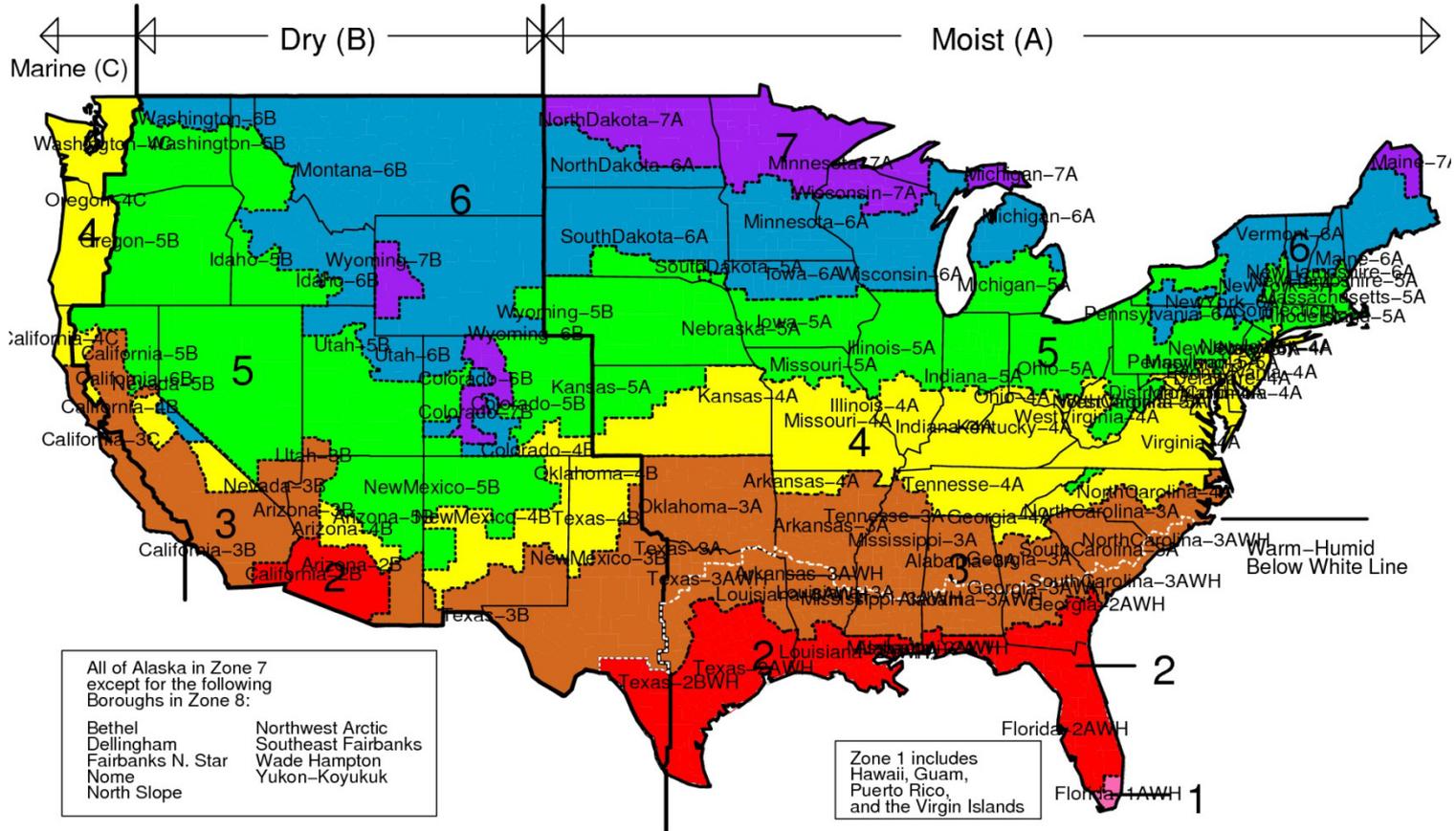
- ▶ **Two prototype models**
  - **2400 sq. ft. detached Single-family home**
  - **Low-rise Multifamily building with 18 units. Each unit a 1200 sq. ft. apartment/condo**
- ▶ **Four common foundation types: heated and unheated basements, vented crawlspaces and slab-on-grade**
- ▶ **Four common heating systems: Electric heat pump, electric furnace, natural gas furnace and oil furnace**
- ▶ **Set of 32 building energy models for each case**



