

2001 Survey of Knowledge, Practices and Needs of Energy Code Officials in New Hampshire and Rhode Island

May 1, 2002



Acknowledgements

- Peregrine Energy Group prepared this report with assistance from Atlantic Research and Consulting, under U.S. Department of Energy grant #DE-FG41-00R-101510 to the Rhode Island State Energy Office and its subcontractor, Northeast Energy Efficiency Partnerships, Inc. (NEEP).
- The authors acknowledge the guidance and assistance provided by the project advisory group throughout the study period. Members of the group included representatives of the NH Public Utilities Commission, NH Governor's Office of Energy and Community Services (ECS), RI Building Code Commission, RI State Energy Office and NEEP.
- Opinions, conclusions and recommendations in this research report are solely those of Peregrine Energy Group and Atlantic Research and Consulting.



Table of Contents

1. Executive Summary		4
2. Background		9
2.1 Project Goals and Objectives	9	
2.2 Summary Description of Energy Codes	10	
2.3 Recent State Training	11	
2.4 Survey Methodology	12	
2.5 Demographics	15	
3. Survey Results		27
3.1 Local Code Official Characteristics	29	
3.2 Resources – Codes and Computers	31	
3.3 Practices	34	
3.4 Barriers to Code Compliance	42	
3.5 Assessment of Code Knowledge	49	
3.6 Technical Assistance	52	
3.7 Training History and Interests	55	
4. Conclusions and Recommendations		66
5. Resources		71
6. Appendix A: Survey Instrument and Tabulations of Survey Results (under separate cover)		



1. Executive Summary

This report presents findings of a survey commissioned by Northeast Energy Efficiency Partnerships, Inc. (NEEP) to examine practices and training needs of local building code officials responsible for compliance with energy efficiency provisions of residential and commercial new construction codes in New Hampshire and Rhode Island.

The study consisted of a telephone survey conducted by Peregrine Energy Group (Peregrine) and Atlantic Research and Consulting Inc. (Atlantic) in the Summer of 2001. We surveyed 120 local officials: 91 in New Hampshire who represent towns with approximately 66% of the state's annual residential new construction, and 29 in Rhode Island who serve towns with approximately 77% of that state's annual residential new construction.

The goals of the survey included 1) examining building code officials' knowledge of and practices in conducting energy code compliance; 2) assessing code officials' estimations of their own competencies with respect to the energy codes; and 3) determining code officials' recommendations for training content and the format that would best address their needs.

Using the most recent data, Peregrine also estimated residential and commercial construction rates in each state and verified contact information for local officials responsible for compliance with the energy codes in each state. We performed these tasks to aid development of the survey sample, to put survey results in perspective and to update records for the state building code officials of New Hampshire and Rhode Island.



1.1 Key Survey Findings

Background

- Of 234 New Hampshire cities and towns, only 59% (136) have local building code officials responsible for compliance with the energy code. In contrast, all Rhode Island communities have energy code compliance addressed at the local level
- Surveys were completed for 91 of 139 NH code officials identified (65% of the sample); and
- 29 of 39 RI code officials (74% of the sample). These are very high response rates. Local code officials in both states were extremely cooperative respondents to a long survey during a busy time of the year

State of Knowledge

- Code officials in New Hampshire and Rhode Island show a great deal of similarity in their areas and levels of knowledge about energy code requirements, compliance and energy efficiency practices
- Code officials in both states rate their knowledge of the residential code as greater than their knowledge of the commercial code. Rhode Island officials express greater confidence in their knowledge of the commercial code than New Hampshire officials
- 39% of the New Hampshire sample are part-time officials. We found a number of significant differences between part-time and full-time code officials:
 - ✓ Part-time code officials generally rate themselves as less knowledgeable than do full-time code officials
 - ✓ Part-time officials consistently found fewer and less severe barriers to energy code compliance than did full-time officials
 - ✓ Part-time officials also have held their positions for a shorter time than full-time officials
 - ✓ Part-time officials are less likely to consult state officials for assistance on energy code-related issues
 - ✓ Part-time officials are significantly less likely to want additional training
- Peregrine's assessment is that part-time officials require some special attention tailored to their limited availability for training and technical assistance



Practices

- Although code officials in each state indicate good knowledge of the residential energy code and fair knowledge of the commercial code, the study indicates their compliance review and inspection practices vary greatly and often are limited in scope
- Workload may be a factor in some of the limited reviews. The study identified workload as a primary barrier to energy code compliance in both states
- Lack of standard compliance procedures (evidenced by strong interest in manuals and checklists for energy code compliance in application review and onsite inspection) may be another factor in limited reviews

Technical Assistance

- About half of the code officials in both states have requested technical assistance from the NH Public Utilities Commission or the RI State Building Code Commission in the past two years. Satisfaction with the assistance was very high (67% in NH and 73% in RI were "Very Satisfied")

Energy Code Training

- Many local code officials in both states received some training in the residential and commercial energy codes during the past two years (Overall, far more received residential code training than commercial code training)
 - ✓ In both states, those who participated in training believe it was well done and useful to them
 - ✓ Around 60% of officials in both states would like additional commercial code training and about half would like additional residential training
 - ✓ The strongest content interests are in commercial construction, particularly in building systems (heating, ventilation, air conditioning, lighting, controls). Many officials also showed interest in commercial building shell concerns and across the range of residential construction concerns, including the codes themselves
 - ✓ In both states and for both commercial and residential construction, very many officials are interested in manuals or handbooks on energy code compliance, and checklists they can use in determining compliance
 - ✓ Finally, very many code officials said they are "Very Likely" to attend training if it is offered (64% in NH, 73% in RI). About half of them would participate in planning such sessions if asked, and they gave permission for release of their names to the state for that purpose



1.2 Conclusions and Recommendations

Conclusions:

Although this study was designed to enable local code officials to rate their own knowledge and competence in energy code compliance, we note significant items that reveal needs for training in each state, particularly concerning the commercial energy codes

- ✓ In each state, especially in New Hampshire, a substantial percentage of code officials have less than five years of experience in the position
- ✓ 59% of all New Hampshire communities have no local official prepared to deal with residential or commercial energy code compliance
- ✓ In the survey sample of 136 New Hampshire towns with energy code compliance officials, 40% were part-time officials. Part-time officials as a group are more in need of energy code compliance training than full-time officials, but are far less likely to attend training. We believe special efforts to reach this group are in order (circuit rider or localized training, for example)
- ✓ Rhode Island has a consistent, integrated institutional energy code compliance structure at the local community level. However, the gaps between compliance knowledge and practice we found in New Hampshire also exist in Rhode Island. Local code officials have consistent interests in training in both the residential and commercial energy codes.
- ✓ Very few officials use computer programs for determining energy code compliance (MECcheck, COMCheck, etc.). Although every RI local building official and almost every NH survey respondent has access to a computer, few have the software installed and in use, particularly part-time code officials in NH. Investigating reasons for the low utilization rate might facilitate getting more value from computer resources.

Recommendations:

Local code officials in New Hampshire and Rhode Island would benefit from new rounds of residential and commercial code training

- ✓ The focus of residential training should be on refreshing and updating knowledge, including:
 1. Practical advice for evaluating applications and making on-site inspections
 2. Compliance checklist tools
 3. Practical uses of MECcheck and other related software – why take the time to use it?
 4. Refreshers in using software
 5. Updates on energy-efficient building practices and new equipment.



- ✓ The focus of commercial training should be to help the code officials who do not have a technical background develop practical understanding of engineering and building systems considerations and code compliance strategies (including consultation with state resources), including:
 - Practical advice for evaluating permit applications and performing on-site inspections
 - Compliance checklist tools
 - Practical use of COMcheck and related software
 - Refreshers in using software
 - Updates on energy-efficient building practices, equipment and designs

Providing training to NH part-time officials will require special efforts. We suggest:

- Ask part-time officials about training and/or outreach methods that work best for them;
- Consider bringing energy code training/consulting services to small communities with no local official involved in energy code compliance or only part time resources, a "Circuit Rider" approach.

Training should also be available to the construction community. Code officials in both states believe practitioners need more training opportunities.

Checklists that walk local code officials through the energy code portion of permit application review and the on-site inspection process would be beneficial. Separate checklists would support commercial and residential code compliance, and they could be developed in multiple formats and degrees of complexity:

- ✓ Residential and commercial permit approval checklists would list the major documents required by code compliance, point to critical items such as heating system size and efficiency, typical window U-factors, note to check for window and door schedules, etc.
- ✓ An on-site checklist might be developed as a laminated document with a suggested order of review, expected findings and illustrations on a two-sided 8 ½" x 11" format, suitable for attachment to a clipboard
- ✓ The NH PUC Web site and an appropriate RI state Web site can provide easy access to checklists and other training materials



2. Background

This report presents the results of a survey of local building code officials concerning compliance with residential and commercial energy codes for new construction in New Hampshire and Rhode Island. Peregrine Energy Group and Atlantic Research Consulting, both of Boston, Massachusetts, conducted the survey in the Summer of 2001 for the NEEP Project Advisory Group. A total of 120 local building code officials participated in telephone interviews concerning their knowledge and needs for training in residential and commercial energy codes.

2.1 Project Goals

Main Goals

1. To assess local building code officials' knowledge about the residential and commercial codes
2. To assess permit application review and inspection practices in communities of the two states
3. To determine if training and other support would most likely increase their ability to effect better code compliance
4. To recommend measures NEEP and the two states might implement to achieve these goals

Supplementary Goals

- A. To identify and verify contact information for local code officials, particularly in New Hampshire
- B. To estimate amounts of commercial and residential construction activity in each state to improve knowledge about the nature and extent of them



2.2 Summary Description of Energy Codes

New Hampshire and Rhode Island adopted comparable versions of residential and commercial energy codes. Both types of codes are **performance-based**. That means the code contains minimum standards (for insulation levels and heating system efficiency, for example), but overall code compliance is attained through a combination of energy efficient design, building shell components and equipment. Depending upon the building type, a building model must attain a passing score to comply with the energy code. The models can be calculated by hand, but compliance is best determined by public domain software such as MECcheck and COMcheck.

