

Reaching ASHRAE 90.1-2007 Wall Insulation Levels in Commercial Buildings

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ABSTRACT

Wall Insulation is an effective way to save energy, reduce heating and cooling costs and keep building occupants comfortable all year long. For the first time in over 19 years, ASHRAE (The American Society of Heating, Refrigerating and Air-Conditioning Engineers) has adopted a significant increase in the minimum required prescriptive R-value (resistance to heat flow) for wall insulation levels. ASHRAE Standard 90.1 *Energy Standard for Buildings Except Low-Rise Residential Buildings*, the national model energy code for commercial buildings, significantly increases wall insulation for mass, steel frame and wood frame walls. These energy efficiency improvements will require new products and systems for reaching these insulation requirements. This presentation will address this newly adopted standard and also provide insight into resources that will assist in evaluating the energy savings of these increases for a particular building in a specific climate zone.

INTRODUCTION

The moment has arrived. Over the past 15 years or so, all the education about energy efficiency of buildings, all the talk about the environmental benefits of energy efficiency, all the advocacy about the moral obligation to support energy efficiency, and commitments to the lofty goals of so many organizations to get to net-zero buildings have resulted in baby steps in improving energy efficiency of commercial buildings. What has most recently been most effective to make major strides in improving energy efficiency? Our pocketbooks! Economists get it right sometimes. It has taken gasoline to hit the magical \$4.00+ per gallon for the US public to begin to change its driving behavior. So too has the situation with rising utility prices resulted in building owners looking hard at what can be done to reduce energy costs.

Now add into the mix the new building envelope requirements contained in ASHRAE 90.1-2007 *Energy Standard for Buildings Except Low-Rise Residential Buildings* along with new regulatory approaches to reduce greenhouse gases. Result - the table has been set for increasing use of PIR and PUR insulation products in commercial buildings.

BRIEF HISTORY OF ENERGY CODES IN THE UNITED STATES

As is the case with most public policy actions, we first needed an incentive to address energy use in buildings. The motivation was the first energy crisis – the Oil Embargo of 1973. In the early part of that year, the United States had been in an increasingly inflationary situation that was brought to a head in October 1973, when the Organization of Arab Petroleum Exporting Countries imposed an oil embargo on most western countries. This caused a drastic cut in supply and energy prices increases that at the time seemed impossible. These were the days of long lines or no fuel at all at gasoline stations. This year ended on a sour note when President Nixon announced that the national Christmas tree lights would not be turned on because of the energy crisis.¹

This shock to the US view on energy caused Congress to pass the Energy Policy and Conservation Act (EPCA) in 1975, which instituted a system of oil price regulation and allocation. In 1978, an amendment was passed requiring states receiving financial assistance from the federal government to initiate "mandatory programs and measures, including: energy conservation standards for new buildings".²

With this federal incentive, states began development of regulations on energy use in buildings. Federal and state governments began funding projects to better understand uses of energy in buildings as well as to explore opportunities to reduce energy use. This understanding led to standards organizations, like the American Society of Heating,

¹ 25th Anniversary of the Oil Embargo of 1973, U.S. Energy Information Agency, 1998

² Building Code Assistance Program, www.bcap-energy.org

Refrigerating, and Air-conditioning Engineers (ASHRAE) and ASTM International to develop some way to measure both product and building energy performance. For example, in 1975, ASHRAE published its first version of a model energy efficiency standard for commercial buildings—ASHRAE 90 (now ASHRAE 90.1).

In the period from 1973 to the mid-1980's when prices continued at high levels, there was strong impetus to improve end use energy efficiency, reduce dependence on oil imports and increasing American oil production.

Once oil prices came down, however, in the mid to late 1980's, share of oil imports rose, efficiency gains lagged and domestic oil production fell. Although the ASHRAE 90.1-1989 version did contain minimum R-value requirements for the building envelope, there was no significant change in energy efficiency consciousness until 1992, when the Energy Policy Act (EPA) was adopted. As part of this legislation, the U.S. Department of Energy was authorized to determine energy efficiency stringency of model energy codes that were in effective at that time:

- 1992 Council of American Building Officials (CABO) Model Energy Code (MEC) for residential construction, and
- ASHRAE Standard 90.1-1989 for commercial buildings.