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# 119 Simulation Locations



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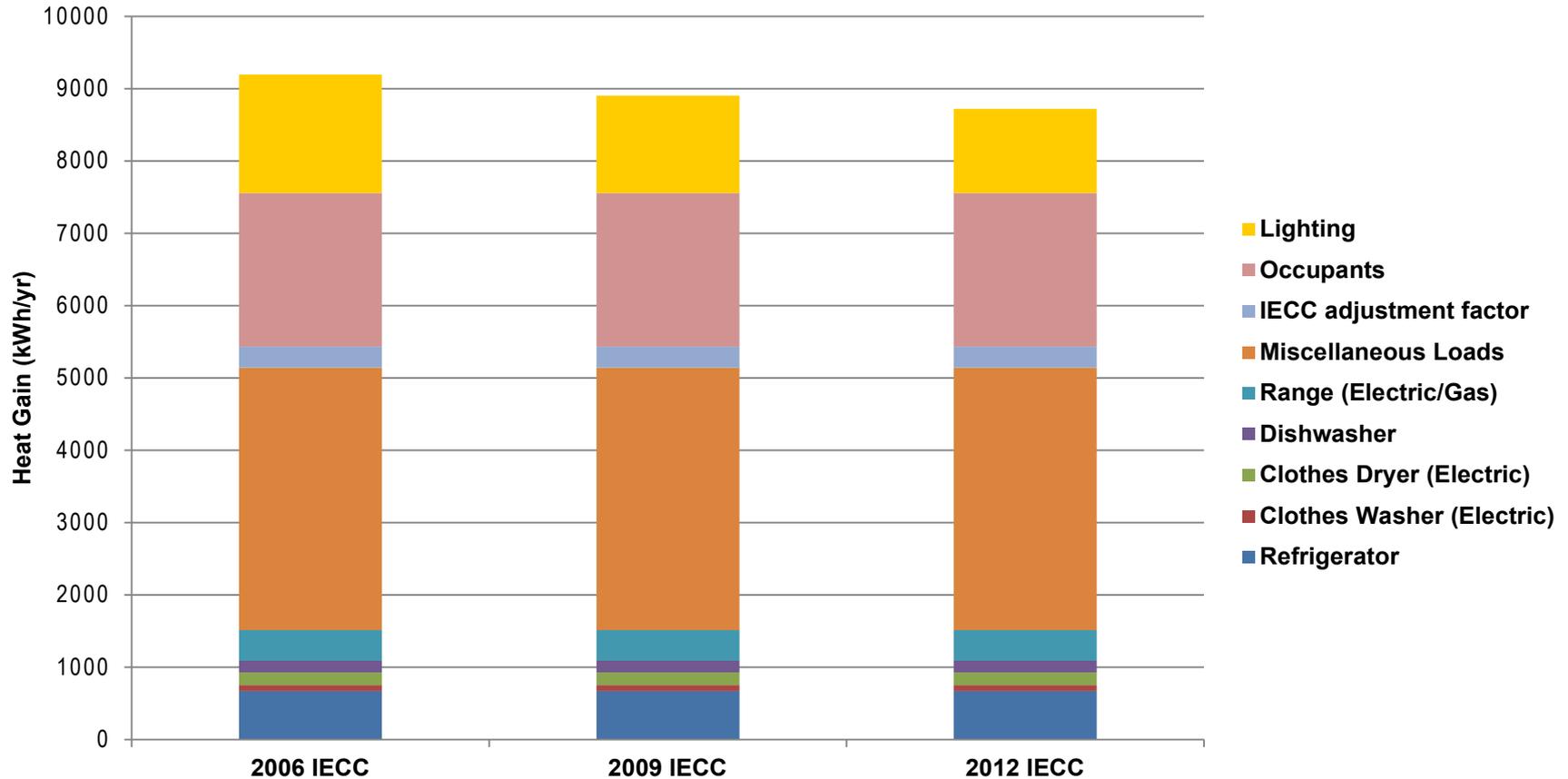
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# Important Assumptions

- ▶ **Mechanical ventilation assumed for all three codes: 2006, 2009, and 2012 IECC**
  
- ▶ **Air leakage:**
  - 8 ACH50 for 2006 IECC (no testing required)
  - 7 ACH50 for 2009 IECC (more sealing requirements, testing is optional)
  - 5 or 3 ACH50 for 2012 IECC (testing is required)
  
- ▶ **Wall construction**
  - 2x4 walls have 16” framing spacing, 2x6 walls have 24” spacing
  - R-5 insulating sheathing assumed to be in addition to (not replacing) OSB/plywood panels



# Internal Heat Gains Assumed in Simulations: Single-Family



Source: Building America Benchmark definition



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# Heating Equipment Percent Shares: Single-Family

