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Whose Needs, Expectations and Performance?

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Abstract:

In the industrialized world the process of developing a Building Code, performance based or otherwise, has many common features. It is inevitably a bureaucratic, multi-interest, and relatively slow exercise. However, in the US, the issues of adoption, acceptance, implementation and enforcement tend to be unique. This presentation discusses some recent experience with developing and implementing building codes in Pennsylvania.

In November 1999, the Pennsylvania Legislature passed Act 45, known as the Uniform Construction Code (UCC), into law mandating a state-wide Building Code. At that time, it was evident that two codes, the so-called International Residential Code 2000 and the International Building Code 2000, were to be adopted and applied state-wide. For Pennsylvania, this initiative was indeed revolutionary as the state would not only have new codes but, more importantly, these codes would apply everywhere in the state. Predictions are that, at long last, the legislation will be implemented fairly soon.

With over 2,500 municipal authorities PA is probably the most democratic in the nation and certainly near the top of the anti-regulation league-table. Remarkably, the building industry, especially the home builders' association, in the state has been very supportive of the legislation. To date, the Pennsylvania Housing Research/Resource Center has played an important but independent third-party role.

The experience in PA has been both enlightening and productive. In this paper, an attempt is made to summarize this experience. Context, political initiatives, technical issues and procedural realities are discussed. The focus is largely on energy provisions for low-rise residential facilities. Where relevant, aspects of performance are considered.

KEY WORDS:

building code, energy conservation, regulation, residential buildings, houses, performance

Introduction

A Building Code is the written product of a committee and the committee members bear considerable resposibility to numerous constituents, especially to the consumer and to the related profeesionals. Building codes, however, need to be initiated, developed, evaluated, approved and then implemented and maintained. The overall process takes time, it is always political, conflict of interest is unavoidable and gratitude is usually in short supply.

The Commonwealth of Pennsylvania is in the throes of implementing new state-wide building codes, a long overdue and momentous event for the building industry. The Pennsylvania Housing Research/Resource Center (PHRC) has been involved in the overall process from an early stage. To date, the PHRC has played an important but independent third-party role which included:

- Proposing and organizing the Pennsylvania Code Training Consortium
- Developing the Alternative Residential Energy Provisions
- Acting as a technical resource to government and others, and
- Developing and delivering the most extensive training program for the housing industry (builders, municipal officials, suppliers, etc.) ever conducted in Pennsylvania.

Our involvement has been effective, productive and edifying. Previous code committee experience does not prepare one for the non-technical dynamics of the overall code process. Early involvement provided a unique opportunity to meet most of the players, to understand some of the politics, to appreciate the realities of Pennsylvania and to develop a better appreciation of what codes should really be trying to do.

The primary objective of this paper is to summarize and document the experience and to identify and discuss some of the issues. The focus is largely on low-rise residential buildings with emphasis placed on space conditioning energy provisions. Aspects of performance will be commented upon where appropriate.

Context: The situation in Pennsylvania [1]

Pennsylvania is one of only 14 states nationwide (and one of two states in the Northeast) that do not have either commercial or residential state-wide building codes. Most states and all the major cities do have some form of comprehensive building code for commercial buildings; however, 15 states do not have a state wide code. Residential buildings appear to be less regulated in that 26 states do not have a state-wide residential building code.

Pennsylvania, with its 2,566 units of local government (cities, towns, boroughs, townships), is considered by too many to be the model of Jeffersonian self-rule. Only one other state (Illinois) has more units of local government. The establishment and enforcement of building codes in

Pennsylvania, with a few exceptions, is at the discretion of these units of local governments. This approach is somewhat unusual. The most common approach is for a code to be established at the state level, with enforcement carried out by county government.

A total of 1,443 municipalities, or over 56%, do not have a building code on the books. Of the 1,123 municipalities that reported having a building code, 74% use the BOCA (Building Officials and Code Administration) code. The prominence of BOCA is not surprising considering that it is used by most of the states in the Northeast. The remaining municipalities used a CABO (Council of American Building Officials) code, or a fire protection manual (FPM), or a local code or local ordinance (LCLO). 15% did not report which code, if any, was in use.

As shown in Figure 1, the majority (57%) of the coded municipalities use an up-to-date code, issued between 1990 and 1998, while 28% of the remainder used a code issued between 1970 and 1989. It was noted that some municipalities are using building codes dating from the 1920's and 1930's.