New Hampshire adopted an energy efficiency code for new construction in 1989 and last updated it in 1996. The legislature is considering another update at this writing.

- ✓ Residential - The New Hampshire code is based on the 1995 version of the Model Energy Code (MEC 95). The residential code applies to any new home with provision for fossil-fueled or electric heat, certain alterations or additions, and commercial buildings of less than 4,000 square feet. These rules require builders to submit an Application for Certification of Compliance to municipalities or to the NH Public Utilities Commission.
- ✓ Commercial - The Commercial aspects of the energy code are derived primarily from the ASHRAE/IES (American Society of Heating, Refrigerating and Air-conditioning Engineers, Inc. & Illuminating Engineering Society) Standard 90.1-1989 for buildings except low-rise residential buildings. Certification of compliance by a NH-registered architect or engineer is sufficient for permit compliance.

Unlike NH, Rhode Island's energy code for new construction is contained within the state building code. Code compliance is a responsibility of the building code official in each of RI's 39 municipalities. Supported by the State Energy Office, the Building Code Commission provides technical assistance and training.

- ✓ Residential - Rhode Island adopted the 1995 Model Energy Code (MEC 95) in 1997
- ✓ Commercial - Rhode Island adopted ASHRAE Standard 90.1-1989 (within the state building code) in 1997



2.3 Recent Code Training In New Hampshire And Rhode Island

New Hampshire

- ✓ **Residential Training.** A contractor, Conservation Services Group (CSG), provided residential energy code training during the last two years. The training consisted of several workshops per year for local code officials, builders, designers and others in the new construction community. Through 2001, CSG conducted 17 sessions and trained a total of 560 people. At the end of this report, we cite a full report of training activities of the Governor's Office of Energy and Community Services.
- ✓ **Commercial Training.** There has been no state-sponsored commercial energy code training to date. There may have been some training sponsored by Building Officials and Code Administrators International (BOCA) or local chapters of American Institute of Architects (AIA) during the past two years. The NH ECS and the PUC are developing commercial training priorities.

Rhode Island

- ✓ **Residential Training.** There has been no formal training in the residential energy code in the last two years
- ✓ **Commercial Training.** There has been no formal training in the commercial energy code in the last two years
- ✓ **Computer Training.** In 1999, the RI Building Code Commission provided desktop computers and residential and commercial code compliance modeling software to every town in the state. The Commission subsequently provided training, often individualized, in every town



2.4 Survey Methodology

The primary data collection method was a telephone survey of local building code officials responsible for energy code compliance. We selected the sample sizes to provide significant results at the 95% Confidence Interval in two states with very small populations. The goals for completed surveys were:

- ✓ 100 surveys in NH (of all 234 communities); and
- ✓ 39 surveys in RI (census of all local building code officials)

Determining the NH population and sample. At the outset of the project, the exact number of NH municipalities that had local officials responsible for energy code compliance was unknown. Communities that do not select a local official can depend on the NH PUC for residential energy code compliance review.

The first tasks in the project were determining which towns had energy code officials and obtaining their names and contact telephone numbers. Peregrine contacted (or attempted to contact) each of the 234 municipalities, using the NH State Municipal Officials Association database. At each contact Peregrine asked “Who in this town or city has responsibility for compliance with the New Hampshire Energy Code?” Peregrine entered responses in the database, with appropriate contact telephone numbers and, where available, best days and times to attempt a contact. The building code officials that Peregrine reached learned that a telephone survey would soon begin. Most appeared to be enthusiastic about participating in it.

This activity revealed a local code official population of 136. The survey goal of 100 completions therefore would provide a survey of 74% of the population, more than sufficient to produce significant results.



RI Survey Sample. Because RI has only 39 municipalities, Peregrine decided to attempt to survey every one. Peregrine used the RI *Directory of City-Town Officials –2001* and a contact list provided by the RI Building Code Commission. Peregrine reached every municipal building department (the Building Code Official directly, if possible), confirmed contact information and gave notice of the impending survey.

Survey Period:

- ✓ The project was begun early in June 2001
 - ✓ The contact process was completed in July
 - ✓ The survey was ready for use in mid-July
 - ✓ Peregrine conducted interviews from July 26 – August 30, and September 10 – 21, 2001
-
- ✓ The survey period was the busiest time of the year in the construction business. Interviewing times ranged from 7:00 AM to approximately 7:00 PM, to accommodate each code official's schedule. Atlantic made up to eight attempts to reach each individual. Messages left included a toll-free number so code officials could initiate an interview or schedule one at their convenience. This process resulted in just nine refusals and one termination of an interview in progress. A number of local code officials never called back despite the repeated attempts.

The final survey completions were:

- NH 91 (67% of the sample frame)
- RI 29 (74% of the sample frame)



Survey Content. The survey consisted of 59 questions, of which five were open-ended. The NH and RI surveys were almost identical, having only minor differences to reflect unique terminology or state requirements. This allowed analysis of the two states as a single survey sample.

There Were Eight Areas Of Inquiry:

1. Background
Title; part-time, full time status; residential and/or commercial code responsibility; town(s) served; years in position; estimates of residential and commercial new construction; estimates of remodeling.
2. Information Resources
Accessibility of energy codes; availability and use of computer and modeling software; others reference materials and people/materials consulted for answers to questions.
3. Residential Code Permit Application/Compliance
Description of permit approval processes; documentation required/provided; types of problems; documentation beyond A/E certification; onsite inspection practices.
4. Commercial Code Permit Application/Compliance
Description of permit approval processes; documentation required/provided; types of problems; documentation beyond A/E certification; on-site inspection practices.
5. Barriers to Code Compliance
Major obstacles to residential/commercial compliance (open-ended and close-ended questions)
6. Assessment of Code Knowledge
Self-assessment of code knowledge; assessment of others (e.g. architects, engineers, builders, insulation contractors, etc.)
7. Technical Assistance
How often assistance requests made to state; form of requests (phone, email, etc); effectiveness of assistance; reasons for not making requests.
8. Training History and Interests
Training received in residential and/or commercial codes in past two years; specific training areas; satisfaction with training; interest in additional training; importance of various training areas; training form and formats preferred; likelihood of participating; interests in working with state to plan training; additional comments or suggestions.

Complete surveys comprise Appendix A.



2.5 Demographics

The populations of NH and RI are small. Economic activities, including new construction, are concentrated mainly in discrete areas of each state. The southern communities of NH have seen the most intense development during the last two decades. In Rhode Island, Providence and its immediate vicinity have the most construction activity. Towns organize and fund most local services.

NH has 234 cities and towns, of which 136 have local officials responsible for energy code compliance. Communities without a local energy code official can send permit applications to the NH Public Utility Commission's Energy Code Coordinator for review. Each year communities submit about 1,000 applications to the PUC.

Most construction activity is concentrated in the southern part of the state, with significant construction in and around the cities of Salem, Nashua, Manchester, Concord and the surrounding communities. Central and northern parts of the state generally have low rates of residential construction.

Communities with the most construction activity are most likely to have a full-time energy code compliance official. Conversely, towns and jurisdictions with less construction activity typically employ part-time energy code officials.

RI has 39 cities and towns. Each municipality has a Local Building Code Official who is responsible for compliance with all residential and commercial building construction codes. The State Building Code Commission provides some services for state-funded and institutional facilities, especially those with large heating and ventilation systems.

Note: Although residential construction data are readily available, commercial construction data are much less accessible since they are not collected by either state. Reliance on survey respondent estimations is likely to be the most accurate source.



2.6 Background

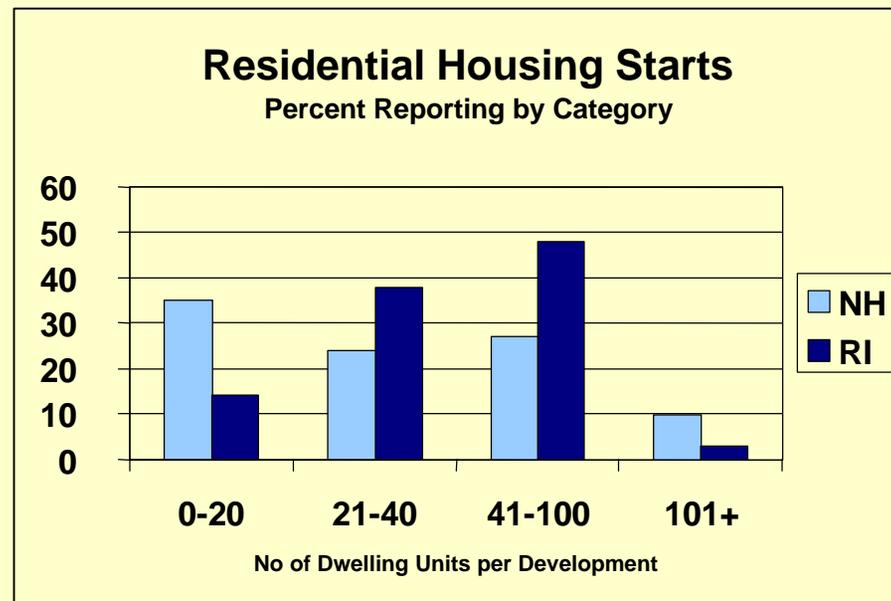
Almost all responding local code officials in both states are responsible for both commercial and residential energy code compliance:

- ✓ RI: 100% (n = 29)
- ✓ NH: 96% (n = 91)

Only a few RI local code officials are part-time (10%).

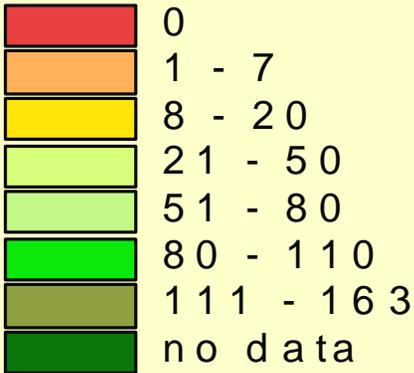
NH has a significant number of part-time officials (39%). However, those officials are involved with only about 17% of the residential construction in the survey sample towns and 11% of average annual residential construction in the state as a whole.