Census Division	Electric Heat Pump	Gas Heating	Electric Furnace	Oil Heating
New England	10.8	57.0	1.1	31.1
Middle Atlantic	24.5	69.2	1.7	4.6
East North Central	22.5	76.2	0.7	0.5
West North Central	39.6	56.7	3.4	0.2
South Atlantic	78.9	19.0	2.0	0.1
East South Central	68.9	28.9	2.1	0.0
West South Central	37.5	48.1	14.5	0.0
Mountain	19.4	77.8	2.6	0.2
Pacific	34.0	62.9	2.9	0.2

Source: 2009 NAHB Builder Survey data

*Heating fuels have different costs and heating equipment types have different efficiencies.*



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# Heating Equipment Percent Shares: Multifamily

Census Division	Electric Heat Pump	Gas Heating	Electric Furnace	Oil Heating
New England	3.0	66.0	0.7	30.4
Middle Atlantic	39.5	49.6	4.9	6.1
East North Central	3.3	96.5	0.1	0.1
West North Central	24.8	68.0	4.3	3.0
South Atlantic	74.9	24.2	1.1	0.0
East South Central	94.1	1.8	4.1	0.0
West South Central	14.6	21.4	64.1	0.0
Mountain	2.8	97.2	0.0	0.0
Pacific	14.9	84.2	0.8	0.2

Source: 2009 NAHB Builder Survey data

# Foundation Percent Shares: Single-family & Multifamily

Climate Zone	Crawlspace	Heated basement	Slab	Unheated Basement
1	0%	0%	100%	0%
2	5%	0%	95%	0%
3	15%	10%	70%	5%
4	20%	30%	40%	10%
5	20%	45%	20%	15%
6	10%	65%	5%	20%
7	5%	70%	5%	20%
8	5%	70%	5%	20%

Source: DOE 2009 Residential Energy Consumption Survey (RECS)

*The IECC has different insulation requirements for the different foundation types.*

# Housing Building Permit Data for Calculating Zone and National Averages

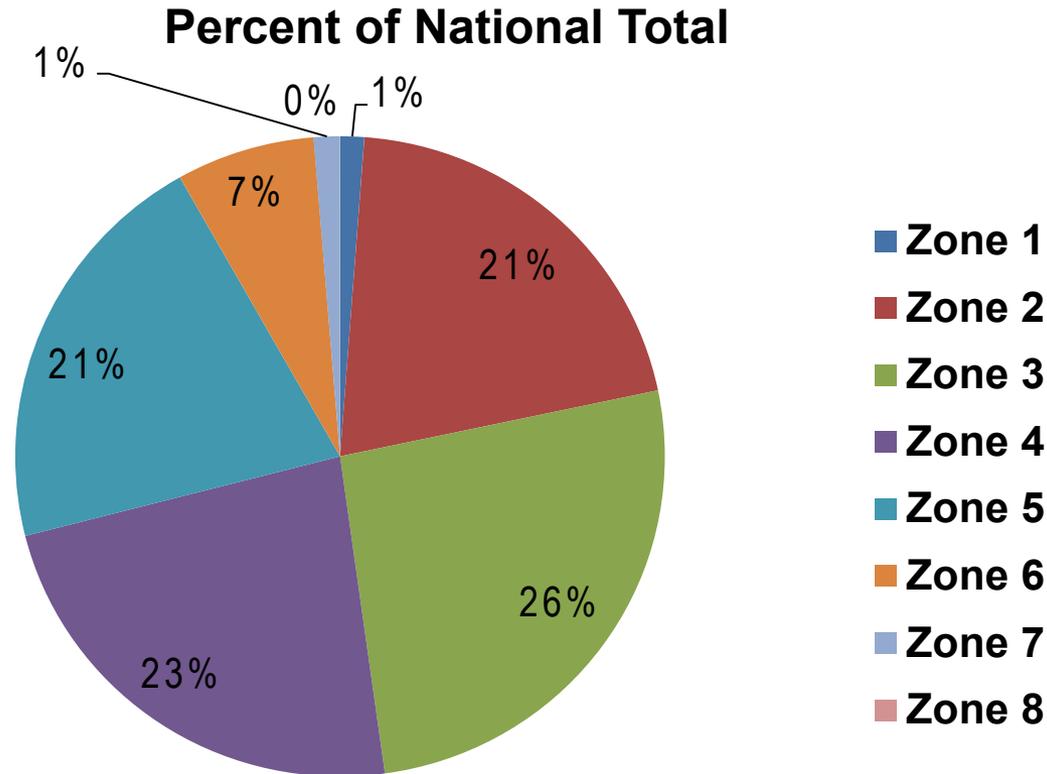
Zone	Single-Family	Multifamily (low-rise)	Combined	% of national total
1	4248	2195	6443	1.2
2	96,420	13,715	110,135	20.5
3	114,038	26,106	140,144	26.1
4	100,716	24,048	124,764	23.2
5	93,068	18,842	111,910	20.8
6	30,065	6872	36,937	6.9
7	5479	1280	6759	1.3
8	65	0	65	0
<b>National Total</b>	<b>444,099</b>	<b>93,058</b>	<b>537,157</b>	<b>100</b>