Source: DCED Local Government Survey

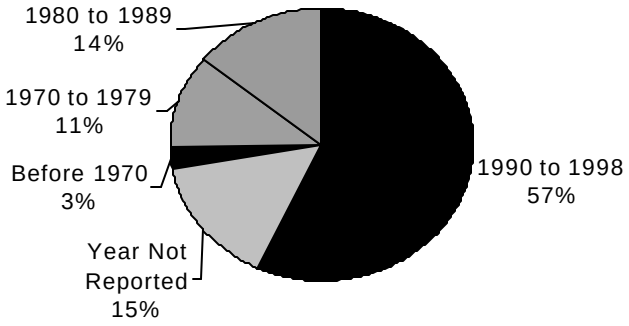

Figure 1: Coded local governments and date of building code in force

Given the variety and age of the codes and the myriad of possible local modifications, the code situation for housing across the Commonwealth could, at best, be described as a disjointed patchwork. This lack of uniformity causes real problems for design professionals and builders who must identify and then comply with the regulations. A related and unreported issue is of course enforcement. The fact that an applicable code can be identified does not guarantee implementation; the smaller the jurisdiction the less the likelihood of implementation.

The lack of a uniform, state-wide building code means that many residents of Pennsylvania, whether they are buying or building a home, have little, if any, assurance that the house has been designed and built or will be built to an appropriate set of qualitative standards. In addition, many builders and developers have problems with the lack of uniformity in standards and variability in enforcement.

Pennsylvania is the most rural state in the nation. This means that a larger proportion of residents live in rural areas than is the case in any other state. They are also living in smaller municipalities or other local government units which, in turn, are less likely to have or even enforce a building code. Approximately 20% of the population of Pennsylvania lives in non-coded areas of the state. A more troublesome finding was that approximately 21.5% of the fastest-growing municipalities did not have building codes. These municipalities account for approximately 31.9% of the housing starts.

The situation in Pennsylvania finally reached the stage that the builder community lobbied for political action to address the need for uniformity and commonality. As the home building industry is usually considered to be conservative and anti-regulation, this pro-active step probably reflects the seriousness of the problem.

Legislative Action

In November 1999, the Pennsylvania Legislature passed the Uniform Construction Code (UCC) legislation into law mandating statewide building codes, one for commercial buidings and another for low-rise residential buildings, across Pennsylvania. The Act requires the Pennsylvania Department of Labor and Industry (DLI) to promulgate regulations to implement the requirements of the legislation. In addition, the law included a provision to consider the development of alternative, prescriptive methods for energy conservation that account for the various climatic regions in the Commonwealth. In deriving these energy standards, the DLI was to seek to balance energy savings with initial construction costs.

At the time, it was evident that the International Code Council's International Residential Code (IRC) 2000 was to be adopted as the statewide code for low-rise housing in PA. The energy provisions are covered in Chapter 11, Energy Efficiency. In December 1999, members of the PHRC Advisory Committee asked the Pennsylvania Housing Research/Resource Center (PHRC) to develop an alternative version of Chapter 11, *Energy Efficiency*, in the IRC 2000. In addition we were asked to consider and evaluate another prescriptive version of the energy requirements in Chapter 11 of the IRC 2000 that had been developed by the National Association of Home Builders (NAHB). This evaluation was to determine if the NAHB proposed path was equivalent to the IRC 2000 and whether it was appropriate for Pennsylvania's climate and construction practices.

On January 6, 2000, the PHRC initiated work on the development of an alternative prescriptive version of Chapter 11 in the IRC 2000 that would be:

- simpler
- more rational
- more flexible
- focused on Pennsylvania

- equivalent to the provisions of the IRC 2000 in relation to space conditioning energy consumption

- independent, as far as possible, of other documents, specifically the IECC, NFRC, IBC, and other documents.

The legislation was quite clear about one thing; the alternative energy code would have to be a prescriptive document, i.e., neither performance nor objective based. Our experience supports this instruction. It is our considered opinion that a distinction must be made between commercial (engineered) and low-rise residential (non-engineered) built facilities. They are different cultures. For low-rise residential construction a largely prescriptive code, but one with some performance provisions, is probably the most appropriate compromise.

After five months, a draft of the PA-Alternative to Chapter 11 of the IRC 2000 together with the draft versions of six supplementary reports was submitted to DLI. The PHRC's performance was, we thought, responsive, productive and appropriate. The following describes what we did to support the adoption process.

STRATEGIES FOR COMPLIANCE

The chart in Figure 2 illustrates how the proposed alternative path fits into the overall regulatory structure for Pennsylvania's UCC. Note that either the IRC 2000 or the PA-Alternative can be chosen while the 2000 IECC code and its options could, if desired or preferred, always be used. We consider this element of choice to be a very real benefit for both the builder and the consumer.