There are few very large residential developments (threshold for “very large” is 100 dwellings).

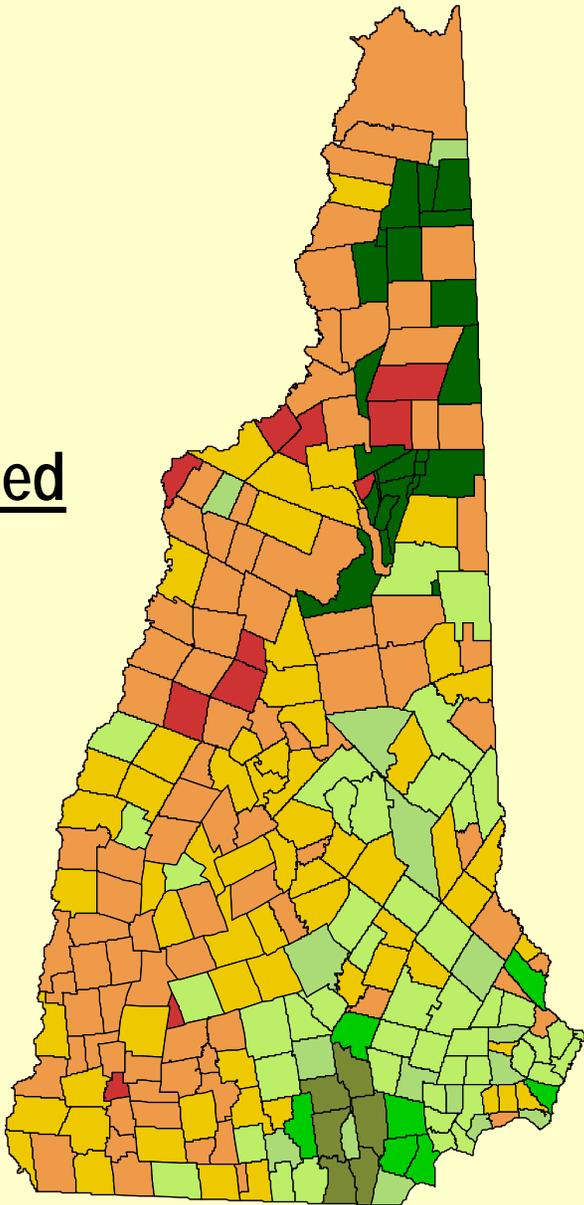


Three-Year Residential Construction Rates (1997-1999) in New Hampshire

Average Residential Permits Issued

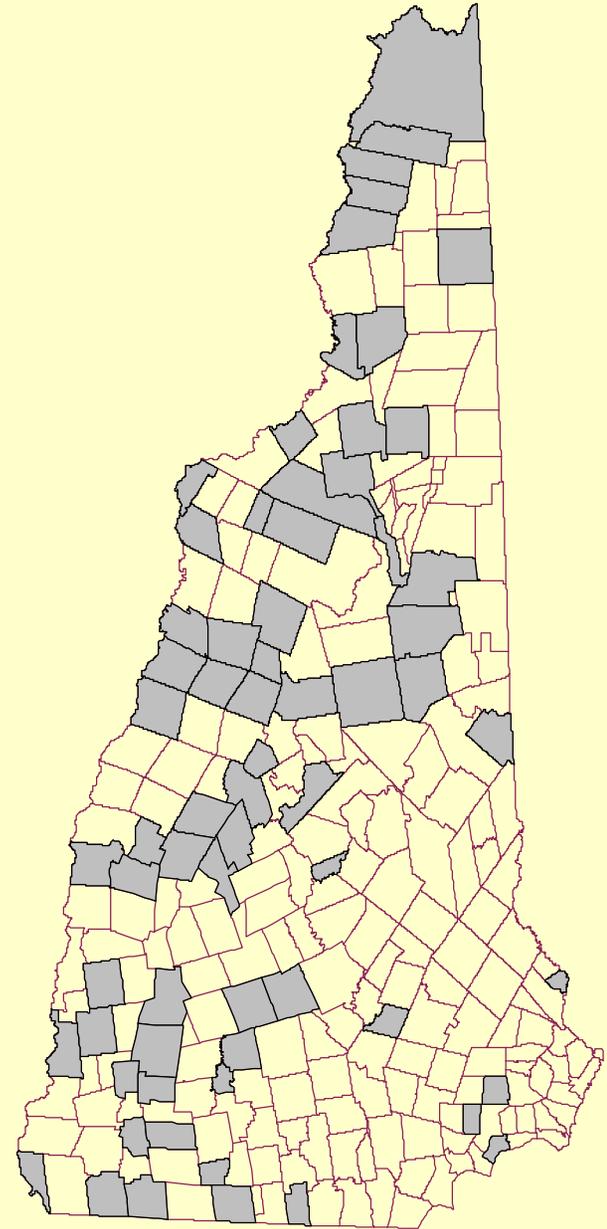


Average of annual permit data.
Source: NH State Data Center



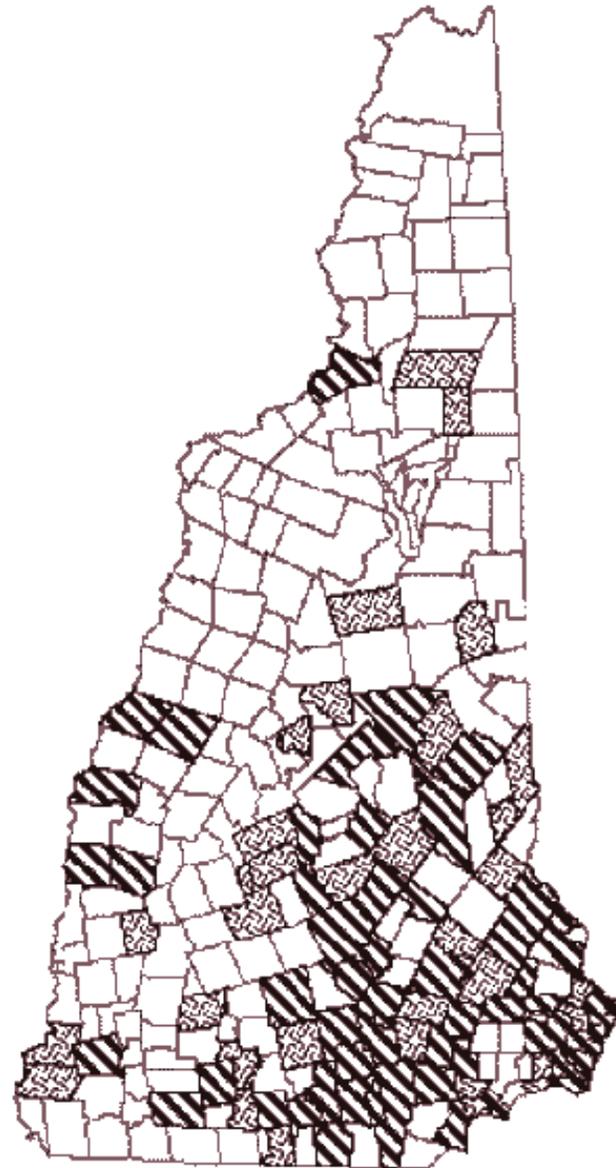
New Hampshire Towns Without Local Officials Responsible for Energy Code Compliance

Shaded Communities Have No
Local Official Responsible For
Energy Code Compliance



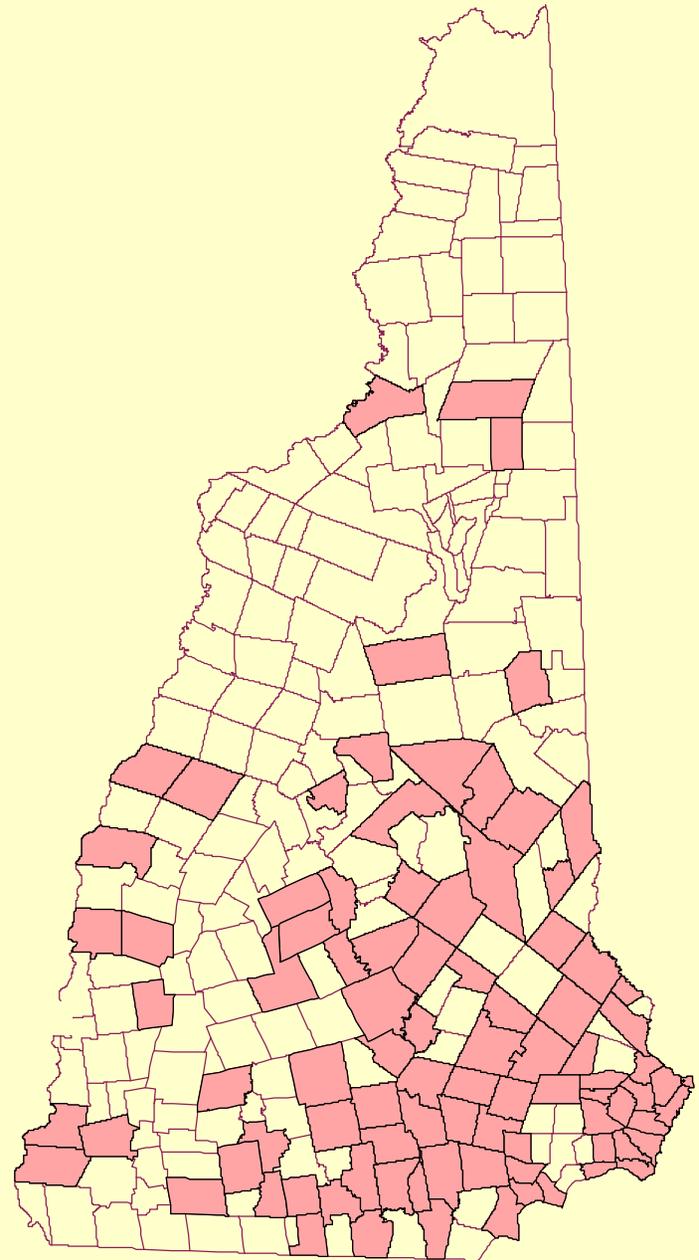
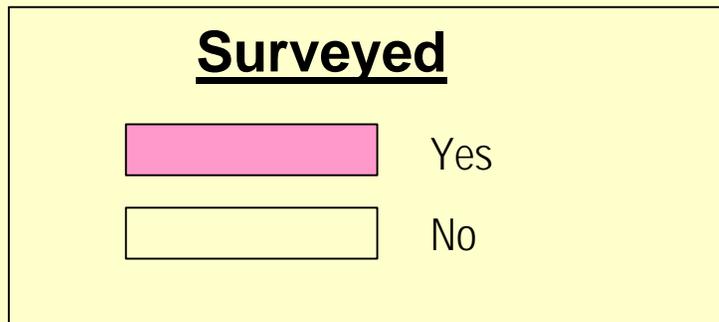
Full-Time and Part-Time Energy Code Officials Surveyed in NH Communities