Source: Census 2010 Building Permits Data



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# Shares of New Construction by Climate Zone



***Most new construction is in climate zones 2 to 5.***

# Fuel Prices

	National Average	Example State - Massachusetts
Electricity – Winter	11.1 cents/kWh	14.8 cents/kWh
Electricity – Summer	12.0 cents/kWh	14.9 cents/kWh
Natural Gas	\$0.963/Therm	\$1.405/Therm
Fuel Oil	\$23.7/MBtu	\$24.06/Mbtu

Source: DOE Energy Information Administration

*All fuel prices are recent residential prices specific to each state.*

# Construction Cost Increase for 2006 to 2009- IECC: Single-Family

Climate Zone	Foundation type	Duct sealing and testing	Improved Air sealing	R-19 to R-20 walls	Windows 0.30 SHGC and lower U	Windows U-0.40 to 0.35	R-30 to R-38 Floors	R-19 Basement wall insulation	50% Energy Efficient Lighting	TOTAL
1	All	\$375	\$120		\$989				\$30	\$1514
2	All	\$375	\$120		\$989				\$30	\$1514
3 – South	All	\$375	\$120		\$989				\$30	\$1514
3 – North	Heated Basements	\$375	\$120		\$989			\$500	\$30	\$2014
3 – North	All but heated basements	\$375	\$120		\$989				\$30	\$1514
4	All	\$375	\$120			\$104			\$30	\$629
5	All	\$375	\$120	\$414					\$30	\$939
6	Heated Basements	\$375	\$120	\$414				\$255	\$30	\$1194
6	All but heated basements	\$375	\$120	\$414					\$30	\$939
7 and 8	Heated basements	\$375	\$120					\$255	\$30	\$780
7 and 8	Floors over unconditioned spaces	\$375	\$120				\$288		\$30	\$813
7 and 8	Slab on Grade	\$375	\$120						\$30	\$525



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# Construction Cost Increase for 2009 to 2012- IECC: Single-Family

Climate Zone	Foundation type	Envelope sealing	Blower door test	Windows - 0.25 SHGC and lower U	Increased ceiling insulation	Increased wall insulation	Hot water pipe insulation	Further duct sealing	75% energy efficient lighting	R-19 Basement wall insulation	TOTAL
1	All	\$480	\$135	\$493			\$400	\$100	\$51		\$1659
2	All	\$480	\$135	\$493	\$336		\$400	\$100	\$51		\$1995
3	All	\$480	\$135	\$493	\$336	\$533	\$400	\$100	\$51		\$2528
4	All	\$480	\$135		\$336	\$533	\$400	\$100	\$51		\$2035
5	Heated basement	\$480	\$135	\$64	\$336		\$400	\$100	\$51	\$255	\$1821
5	All but heated basement	\$480	\$135	\$64	\$336		\$400	\$100	\$51		\$1566
6, 7 and 8	All	\$480	\$135	\$64		\$1,567	\$400	\$100	\$51		\$2797



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# Construction Cost Increase for 2006 to 2009- IECC: Multifamily

Climate Zone	Foundation type	Duct sealing and testing	Improved Air sealing	R-19 to R-20 walls	Windows 0.30 SHGC and lower U	Windows U-0.40 to 0.35	R-30 to R-38 Floors	R-19 Basement wall insulation	50% Energy Efficient Lighting	TOTAL
1	All	\$255	\$60		\$327				\$18	\$660
2	All	\$255	\$60		\$327				\$18	\$660
3 – South	All	\$255	\$60		\$327				\$18	\$660
3 – North	Heated Basements	\$255	\$60		\$327			\$73	\$18	\$733
3 – North	All but heated basements	\$255	\$60		\$327				\$18	\$660
4	All	\$255	\$60			\$34			\$18	\$367
5	All	\$255	\$60	\$149					\$18	\$482
6	Heated Basements	\$255	\$60	\$149				\$37	\$18	\$519
6	All but heated basements	\$255	\$60	\$149					\$18	\$482
7 and 8	Heated basements	\$255	\$60					\$37	\$18	\$370
7 and 8	Floors over unconditioned spaces	\$255	\$60			\$96			\$18	\$429
7 and 8	Slab on Grade	\$255	\$60						\$18	\$333