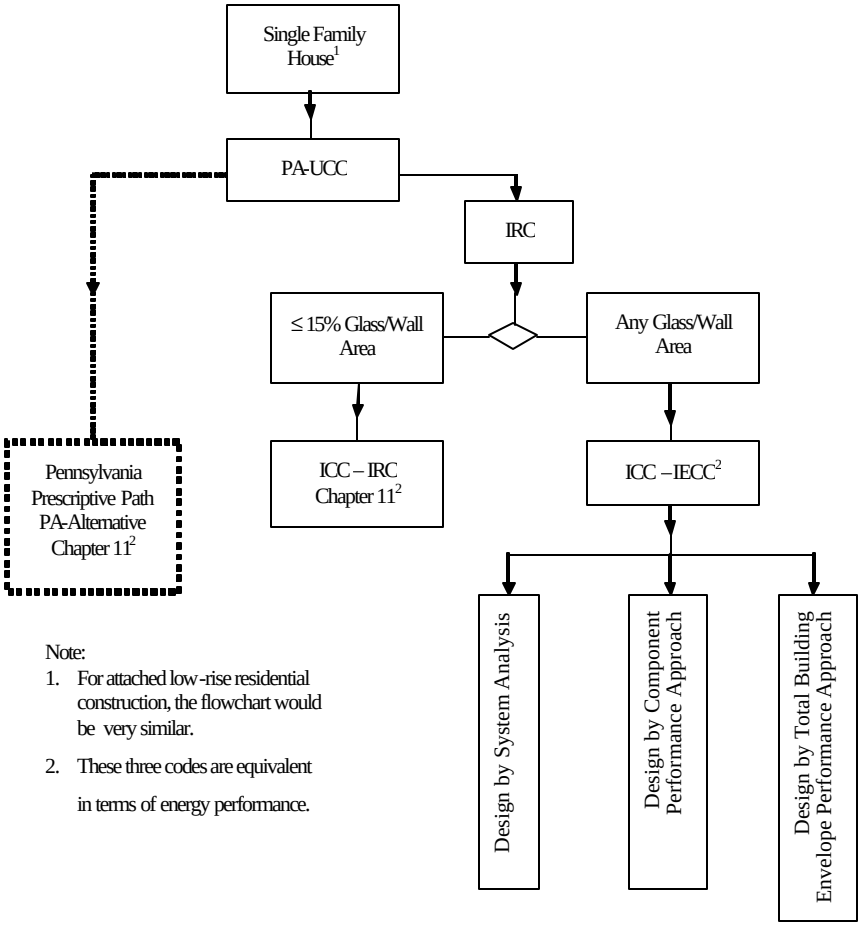

Figure 2: Flowchart Showing the Various Regulatory Paths

Development of the Alternative [2]

This exercise had six distinct parts. The following is a summary of those parts that are of technical interest.

1. Glazing Ratio [3]

The glazing ratio is defined as the area of glazing divided by the area of exposed exterior wall. The magnitude of the glazing ratio (less than or equal to 15% for detached houses, 25% for townhouses) is the major, up-front determinant as to whether the IRC Chapter 11 can be used. If greater than 15% or 25% a much more detailed and complex approach must be used. There are two problems with this: first, the builder has to do this up-front calculation and, second, these "national threshold values" may have little relevance for Pennsylvania.

Because of the very short timeframe available for the development and promulgation of the new state-wide building code, there was no time to undertake any sort of physical survey. It was decided to examine a set of Act 222 field data survey forms that were available. Act 222 of 1980 is the Building Energy Conservation Act that established the current energy standards for housing

in Pennsylvania. These standards will be superseded by the UCC. Under Act 222, new home owners can request that their home be inspected for compliance with Act 222's energy provisions.

For the purpose of planning for space conditioning energy conservation, the survey data was more than sufficient to permit the following **conclusions** to be drawn:

- For new, detached, single-family houses in Pennsylvania the average glazing ratio, irrespective of whether it is based on exposed wall area or heated floor, is significantly less than 15%, which is the target glazing ratio for Chapter 11 in the IRC 2000.

- An average value of about 12% would seem to be appropriate for a state-wide glazing ratio (relative to total exposed wall area) for new housing in Pennsylvania.

- For both mid- and end-unit townhouses, the glazing ratios, both wall and floor-based values, are less than 15% and thus much less than 25%, the target value used for Chapter 11 in the IRC 2000.

Clearly, there was little reason to impose this threshold on housing in Pennsylvania and good reason to remove this up-front exercise from any alternative energy code.

This data also produced some interesting **findings**:

- The determining factor in the decision as to where to place the windows in a house or townhouse is the orientation of the street. Solar advantage does not appear to be of much significance.

- In general, the largest proportion of the glazing is placed on the rear face of the house or town house unit. The front of the house or townhouse unit also has a large proportion of glazing while the sides have much less.

- The colder the climate, the lower the average glazing ratio.

- The smaller and/or less costly the house, the lower the average glazing ratio.

This last point raised an important issue. Codes traditionally addressed life, health and human safety concerns and compliance did not permit exclusions. Space conditioning energy consumption is a very different issue having more to do with commodity supply and future cost. Why in fact, if the overall energy use is, on average, well below a desirable threshold, should every house that is built have to meet a glazing ratio threshold? This issue was particularly important for the strategists and the lawers. We believe that common sense prevailed and the PA-Alternative code may have initiated a legal precedent. In this case, the performance of the lawyers was commendable.