 Full-Time
 Part-Time



Surveyed Communities in New Hampshire

(91 of 136 Towns with Code
Officials)



Distribution of Full-Time and Part-Time Rhode Island Building Code Officials in Completed Survey

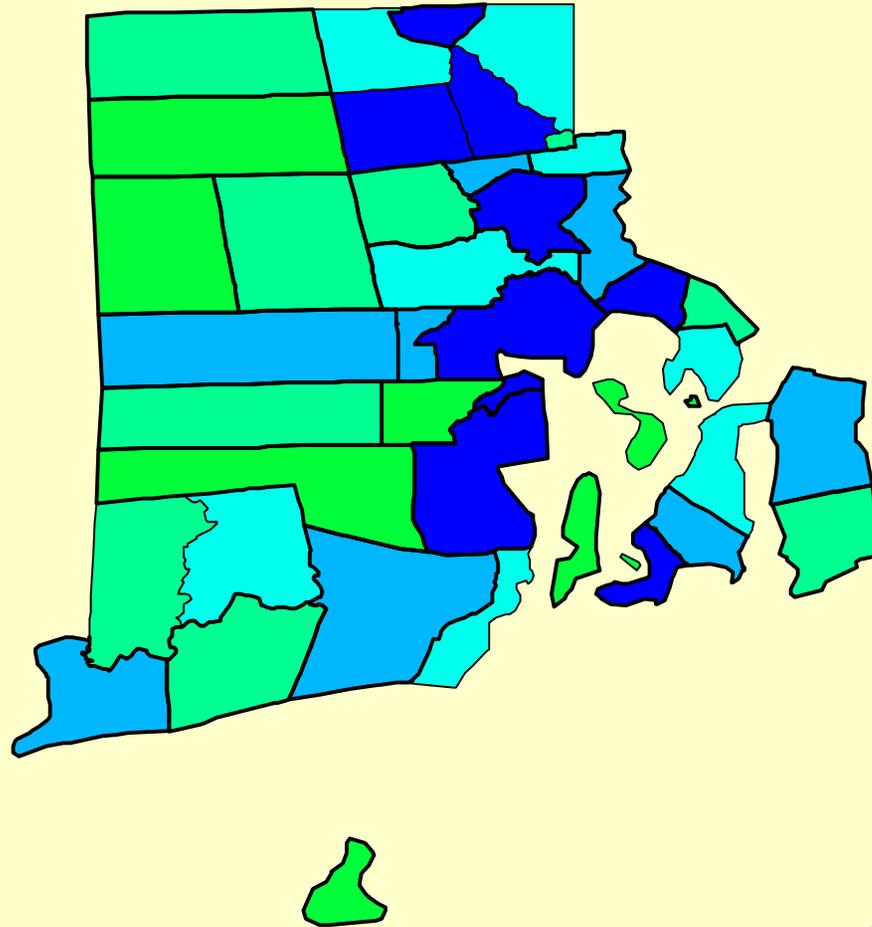
Full- or Part-Time Employees



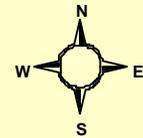
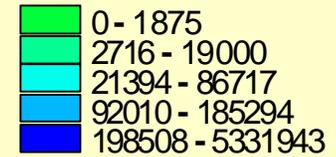
Total completed interviews = 29
Number of full-time officials = 26
Number of part-time officials = 3



Rhode Island Commercial Construction in Square Feet



commercial construction (sq feet)

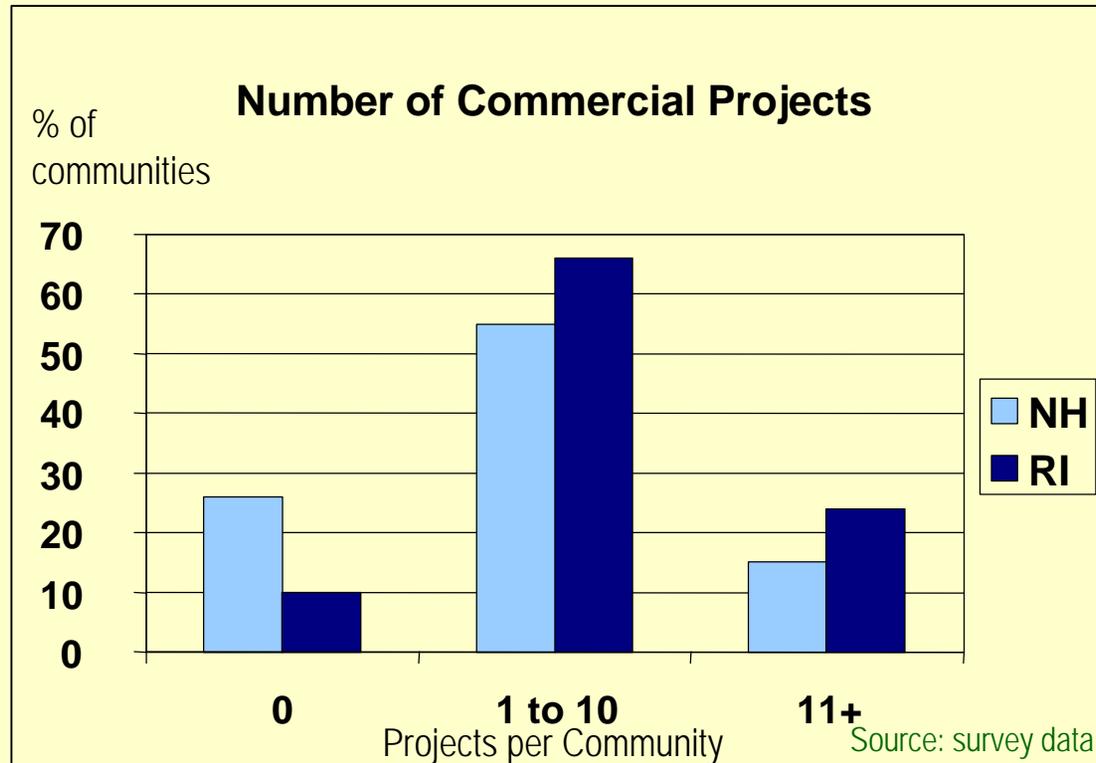


Source: RI Economic Development Corp.

10 0 10 20 Miles



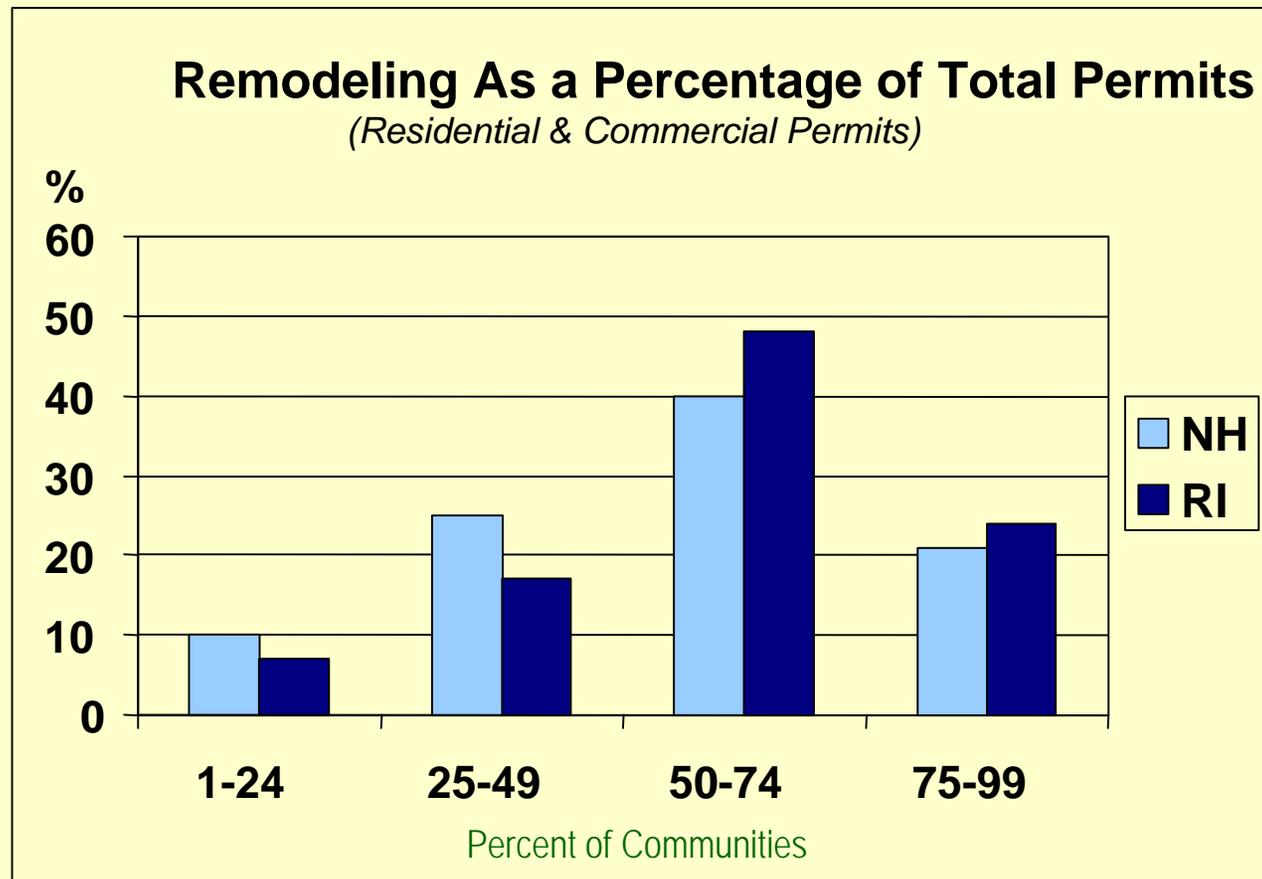
- **Commercial construction activity was modest.** The local energy code officials estimated the number of projects in their respective towns:
 - ✓ 26% of NH towns reported no commercial construction at all
 - ✓ 52% of towns in RI and 33% in NH did not estimate project sizes