This assessment role for the U.S. Department of Energy (DOE) continues today. After DOE determines that a new revision of ASHRAE 90.1 provides increased energy efficiency, each state has 2 years to certify that it has made revisions to its own energy code, so that it meets or exceeds the requirements of the latest version of the national models. A state may decline to adopt a residential energy code by submitting a statement to the Secretary of the DOE, detailing its reasons for doing so. The CABO MEC was last promulgated in 1995 and has since been replaced by the International Energy Conservation Code (IECC).

For example, on January 4, 2001, the DOE issued a determination that the 1998 and 2000 IECC will improve on energy efficiency. On July 15, 2002, a positive determination was issued for ASHRAE Standard 90.1-1999.³ According to its own website, DOE is still in the process of assessing the 2007 version of ASHRAE 90.1. A deficiency of this process, in this author's opinion, is the lag time between development of new standards, DOE's determination and state or local adoption.

ENERGY CODE BASICS

As is the case with building codes, state and local energy codes are usually updated on a regular basis, but the process may differ from place to place. For example, in some states, the legislature may directly update the code through passage of a law. In others, such as the State of Florida, the legislature granted authority to the Florida Building Commission to update the code every three years. Other states, such as Colorado do not allow a statewide building code, so the responsibility of code adoption is left to cities or counties. Regardless of the agency updating the code, local amendments to the model energy code may also be added, based on climate, energy sources, or economic conditions. All of these possibilities for change add a great deal of complexity to building code compliance for manufacturers of products, systems or methods of construction, especially if their market is nationwide.

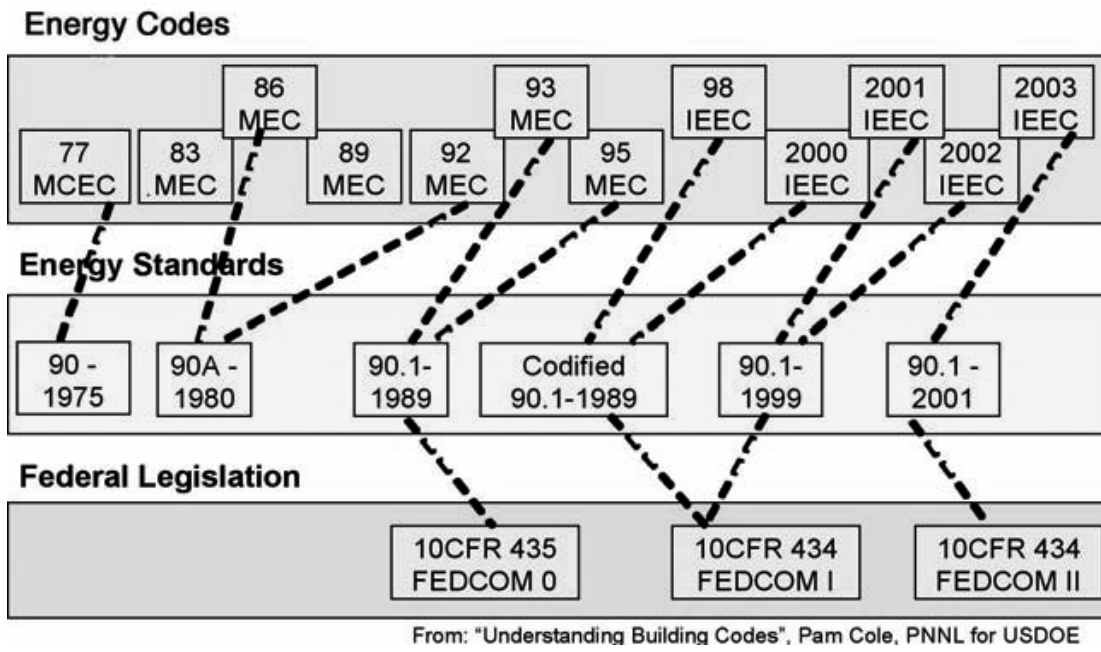
The best advice is to be aware that a code in a specific locality may vary greatly from model codes. Always consult the local jurisdiction for their specific requirements. One of the best resources for up to date information on state energy codes is the Building Code Assistance Project (www.bcap-energy.org), whose mission is to support states in efforts to strengthen and/or adopt, and implement new energy codes:

- Non-profit advocacy group based in D.C.,
- Founded in 1994 in response to 1992 EPA
- A joint initiative of the:
 - *Alliance to Save Energy*
 - *National Resource Defense Council*,
 - *American Council for an Energy Efficient Economy*
- BCAP's mission is to promote the adoption, implementation, and advancement of effective energy codes
- Funded primarily by U.S. Department of Energy
- Additional funding from foundations, industry, and other government agencies

Figure 1 provides a brief snapshot of how building codes, standards development, and federal regulation have historically traveled lockstep since the mid-1970s.⁴

³ Building Code Assistance Program, www.bcap-energy.gov

⁴ R. Christopher Mathis, *Insulation Beyond the Code*, Construction Specifier, August 2007.



Key:

MEC = Model Energy Code published by the Council of Building Code Officials, discontinued in 2000

IEEC = International Energy Conservation Code published by the International Code Council

Energy Standards = ASHRAE 90.1

10 CFR 434 and 435 = Energy Code for New Federal Commercial and Multi-Family High Rise Residential Buildings

Figure 1. Connections between Model Energy Codes, Energy Standards and U.S Legislation

Energy codes generally provide two methods for compliance: the prescriptive path and the performance approach. The dominance of one method over another varies widely, especially by locality. The prescriptive path is sometimes referred to as the “cookbook” method, i.e., a check off list of energy related items that must be incorporated into the house or commercial structure. Sometimes trade offs are allowed between specific building components, such as more ceiling insulation in a home in exchange for larger windows.

The performance approach provides the greatest degree of flexibility in building design. This method utilizes an energy budget or total allowable energy use. In general, any combination of building components and equipment is acceptable as long as the energy budget is not exceeded.⁵

THE COMMERCIAL BUILDING SECTOR

According to the US Energy Information Agency 2007 Annual Report, the buildings sector accounted for approximately 39% of all energy consumed in the United States. As shown in Figure 2, approximately 18% of all energy was used in the commercial sector. Figure 3 illustrates the rising trend in electricity consumption and the expenditures by energy type in the commercial sector.⁶

⁵ Building Code Assistance Program, www.bcap-energy.org

⁶ U.S. Energy Information Agency, 2007 Annual Report, <http://www.eia.doe.gov/emeu/aer/consump.html>

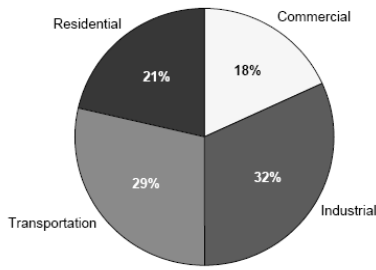


Figure 2. U.S. Energy Consumption by Sector

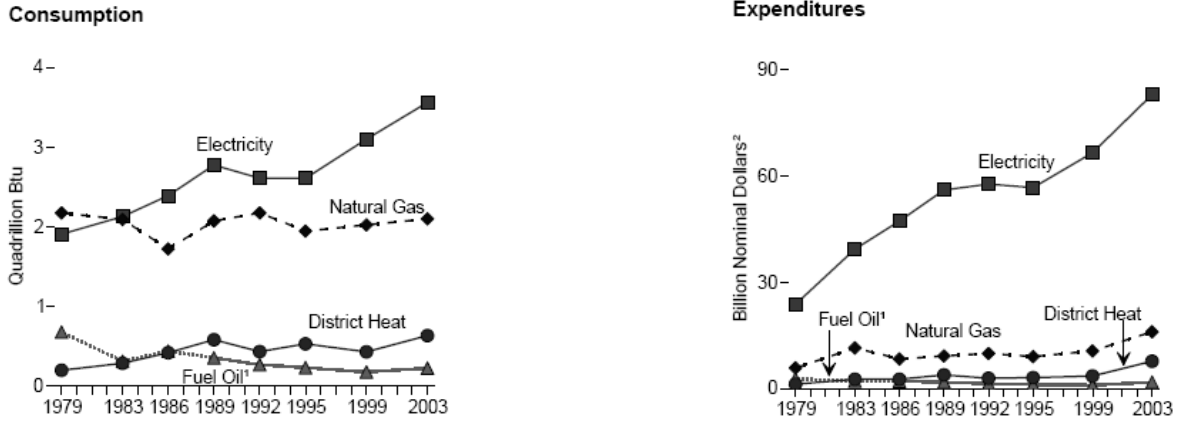


Figure 3. Commercial Building Sector Consumption and Expenditure Trends

When one considers that over 90% of electricity is generated by fossil fuels, as shown in Figure 4, the clear connection between reducing energy use and, in turn, reducing greenhouse gas emissions, in commercial buildings is irrefutable.