2. Climatic Considerations [4]

The IRC 2000 and the IECC identify climatic zones on the basis of Heating Degree Days (HDD). Accordingly, in the IRC, Pennsylvania is covered by six zones. The **objective** of this brief project was to review weather records and data on housing starts and, within the very tight constraints on time and funds, assess the IRC 2000 climatic criteria.

The following **findings** were noteworthy:

1. The metropolitan areas of Philadelphia and Pittsburgh are critical in that they account for a significant proportion of all housing starts in Pennsylvania.

2. In the case of both Philadelphia and Pittsburgh, the listed HDD value is very close to a DOE climatic zone threshold value, e.g., 4,954 (46 HDD from 5000) and 5,957 (43 HDD from 6000) respectively; less than 1% in each case.

3. However, according to the 1981 ASHRAE Handbook of Fundamentals data, the HDD values for both cities actually depend on which weather station is used. Further, if another station (e.g., the airport) were to be used, the HDD value would cross the HDD threshold between climatic zones. It is also worth noting that the measured HDD value for a city or urban location is usually lower than that at an airport location.

4. If recent data from the PA Climatologist (web data source) were to be used then the HDD values of at least four cities (Reading, Lancaster, Erie and Bradford) would have to be revised and in each case a climatic zone threshold would be crossed.

5. For energy conservation planning purposes, it might also be better to use the sum of HDD and CDD values rather than HDD alone.

These findings are troubling in that they prompt questions, such as:

- why should the poltical boundaries that often delineate a region have any bearing on climate?

- would it not make practical sense to use population centers as the focal point for a climate zone for the purpose of regulation?

- why ignore cooling demands and which data does one choose to be representative of energy consumption in the buildings involved?

For the purposes of simplicity, brevity and equity, there was every reason to support a reduction in the number of climatic zones in Pennsylvania from six to three “space conditioning energy consumption” zones. The more rational climate map is shown in Figure 3.