- ✓ Two Rhode Island communities dominated commercial construction in terms of square footage. Providence produced 50% (5.3 million square ft.) and Warwick produced 13.6% (1.4 million square ft.) of the total commercial square footage during the period 1997-1999. (source: RI Development Corporation)



- Remodeling is a high percentage of all permitted jobs in both states
- Survey question: "About what percentage of your permitted jobs were remodeling jobs?"



Note on Remodeling

Reported in the 2000 Massachusetts Board of Building Regulations and Standards (BBRS) residential energy code study (see www.state.ma/bbrs/residential_evaluation.htm) were indications from code officials that remodeling jobs make substantial demands on their time, since most remodelers are homeowners and do not know much about building code or energy code requirements. Burdensome attention to remodeling jobs did not surface in this study as a barrier to ensuring code compliance, but there is no reason to assume the reported phenomenon stops at the borders. Remodeling activity may reduce the amount of time NH and RI code officials have for attending training and performing critical compliance functions related to new construction. It may be worth addressing in future assessments and training.

End of Section 2



3. Survey Results

This section describes the findings of the survey. In most instances we report the results separately by state. Note also that where we use percentages in graphs and tables they represent percentages of the total number of surveys in each state (NH = 91, RI = 29), unless otherwise noted.

Survey Analysis. At the survey's completion, Peregrine provided raw tabulations and preliminary findings to the Project Advisory Group. Tabulations for each state are in Appendix A, a separate document.

Peregrine, Atlantic and the Project Advisory Group then engaged in an interactive process to determine the “banners” by which the survey results would be cross-tabulated and examined for significance. A set of cross-tabulations was performed for each state and an additional set was performed for both states combined. Since the states appeared similar in many characteristics, we hoped that combined cross-tabulations might result in more robust findings or reveal significance in some items for the group as a whole.

The cross-tabulation categories were:

- ✓ Amount of residential or commercial construction in official's territory (self-reported)
- ✓ Job Title (type of position held by code official)
- ✓ Length of service
- ✓ Receipt of training in past two years
- ✓ Assessment of effectiveness of state-provided technical assistance
- ✓ Knowledge of residential code (self-reported)
- ✓ Residential energy code items included in local on-site inspections
- ✓ Full-time vs. part-time employment status

Of these cross-tabulations, the only set with significant, even systematic differences was the NH cross-tabulation of full-time and part-time local code officials.



New Hampshire full-time versus part-time code officials. In New Hampshire, 39% of the local building code officials interviewed described themselves as part-time officials. While these officials are not involved in a large share of the total construction in the state, they are a significant portion of the code officials among the towns that have a local official enforcing the residential and commercial energy codes. Several significant characteristics of part-time officials emerged from the survey sample.

Part-time local code officials:

- ✓ Are more likely to have less than six years of experience in their positions
- ✓ Are less likely to have the residential and commercial energy codes available
- ✓ Are less likely to request technical assistance from the state
- ✓ Consistently rated barriers to code compliance lower than did full-time officials
- ✓ Rated their knowledge of the commercial energy code lower than full-time officials
- ✓ Are less likely to participate in future training activities
- ✓ Are more likely to work in areas with less construction activity taking place

Peregrine speculates that many of these differences result from employment arrangements in some communities. Part-time code officials:

- May not have all the same responsibilities as full-time officials, which could account for differences in their perceptions about barriers (more discussion of barriers follows)
- May be compensated only for time spent on permit or inspection work, not for attending training
- May have small supply budgets, hence less likely to have codes or other important tools and references

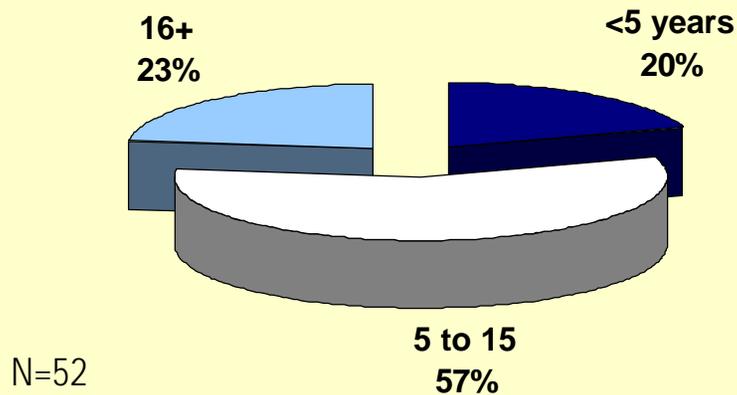


3.1 Local Code Official Characteristics

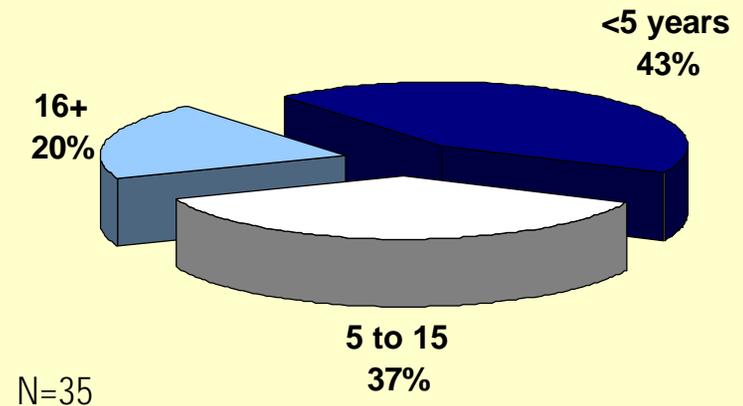
New Hampshire

- We interviewed 91 local building code officials in New Hampshire
- Almost all identified themselves as local building code officials. Several identified themselves as inspectors
- Most officials had at least five years of experience. Among part-time officials, almost half had fewer than five years of experience

NH Full-Time Officials Yrs of Experience



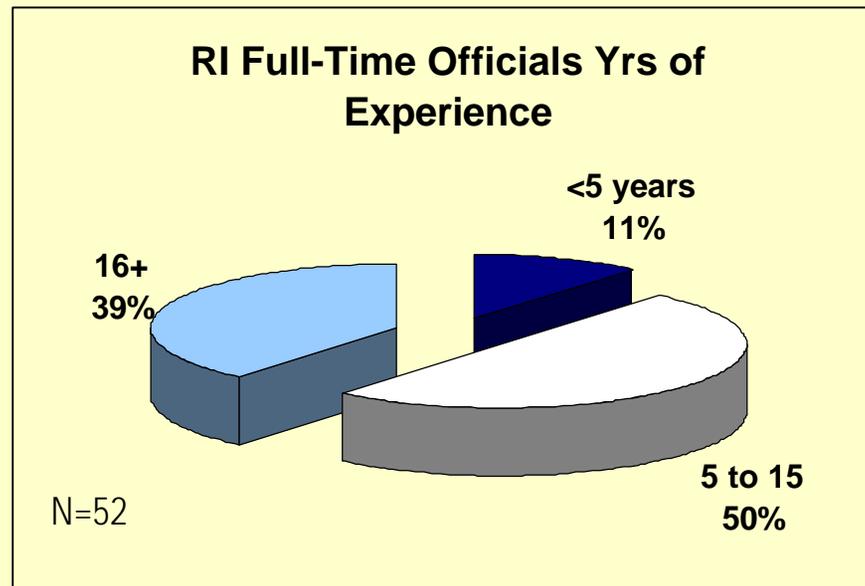
NH Part-Time Officials Yrs of Experience



3.1 Local Code Official Characteristics (continued)

Rhode Island

- We interviewed 29 building code officials in Rhode Island
- Almost all identified themselves as local building code officials. Several identified themselves as inspectors
- Most Rhode Island officials have at least five years of experience. Of the three part-time officials, just one has less than five years of experience.



3.2 Resources

This section of the survey dealt with the resources local code officials have at hand for energy code compliance, including the energy codes themselves, other documents and people they consult when they have questions. We also examined availability and use of computers and compliance software.

Energy Codes

Most local code officials in both states have copies of both the residential and commercial energy codes. There is some difference between part-time and full-time NH local code officials, but it is not statistically significant. *Note: the following chart reports actual numbers, not percentages.*

Have the Residential and Commercial Energy Codes			
	NH		RI
	Full-Time	Part-Time	All
Both	40	20	24
Residential only	9	10	2
Commercial Only	1	0	0
Neither	3	4	1
Don't Know	3	1	2



Computer Resources

Computers are readily accessible in both states. The RI Building Code Commission provided computers and on-site training in MECcheck software to local building code officials approximately three years ago, but few local code officials in either state have residential or commercial energy software installed and in use. Very few local code officials use any of the modeling programs to check the assumptions and calculations presented to them in permit applications.

Although the survey did not ask the reason for the low rates of use, we suspect local code officials have not found the time and/or need to integrate use of the software with their routine operations. The real reasons have implications for the design of future training, so our suspicion should be tested.