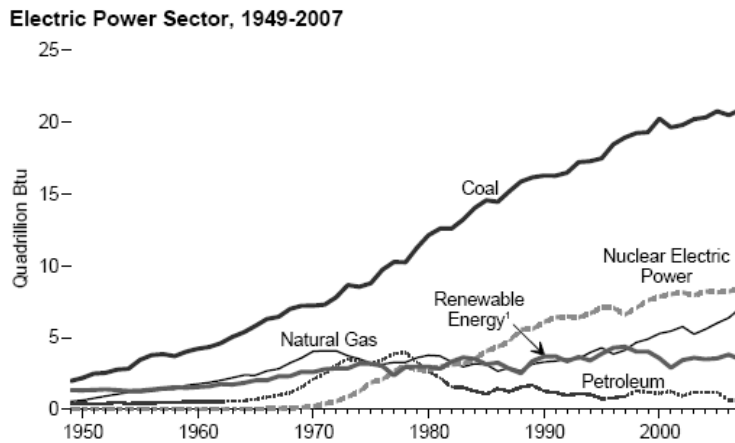


Figure 4. Fuels Used to Generate Electricity, U.S.

ASHRAE 90.1-2007 MINIMUM R-VALUES FOR ROOFS AND WALLS

ASHRAE Standard 90.1 *Energy Standard for Buildings Except Low-Rise Residential Buildings* applies to commercial buildings, high rise residential buildings (higher than 3 stories) and semi-conditioned spaces, such as warehouses, etc. It covers:

- New buildings and their systems
- New portions of buildings and their systems
- New systems and equipment in existing buildings

ASHRAE 90.1 is based on climate zones as shown in Figure 5.

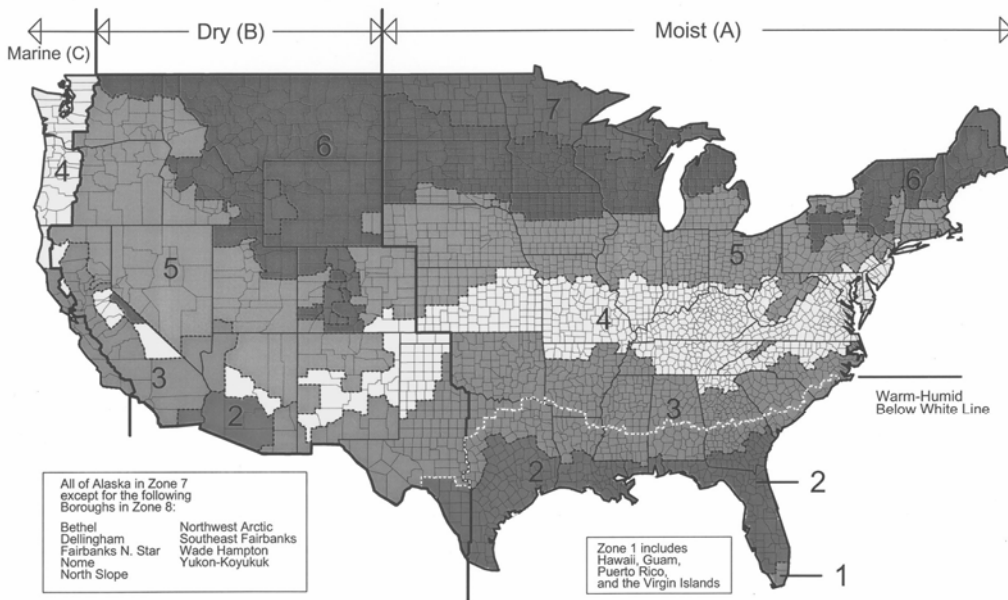


Figure 5. ASHRAE 90.1 Climate Zone Map

The newly adopted ASHRAE 90.1-2007 minimum R-values for the building envelope of commercial buildings are shown in Table 1.⁷ R-values are listed for the roof, based on continuous above roof deck insulation, or in the attic space. Wall R-values are identified by wall type.