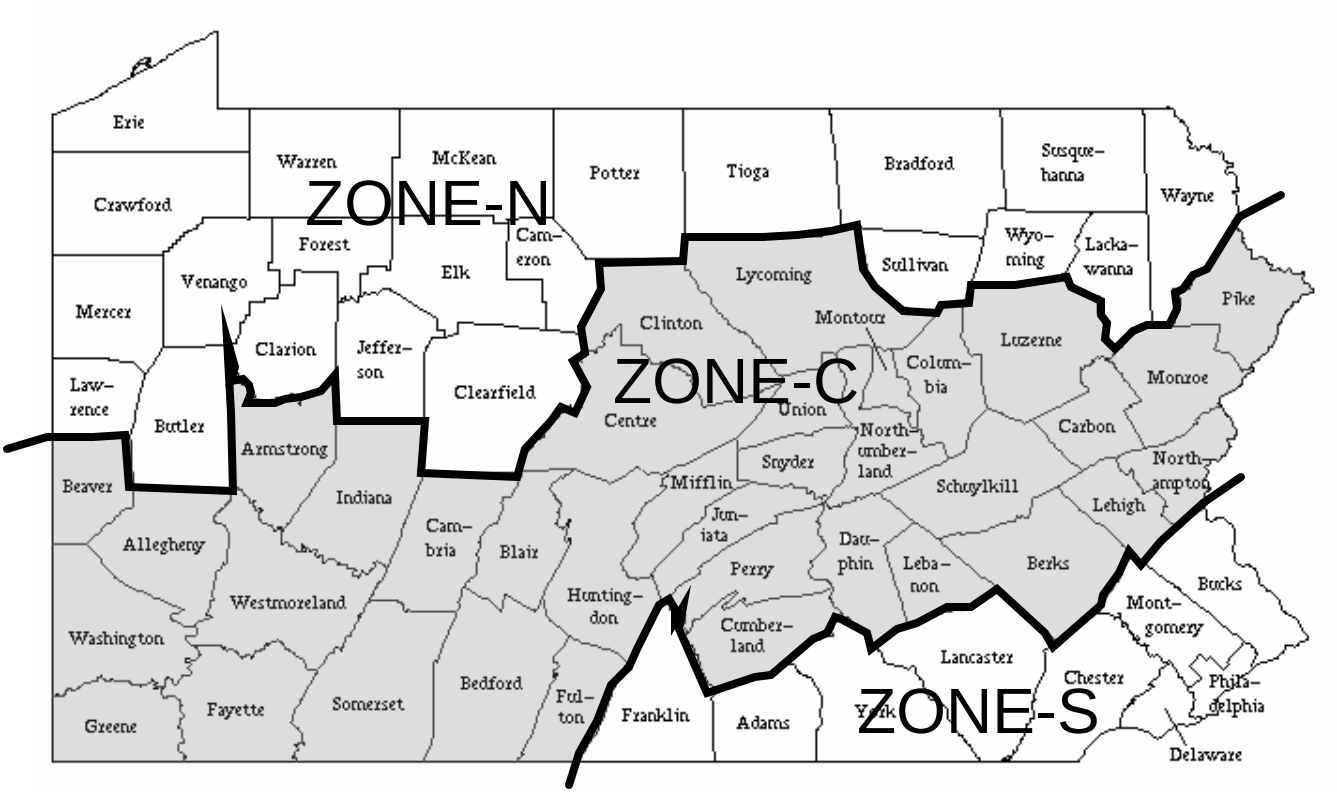

Figure 3: Climate Map for Pennsylvania

3. Drafting the Alternative Energy Code for residential construction [5]

This task comprised the drafting of the PHRC PA-Alternative Chapter 11: Code for the *Conservation of Space Conditioning Energy for Housing in Pennsylvania*. This alternative chapter has since been issued under the revised title of *Pennsylvania's Alternative Residential Energy Provisions*. Needless to say, there was significant opposition to this alternative code, especially, from the insulation industry, the steel industry and certain individuals. Some of the criticism concerned procedure: since the alternative code was drafted largely by two individuals in less than six months, the manner, the speed and the nature of some of the changes probably warranted some criticism and, at the very least, some discussion. This was provided as the regulations went through the customary approval process.

4. Code Justification

It was essential that any changes made to the IRC 2000 code be demonstrably justified by means of energy consumption equivalence. We were obliged to evaluate and document this equivalence for first, the so-called thermal envelope and, second, for the trade-offs that were introduced into the alternative code.

4A. Energy Equivalence for the Thermal Envelope [6]

A study was conducted to compare the energy consumed for space conditioning by representative houses designed to meet five different energy codes, namely:

- **Act 222:** The Building Energy Conservation Act (Act 222 of 1980), and corresponding regulations that created the existing energy efficiency requirements for buildings in Pennsylvania.

- **2000 IECC, Chapter 5:** Chapter 5, Residential Building Design by Component Performance Approach, Section 502.2.1. On an individual component basis, the 2000 IECC provides performance requirements for building components (walls, floors, ceiling, etc). These requirements are for the entire component. For example, walls include the walls, windows and doors that are weighted by area to determine the combined thermal transmittance value. This section of the code for northern climates had remained basically unchanged since the 1992 Model Energy Code.

- **IRC 2000, Chapter 11:** Chapter 11, Energy Conservation, of the IRC 2000. This code is based on 15% window-to-wall area for detached houses and is essentially the same as *Chapter 6, Simplified Prescriptive Requirements for Residential Buildings*, Type A-1 and A-2, of the 2000 IECC.

- **NAHB Proposed Chapter 11:** The proposed code developed by the National Association of Home Builders (NAHB) as a replacement for the existing Chapter 11 of the IRC 2000.

- **PHRC PA-Alternative Chapter 11:** The PA-Alternative Chapter 11 developed by the PHRC.

A comprehensive thermal envelope comparison was performed using the overall heat loss (Uo) calculations and methodology as presented in *Comparison of Current State Residential Energy Codes with the 1992 Model Energy Codes (MEC) for One and Two Family Dwellings: 1994*, developed for DOE by Pacific Northwest Laboratories. This methodology had been used to determine whether the energy codes used in various states met or exceeded the MEC, as required under the Energy Conservation Act (42 USC 6831 et seq.) as amended by Section 101 of the Energy Policy Act of 1992 (EPAct, Public Law 102-486).

The methodology evaluates the overall heat loss coefficient (U_o-value) for two prescribed model houses. For Pennsylvania, the U_o values were then weighted by housing starts in 24 cities and towns across the Commonwealth, and for three foundation types.

In order to physically demonstrate the relative difference in overall thermal envelope performance as a result of applying the various codes, the U_o values are presented in Figure 4. Since one purpose of this evaluation was to determine whether the three proposed codes were equivalent to the 2000 IECC, (*Chapter 5, Residential Building Design by Component Performance Approach, Section 502.2.1, Compliance by performance on an individual component basis)*, the value for U_o

obtained for the 2000 IECC (92 MEC) was used as the baseline, or zero, to establish the percentage difference in each case.