	<i>NH</i>	<i>RI</i>
Have Computer	89%	97%
<i>Software Installed and in Use:</i>		
NHcheck	28%	na
MECcheck	6%	5%
COMcheck	0%	10%
ASHRAE	0%	10%



Other Resources

The survey asked what other sources local code officials rely on as references, including whom they consult. In NH, only three out of ten part-time officials consult state officials while six out of ten full-time officials do.

Energy Code References		
	NH	RI
State Official	63%	62%
BOCA Materials	23%	4%
Use Only State Code	11%	31%
Various Other	3%	3%

Whom Do You Consult on Code Questions? (multiples taken)			
	NH		RI
	F-T	P-T	
State Official	59%	29%*	93%
Local Code Official (in another town)	16%	17%	17%
BOCA Regional or National	33%	34%	17%
Energy Code	18%	20%	10%
Local Code Official (in same town)	9%	17%	7%
1995 MEC Commentary	3%		
Other	2%	9%	3%
*There is a significant difference between NH Full-Time & Part-Time Officials			



3.3 Practices

In this section of the survey we asked officials about code compliance practices in their review of building permit applications and about their practices in inspecting residential and commercial building construction for code compliance. In another section of the survey we asked respondents about the ease or difficulty of assessing code compliance during inspections.

The survey did not specifically seek to reconcile the answers on practices and perceptions of difficulty in inspections, but we note there are some discontinuities in the answers. The results do not line up perfectly by category because some of the categories differed slightly between the two sets of questions. Nonetheless, there are some notable discrepancies, apparent from the charts and graphs found in this section.

One notable discrepancy involved the inspection of ducts in residential new construction. A number of recent studies of new residential and commercial buildings identified losses from poorly constructed, insulated or sealed ducts as a substantial energy concern. Respondents in this survey indicated that duct inspections are not difficult to perform, but very few of them cite duct inspections as a regular inspection activity.

The survey did not ask why some measures are inspected so infrequently; this is an area for further investigation, possibly as a part of training design.



New Hampshire: Documentation in Building Permit Applications

NH Residential. The New Hampshire Energy Code requires submission of an Energy Code Application to accompany all residential permit applications. The Energy Code Application, which is available on the PUC Web site, requests basic information about the proposed residential structure, including a simple plan drawing of what the home will look like (see page five of the Residential Energy Code Application).

The survey asked Local Code officials how frequently the Energy Code Application form and its principal parts are included with permit applications, using a scale of "Always, Sometimes, Never". The survey also asked how often applicants submit printouts produced by MECcheck (which would show the home has a passing grade as modeled) and how often other documentation such as an architect or engineer certification is included.

Following are some results of this question:

- Only 43% reported that the Energy Code Application is always included in permit application submissions
- 13% say the Energy Code Application forms are never included. The remainder, 44%, report Energy Code Applications "Sometimes" accompany permit applications
- Almost half (48%) reported that applications always include window and door schedules (these are important for calculating glazed areas and are documentation that plans specify windows with appropriate U-factors)
- 14% say applicants never include window and door schedules
- For the page five drawing, "Always" = 43%, "Never" = 14%
- 10% report that NH-certified architect or engineer certification is always included (this certification is not required for residential permits, but satisfies code requirements)



NH Commercial building permit applications for facilities in excess of 4,000 square feet do not require the energy code application form. Commercial applications do, however, require certification by a New Hampshire-registered architect or engineer that the facility complies with the energy code.

- Only 48% of code officials say they always find an architect or engineer certification on commercial applications
- 11% never find an architect or engineer's certification on commercial permit applications
- Only about 6% (two responses combined) say they always find a computer printout showing a commercial facility has met the commercial code performance standards as specified. 49% say they never find such printouts
- 42% always find window and door schedules and 9% never do. While not required, such schedules facilitate evaluation of proposed structures



Rhode Island: Documentation in Building Permit Applications

Rhode Island does not have a specific energy code compliance document required for building permit applications. As noted, Rhode Island energy efficiency-related aspects of the building code are part of the new construction codes and not specifically called out as an energy code. We asked local code officials to gauge overall practices and areas for training. While we found some differences between the states, the results indicate there is significant room for improvement in RI, too.

RI Residential

- ✓ Only 7% (two code officials) say they always receive a MECcheck computer printout, while 48% say they never receive one
- ✓ Almost one third (31%) always receive window and door schedules (48% NH officials always receive these)
- ✓ 24% always receive building area calculations, but 45% never do

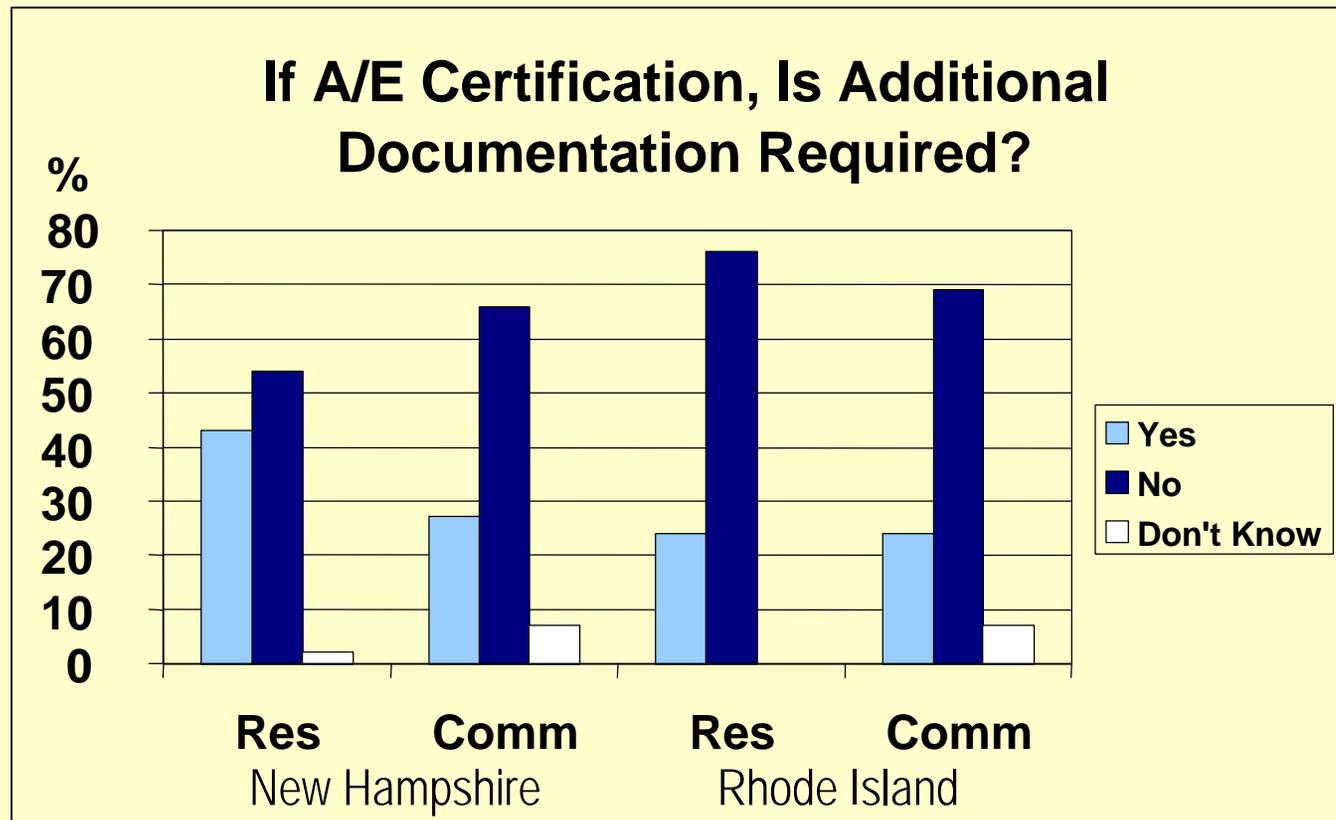
RI Commercial

- ✓ Only 7% of officials receive a computer printout; 31% never receive a printout
- ✓ 62% always receive an architect or engineer certification; 38% receive certifications "Sometimes"
- ✓ 69% always receive window and door schedules; only 3% (one official) never receive schedules



Documentation In Addition To Architect/Engineer Certification

We asked officials if they require additional documentation when an application includes an architect or engineer certification. For permit approval the New Hampshire code requires A/E certification of energy code compliance. In each category below, when an A/E stamp is provided, most officials do not require additional compliance documentation.