Climate Zone	Roof R-Values (by Location) ci = continuous insulation		Wall R-values (by Type) ci = continuous insulation		
	Above Roof Deck	Attic	Mass (Masonry, Concrete)	Steel Frame	Wood Frame
1	15 ci	30	0	13 (cavity)	13 (cavity)
2	20 ci	38	5.7 ci	13 (cavity)	13 (cavity)
3	20 ci	38	7.6 ci	13 (cavity) + 3.8 ci	13 (cavity)
4	20 ci	38	9.5 ci	13 (cavity) + 7.5 ci	13 (cavity) + 3.8 ci
5	20 ci	38	11.4 ci	13 (cavity) + 7.5 ci	13 (cavity) + 3.8 ci
6	20 ci	38	13.3 ci	13 (cavity) + 7.5 ci	13 (cavity) + 7.5 ci
7	20 ci	38	15.2 ci	13 (cavity) + 7.5 ci	13 (cavity) + 7.5 ci
8	20 ci	49	15.2 ci	13 (cavity) + 15.6 ci	13 (cavity) + 7.5 ci

BUILDING ENVELOPE INSULATION

Roof Insulation

Polyiso boardstock and spray polyurethane insulations have dominated the commercial roof market as continuous insulation above the roof deck at a time when the minimum R-value was 15. This new increase to R-20 (except in Zone 1) sets a new bar, and once certified by the US Department of Energy (DOE), exceeds all current state energy codes. It also dramatically increases roof R-values for those “beyond the code” programs like Energy Star and the U.S. Green Buildings Council’s Leadership in Energy and Environmental Design (LEED) where these programs offer points for exceeding the code by 15%, 30%, 50%, etc. The market expansion for PUR/PIR products will be realized in thicker insulation. Technical adaptations to these increased thicknesses at roof curbs and parapets may be necessary.

Attic Insulation

In recent years, attic insulation has been a high growth market for both open and closed cell spray polyurethane insulation. This increase in minimum R-values will continue to drive the market toward PUR/PIR and away from not in kind insulations like fiber glass and cellulose.

Wall Insulation

⁷ ASHRAE 90.1-2007 *Energy Standard for Buildings Except Low-Rise Residential Buildings*, published by ASHRAE at www.ashrae.org

In many ways the prime market opportunity presented by ASHRAE 90.1 – 2007 for PUR/PIR insulation is in commercial wall applications, most notably mass (concrete and masonry) and steel frame. These new minimum R-values for walls cause some design implications that can only be resolved through the use of PUR/PIR insulations.

Insulating mass walls can take several forms:

- Cavity Wall – A cavity wall consists of two wythes of masonry, separated by a cavity of varying dimensions. The wythes are generally tied together with corrosion resistant wall ties and are separated by an air space and a layer of insulation board on the exterior of the inner wythe. Wythes may consist of solid brick, hollow brick, structural clay tile, solid concrete, or hollow concrete units (block). See Figure 6.

As stated by the Masonry Advisory Council, “an airspace is designed between the veneer and backup to allow moisture to drain down the cavity and exit at flashing and weep holes. A clean airspace provides a space for water to drain down where it can be directed to the exterior at flashing locations. The purpose of a cavity wall is to manage water by removing it to the outside, not collect it in the cavity space.”⁸

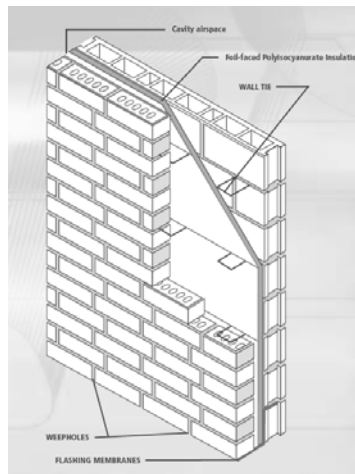


Figure 6. PIR Insulated Cavity Wall

When rigid insulation is placed inside the cavity, a 1” air space must be maintained. Since the required R-value for insulating these types of wall has increased, use of high R-value foil-faced polyiso insulation, allows the architect, designer, specifier, and contractor to provide the best insulation value while maintaining the correct air space design requirement and the most cost effective wall design.