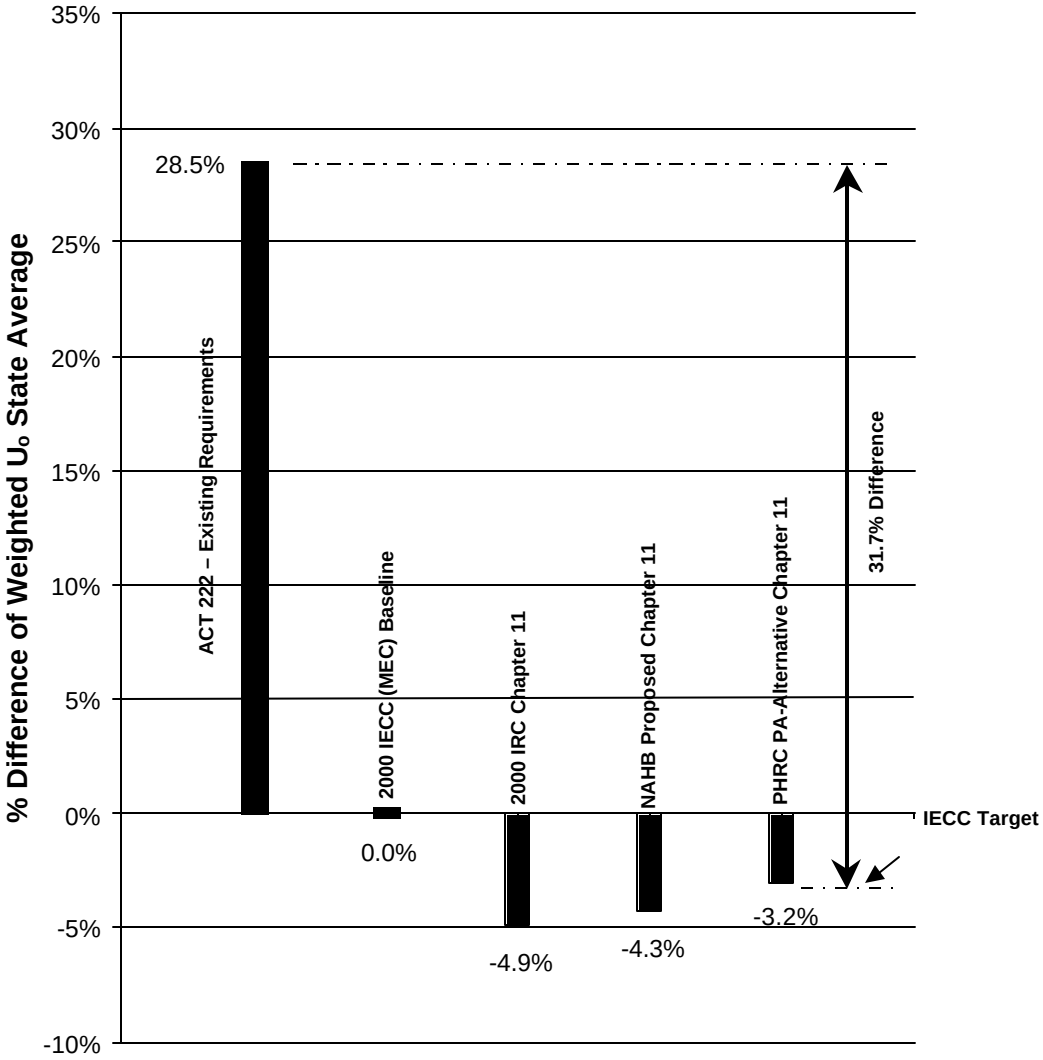

Figure 4: Thermal Envelope Comparison --- Window-to-Wall Area Ratio of 14.2% in all cases

For all practical purposes, the thermal envelope provisions contained within each of the three versions of Chapter 11, namely, the IRC 2000, the NAHB, and the PHRC PA-Alternative, are essentially equivalent and all exceed the IECC provisions for a glazing ratio of 14.2.

Relative to current practice in Pennsylvania, the adoption of the IRC 2000 and thus the 2000 IECC will have a major impact (an energy savings of about 30%) not only on energy conservation and construction practices, but also on builders, regulators, home buyers and owners.

Considering that the average statewide window-to-wall area ratio for new housing in Pennsylvania is significantly lower than 15% (and thus 14.2%), the energy performance of the thermal envelope of new housing could be expected to be even lower than that shown in Figure 4. To assess the significance of the window-to-wall area ratio with regard to space conditioning energy performance, refer to Figure 5.