"A/E" = state registered Architect or Engineer



On-site Inspection Practices: Disparity Between Practice and Expectations

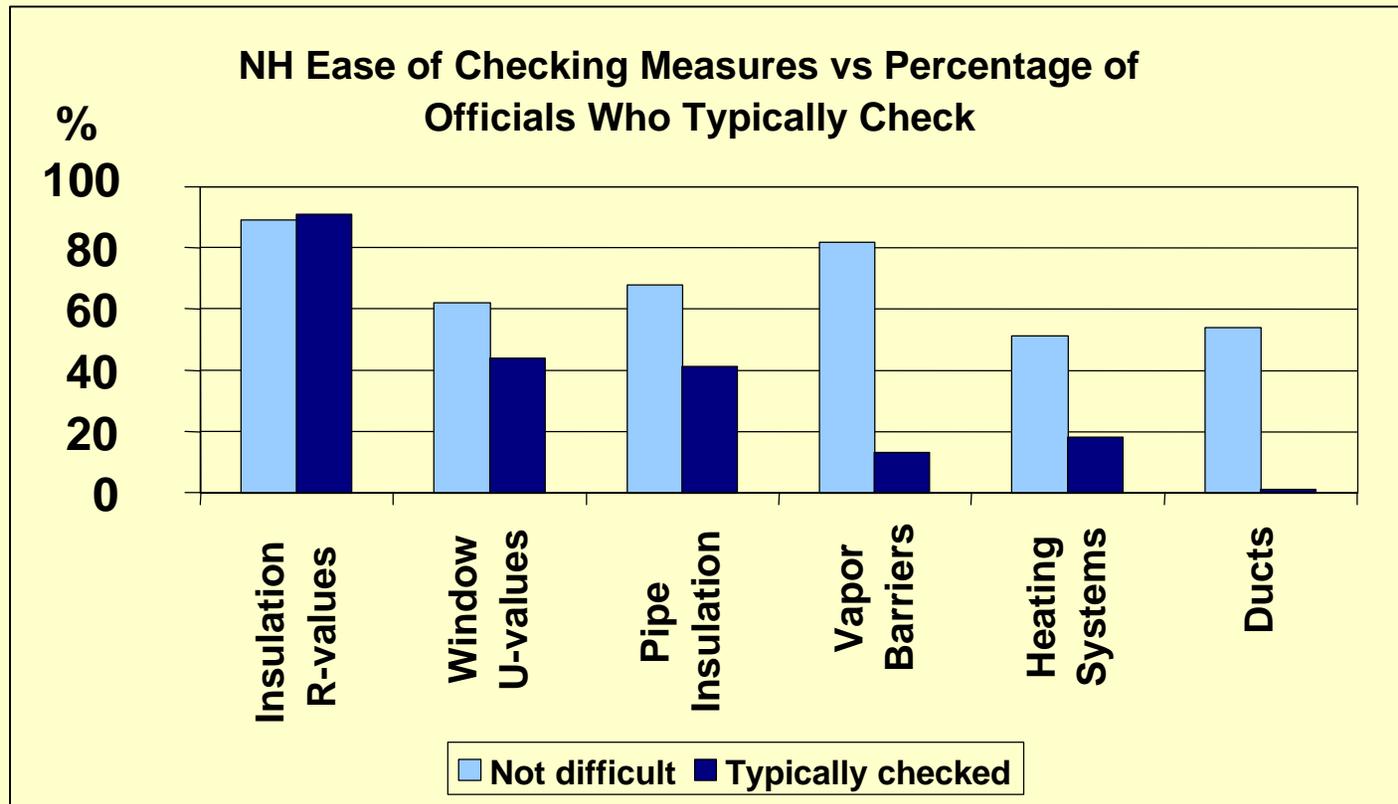
- We asked local code officials in both states about measures they check when they do on-site inspections (almost all say they do inspections). Later, we asked them how difficult it is to inspect particular measures. As previously noted, their answers included some discrepancies.
- The charts on the next two pages show the extent of the discrepancy in each state with respect to residential construction, where the discrepancies were most apparent. As noted, the categories in each of the questions did not match exactly. The chart presents comparisons only for those measures that have a clear comparability.



Inspection Ease versus Practice

Almost every local code official conducts on-site inspections. We asked officials to rate the difficulty of inspecting a number of measures. The following table presents the measures rated “not at all difficult”, the percentage of officials making that rating and the percentage who say they typically check the measure in residential construction.

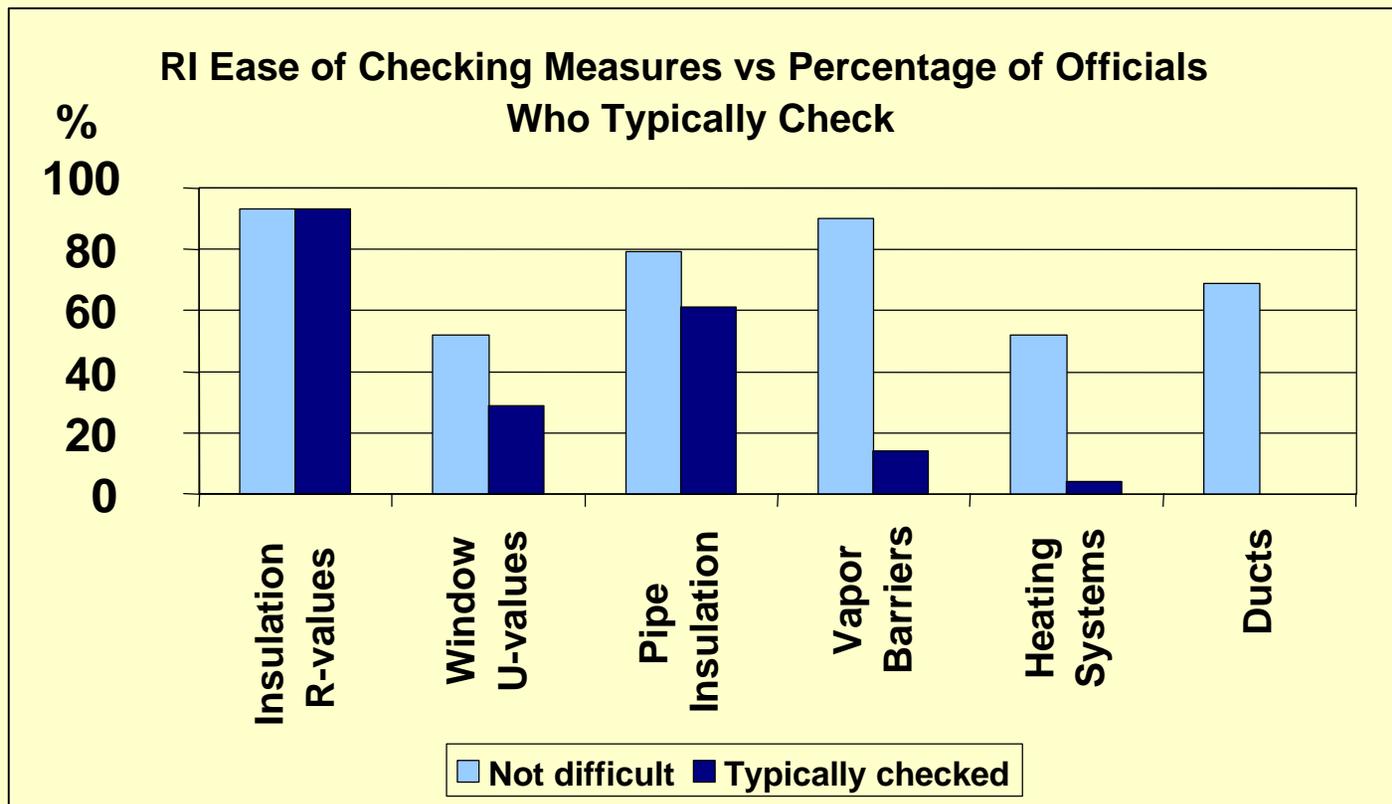
New Hampshire:



Inspection Ease versus Practice (continued)

Rhode Island:

This chart shows discrepancies regarding **Ducts** (none say they check), **Vapor Barriers** and **Window Efficiencies**, pointing to possible areas for training



3.4 Barriers to Code Compliance

This section of the survey asked local code officials about barriers they found that affected compliance with the residential and commercial energy efficiency codes. We initially asked the questions as open-ended questions. We asked a second group of questions using lists of possible barriers. A sample of responses to the open-ended questions includes the following mentions:

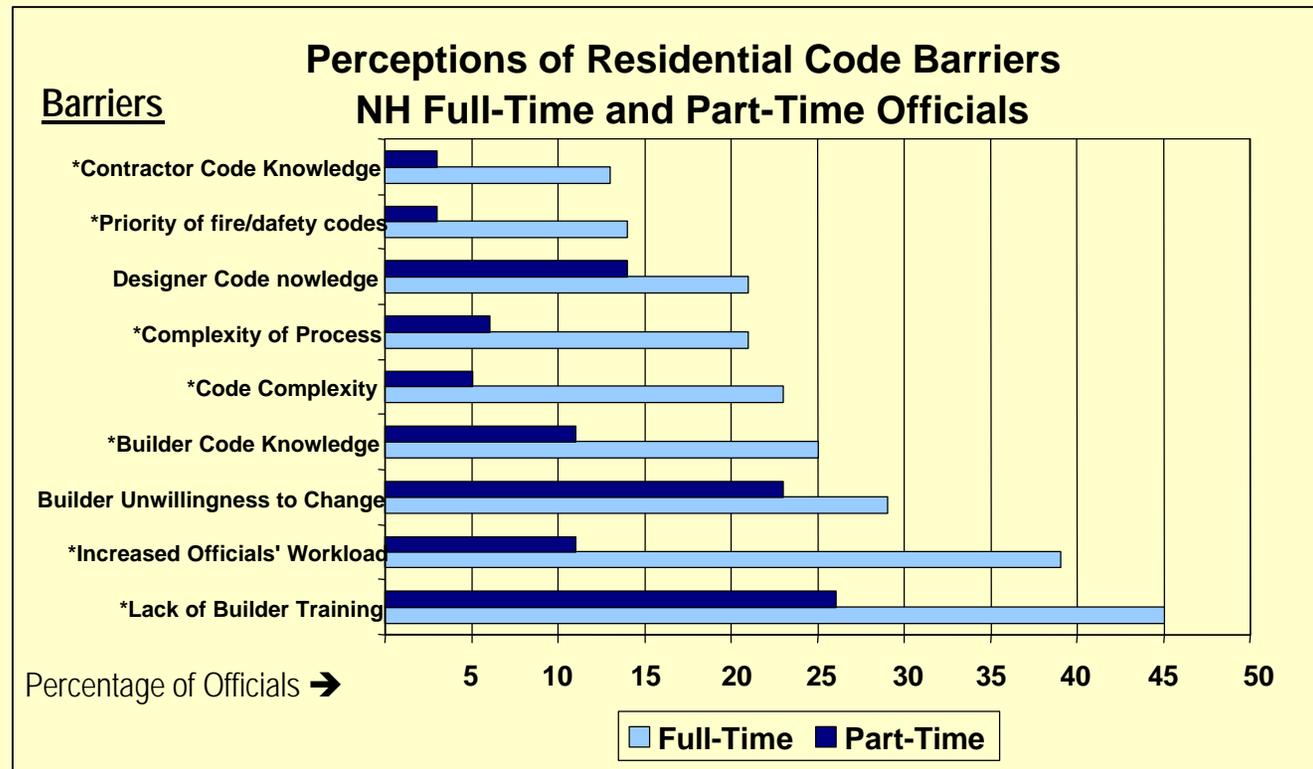
- ✓ Contractor/homeowner lack of interest (15% NH)
- ✓ Energy documentation does not match building plans (10% RI)
- ✓ Cutting costs/job is rushed
- ✓ Codes hard to understand
- ✓ Missing door and window schedules
- ✓ Forms submitted incomplete
- ✓ No MECcheck or NHcheck output submitted
- ✓ Specs for HVAC equipment not provided
- ✓ Inspectors lack training
- ✓ Homeowners want large windows (too much glass)
- ✓ Contractors unwilling to change practices



Substantial Barriers to Ensuring Residential Energy Code Compliance

Following the open-ended questions we provided lists of possible barriers to ensuring energy code compliance. The following (several) charts show responses for each state identifying "Substantial Barriers" to ensuring code compliance.