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# Construction Cost Increase for 2009 to 2012- IECC: Multifamily

Climate Zone	Foundation type	Envelope sealing	Blower door test	Windows - 0.25 SHGC and lower U	Increased ceiling insulation	Increased wall insulation	Hot water pipe insulation	Further duct sealing	75% energy efficient lighting	R-19 Basement wall insulation	TOTAL
1	All	\$240	\$135	\$163			\$200	\$100	\$29		\$867
2	All	\$240	\$135	\$163	\$112		\$200	\$100	\$29		\$979
3	All	\$240	\$135	\$163	\$112	\$191	\$200	\$100	\$29		\$1170
4	All	\$240	\$135		\$112	\$191	\$200	\$100	\$29		\$1007
5	Heated basement	\$240	\$135	\$21	\$112		\$200	\$100	\$29	\$37	\$874
5	All but heated basement	\$240	\$135	\$21	\$112		\$200	\$100	\$29		\$837
6, 7 and 8	All	\$240	\$135	\$21		\$562	\$200	\$100	\$29		\$1287



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# Contact Information

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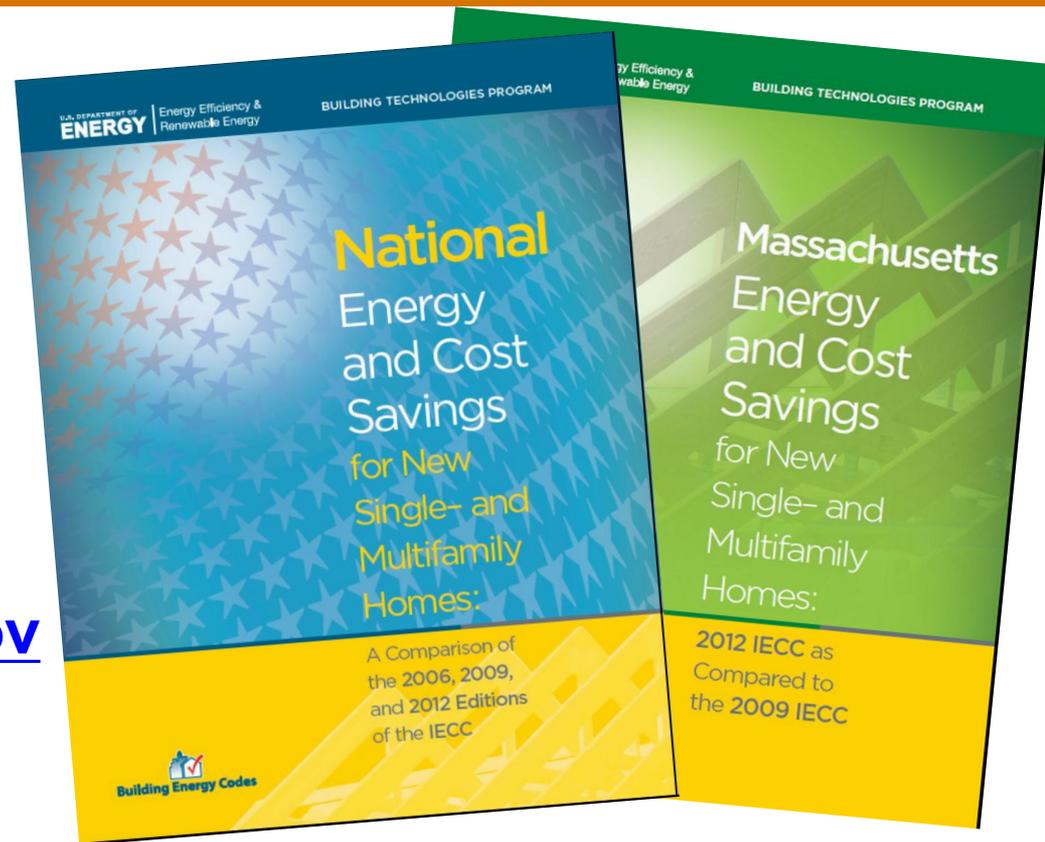
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**509 372-6554**

**<http://www.energycodes.gov/development/residential/>**



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