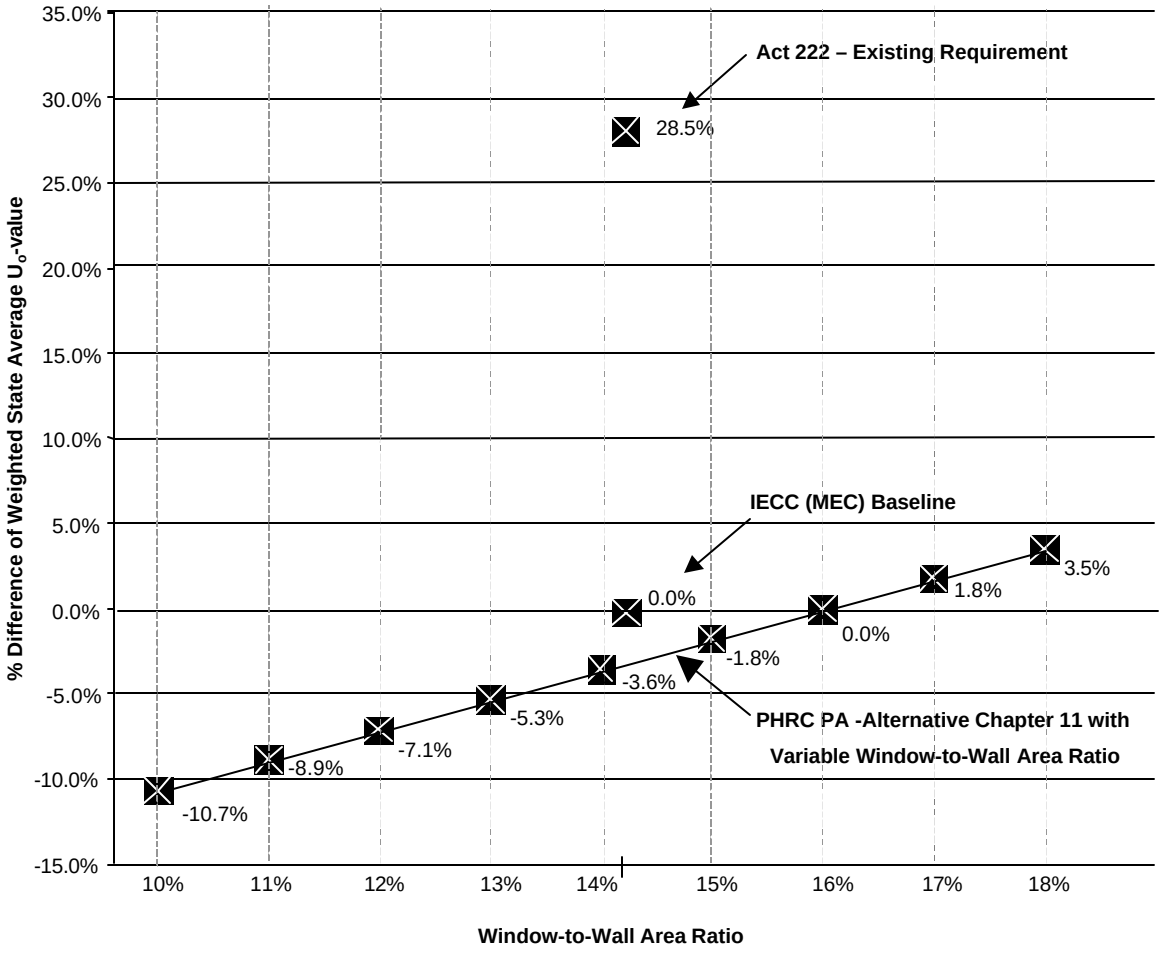

Figure 5: Thermal Envelope Comparison for PA Compressed Climate Zones

For a window-to-wall-area ratio of 14.2%, the PA-Alternative is 3.2% (see Figure 5) better than (i.e., less than) the 2000 IECC. For a window-to-wall area ratio of 15% (the IRC 2000 threshold), the difference is 1.8%. In Pennsylvania, the average window areas are more likely to be in the 12% range. For a window-to-wall area ratio of 12%, under the PA-Alternative, the difference is -7.1%. These differences indicate that the PA-Alternative would in fact (because the average

glazing for the state is probably about 12%) not only be "energy equivalent" to both the IRC 2000 and the 2000 IECC, but would, by a not insignificant amount, surpass them. For PA, the extent of space conditioned energy saving is even greater than the 2000 IECC and IRC 2000 requirements would suggest – some 35% relative to the current Act 222 requirements. Clearly, equivalence, at least for the thermal envelope, has been demonstrated.

4B. Trade-Offs [7]

A number of trade-off opportunities were introduced in the PA-Alternative, largely to encourage innovation and to reward the enterprise of builders / developers who attempt to provide a tighter enclosure and / or introduce high efficiency appliances and equipment. With each trade-off, space conditioning energy equivalence had to be ensured. The introduction of trade-offs is a significant departure from and improvement over the IRC 2000.

The two sets of **trade-offs** to be evaluated were the following:

(i) **Low infiltration** houses with less than 0.35 air changes per hour, are permitted one of the following two options:

   a) Reduced window and wall thermal resistance requirements

   b) Reduced slab-on-grade foundation insulation requirements

(ii) The installation of **High Efficiency HVAC equipment** permits one of the following three options:

   a) Reduced window and wall thermal resistance requirements

   b) Reduced foundation insulation requirements

   c) Elimination of basement insulation if basement walls have, on average, fewer than 12 inches exposed wall height above finished grade. This evaluation will apply to the basement regardless of whether the space is conditioned space or unconditioned.