- Concrete block walls – Solid concrete block walls can be easily insulated with PUR/PIR insulations, whether boardstock or spray applied. In general, if applied on the inside of the wall, a thermal barrier, such as ½” gypsum board is necessary. If installed on the exterior of the wall, a weather resistant barrier, such as stucco or other exterior finish may be used.
- Tilt-up Panels – Tilt-up concrete construction is accomplished by casting walls and even, in some cases, roofs either on the job site or in a manufacturing facility. As shown in Figure 7, the panels are then lifted into place and structurally secured.

⁸ Masonry Cavity Wall Design Guide, Masonry Advisory Council, www.maconline.org



Figure 7. Tilt-up Wall

According to the concrete industry, over 15% of all industrial buildings are tilt-up, ranging in size from 5000 to over 1.5 million square feet.⁹ In this type of construction, the insulation can be installed on the exterior of the wall with a weather resistant finish, on the inside wall, or most effectively, by using the “sandwich” approach. In this case a layer of rigid insulation is placed between two layers of concrete, and then the entire insulated panel is lifted into place. The increased R-values called for by ASHRAE 90.1-2007 definitely will require higher R-value/inch than is now currently used. PUR/PIR fits the need very well.

For steel frame walls, ASHRAE 90.1-2007 recognizes the thermal short circuiting, or energy loss that occurs at the steel frame. Insulating the cavity alone is just not adequate. By installing polyiso boardstock on the exterior of the steel frame, the energy loss at the highly conductive steel frame is drastically reduced. Having the new requirements for continuous insulation on the interior or exterior of steel frame commercial buildings will drive demand for high R-value/inch insulations, such as PUR/PIR.

A WORD ABOUT “BEYOND THE CODE” PROGRAMS

As a reminder, all model codes and standards, such as ASHRAE 90.1 are *minimum values* – in other words, construction can’t be any worse than the code. The prospects for ever rising energy prices, and indeed, insecurity about energy availability are causing architects, designers, contractors and building owners to demand higher energy efficiency for their buildings. There are many such programs, either in place or in development. A few examples:

- USGBC LEED programs
- Energy Star
- ASHRAE *Advanced Energy Design Guides* for various building types
- Architecture 2030.org
- The Building Energy and Environmental Program (BEEP) instituted by the Building Owners and Management Association (BOMA) has aimed for a 30% reduction in energy use in commercial buildings. To this end, BOMA has a series of six webinars (also available on CD and Audio) that are designed to educate building energy managers on the value of energy efficiency improvements:
 - Introduction to Energy Performance
 - How to Benchmark Energy Performance
 - Energy Efficient Audit Concepts and Economic Benefits
 - No- and Low-Cost Operational Adjustments to Improve Energy Performance
 - Valuing Energy Enhancement Projects and Financial Returns
 - Building an Energy Performance Awareness Program

⁹Concrete Buildings, Tilt-up and ICF Concrete Buildings, <http://www.concretebuildings.org/Tilt-Up%20Home.html>

- Development of ASHRAE 189 Standard for the Design of High-Performance Green Buildings except Low-Rise Residential Buildings is currently underway.

It is also worthy to note that most energy codes and standards address new construction, yet the vast majority of existing buildings are poorly insulated. Attempting to increase thermal performance of the building envelope during renovation or repair by aiming at these standards and energy code requirements for new buildings will result in improved occupant comfort, reduced energy costs and environmental benefits.

SUMMARY

Although ASHRAE 90.1-2007 has made a tremendous leap forward in improving the energy efficiency of the building envelope, much work remains. The best advice to architects, designers, specifiers, contractors and building owners is, “don’t wait for the state.” Make energy efficiency decisions based on the long term use of the building and gain economic and environmental benefits as well. PUR/PIR insulation became a market force during the first energy crisis in 1973 and is poised to once again provide perfect answers to this new demand.

REFERENCES

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BIOGRAPHIES

Lorraine Ross



Lorraine Ross is President of Intech Consulting Inc., a building code development and technical assistance company based in Gulfport, FL. She has been involved in the building code arena since 1984, and has served on many code-related technical advisory panels. She is closely involved in code development nationwide and in a number of individual state activities especially the state of Florida. Lorraine is also Vice President of BRB Code Educators Inc., a building code and technical training company accredited by the state of Florida as a course provider for continuing education that is required for license renewal by contractors, architects and code administrators.