The evaluation of each set of trade-offs for equivalency to the 2000 IECC was accomplished using the DOE-2 (PowerDOE®) building performance modeling software which permits system or whole house assessment. A detailed comparison of the effect of the various trade-offs in the PA-Alternative was made. The effect of these regulatory trade-offs was assessed for five locations in Pennsylvania including Erie, Philadelphia, and Pittsburgh. Equivalence was demonstrated and details of this work are contained in both a report.

5. Steel Stud Framing [8]

Given the climatic and other conditions that currently prevail in Pennsylvania, it was considered that the design provisions of the IRC 2000 would yield steel-framed wall assemblies with a relatively high probability of a moisture problem. The problem would largely be due to air exfiltration and the accumulation of condensate within the stud space. A revised set of

recommendations are provided in the PA-Alternative. Not unnaturally, the light gage steel industry did have some concern with these revisions and their implications.

Commentary

The PHRC was offered the rare opportunity to critique and improve one very important chapter in a new national building code, the IRC 2000. In spite of being constrained by time and money and the singular responsibility of impartially and jointly serving the energy consumer, and the Commonwealth of Pennsylvania as well as the home building industry, most of the objectives have been met. Indeed, the energy provisions contained in the PA-Alternative are simpler, more rational, and more flexible and thus better for Pennsylvania. Corrections were made to both recommendations and nomenclature. The two trade-off opportunities are of particular staregic significance. A quantitative threshold was introduced to encourage builders to pay attention to air leakage and be rewarded for doing so. A similar incentive was provided to encourage the use of higher efficiency equipment. Moreover, space conditioning energy equivalence with Federal (DOE) strategic policy has been maintained. Finally, it needs to be said that, while the PA-Alternative may be a significant improvement over the IRC energy provisions, both documents still leave much to be desired; both could be improved. Two concerns that still need to be addressed are:

(i) Terminolgy needs clarification. For example, terms such as "Weather-resistive Barrier" need to be eliminated, the misuse of the term "Vapor Barrier" should be corrected and the definition of conditioned space is going to prove to be troublesome for many years.

(ii) By only permitting the specified thermal insulation to contribute to the R-value of the enclosure element, the contribution of the cladding, air space, radiant heat retarders and other layers is totally discounted. In dumbing down to the builder, the Code Committee has effectively promoted the insulation industry at the expense of all the other materials in the enclosure. This situation should not be allowed to continue in the 2006 version of the IRC.

The Current Situation

It is now late 2003, some four years after the legislation was passed. There have been periods of institutional limbo. Instead of implementing the IRC 2000, the later version, IRC 2003, has been issued and chosen. Chapter 11 of both versions are nearly identical. For the reason that anything that is said in regard to these delays could be incriminating, little, if anything will be said. For a variety of reasons (and some still have to be resolved) formal, state-wide adoption has still to be given. The latest news is that the regulations will, hopefully, be adopted sometime early in the new year. Given that the Commonwealth of Pennsylvania is the most democratic of all states, the adoption of a new, state-wide building code for low-rise residential construction and for commercial construction is truly revolutionary and, perhaps, four years is not such a long time.

Conclusions

The experience of being involved in what is likely to be the most important change ever to be imposed on the design and building of built facilities in Pennsylvania, has been both interesting

and educational. Firstly, the procedure involved is much more complex and political than one would have thought. Secondly, it sheds needed light on the difference between prescriptive and performance based codes.

The most important objective is to get the relevant client groups (the developer, builders, code officials, etc.) to buy into the intent and content of the code. The language has to be user friendly, and for obvious reasons, the nature and language of residential code documents should not be the same as for commercial facilities. Clarity and brevity are essential. However, obvious dumbing-down should be avoided, especially, if it could lead to confusion and problems in the future. The performance of the performers is paramount and this is not necessarily the result of a performance based code.

When dealing with total R-values or window units, it is clear that some very real progress has been made since the initial oil crisis of the 1970's. Precision in identifying the right R-value or window is not as important as it used to be; currently, we are using much higher R-values and better windows than we used to. Issues such as airtightness are now relatively more important. Climate zoning is by no means precise, and in many instances, the massing of adjacent buildings and the position of the house are more significant parameters for performance.

Even more important is the need for training and education on how to design and build better enclosures and how to avoid problems, especially moisture related problems. The fact that someone is knowledgeable of the code is not an indicator of real understanding of how the enclosure or the building performs. In fact, the performance of many code officials is handicapped by their lack of understanding of the basic building science. The performance of code officials is likely to be more important, especially in the short term, than the purity and precision of any code. Unfortunately, the same can be said for many Architects and Engineers. No matter how good the code, it is no substitute for understanding; at best it can mitigate what used to be done.

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