Full-time and part-time NH code officials varied significantly in seven of the categories, with fewer part-time officials ALWAYS perceiving barriers than full-time officials. This may reflect differences in responsibilities, as shown in the estimation of increased work load, but it also shows up in estimations of items such as builder and contractor knowledge, and builder willingness to change practices, suggesting a systematic difference in perceptions between full-time and part-time officials.



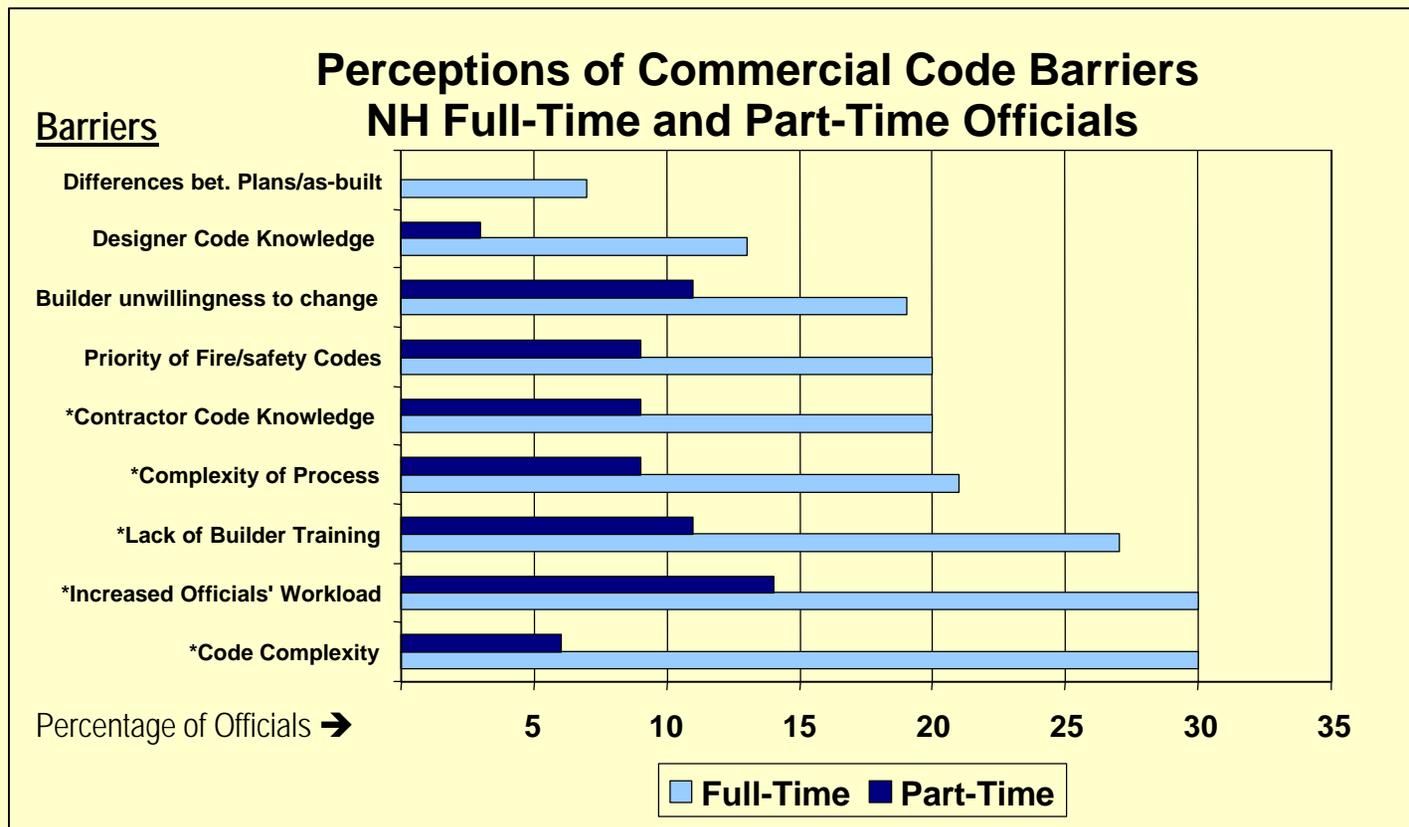
* Indicates statistically significant difference



Substantial Barriers to Ensuring Residential Energy Code Compliance (continued)

New Hampshire Commercial Barriers

The following chart shows similar perceptions of barriers to commercial code compliance in New Hampshire and also shows the same set of significant differences in perception between full-time and part-time local building code officials.



Top 5 New Hampshire Barriers

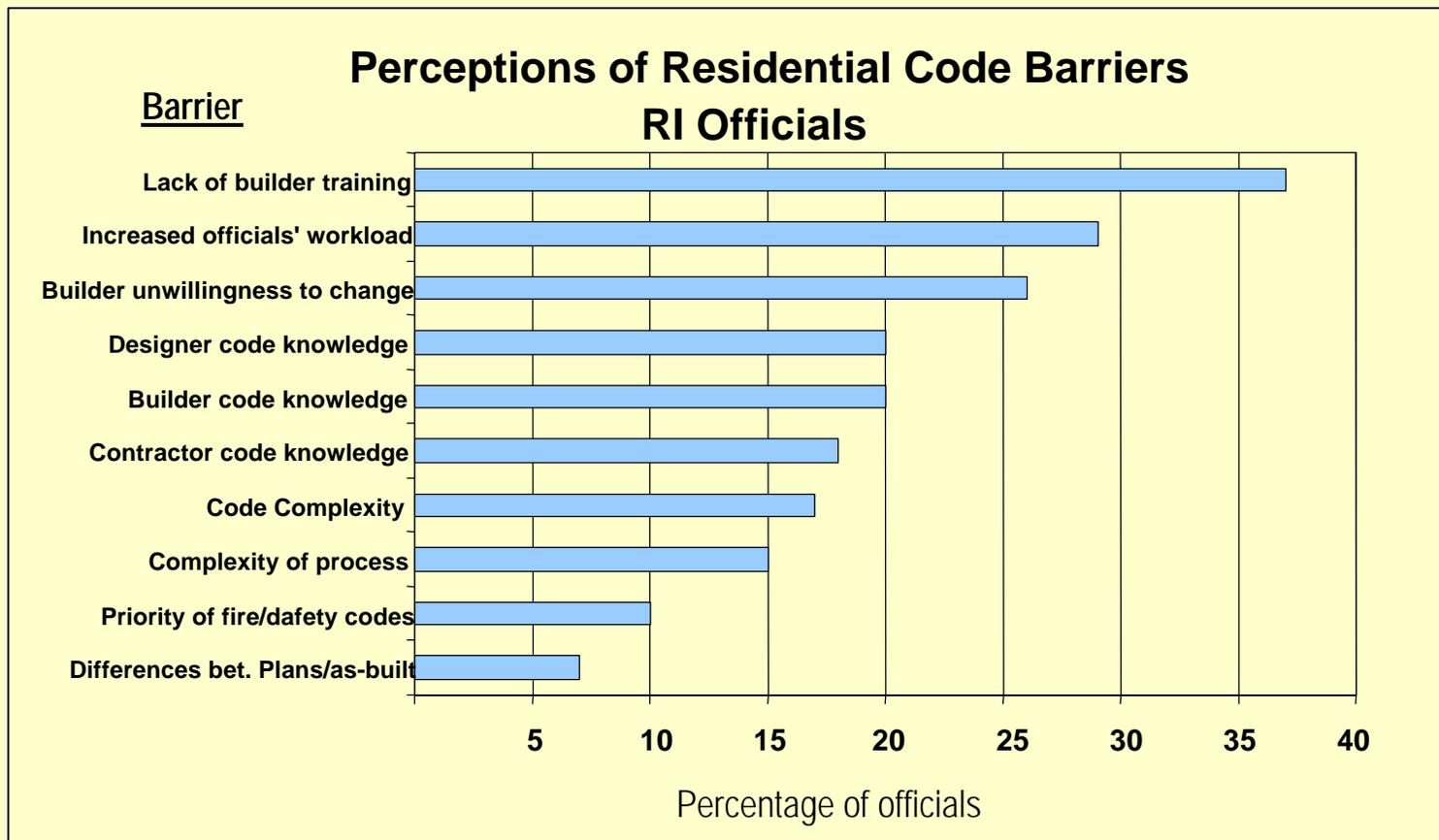
The comparison of the top residential and commercial barriers named by full-time New Hampshire local code officials shows a great deal of similarity, focusing on code knowledge of builders and increased workload attributable to the energy codes. Three of the top five barriers are the same in commercial and residential construction. These findings suggest that designers of further training related to NH energy code compliance should carefully consider these barriers.

<i>Top 5 Barriers to New Hampshire Residential and Commercial Code Compliance</i>		
	Residential	Commercial
1	Lack of builder training opportunities	Code complexity
2	Increased code official workloads	Increased code official workloads
3	Builder unwillingness to change practices	Lack of builder training opportunities
4	Lack of builder knowledge	Complexity of the process
5	Code complexity	Lack of contractor knowledge

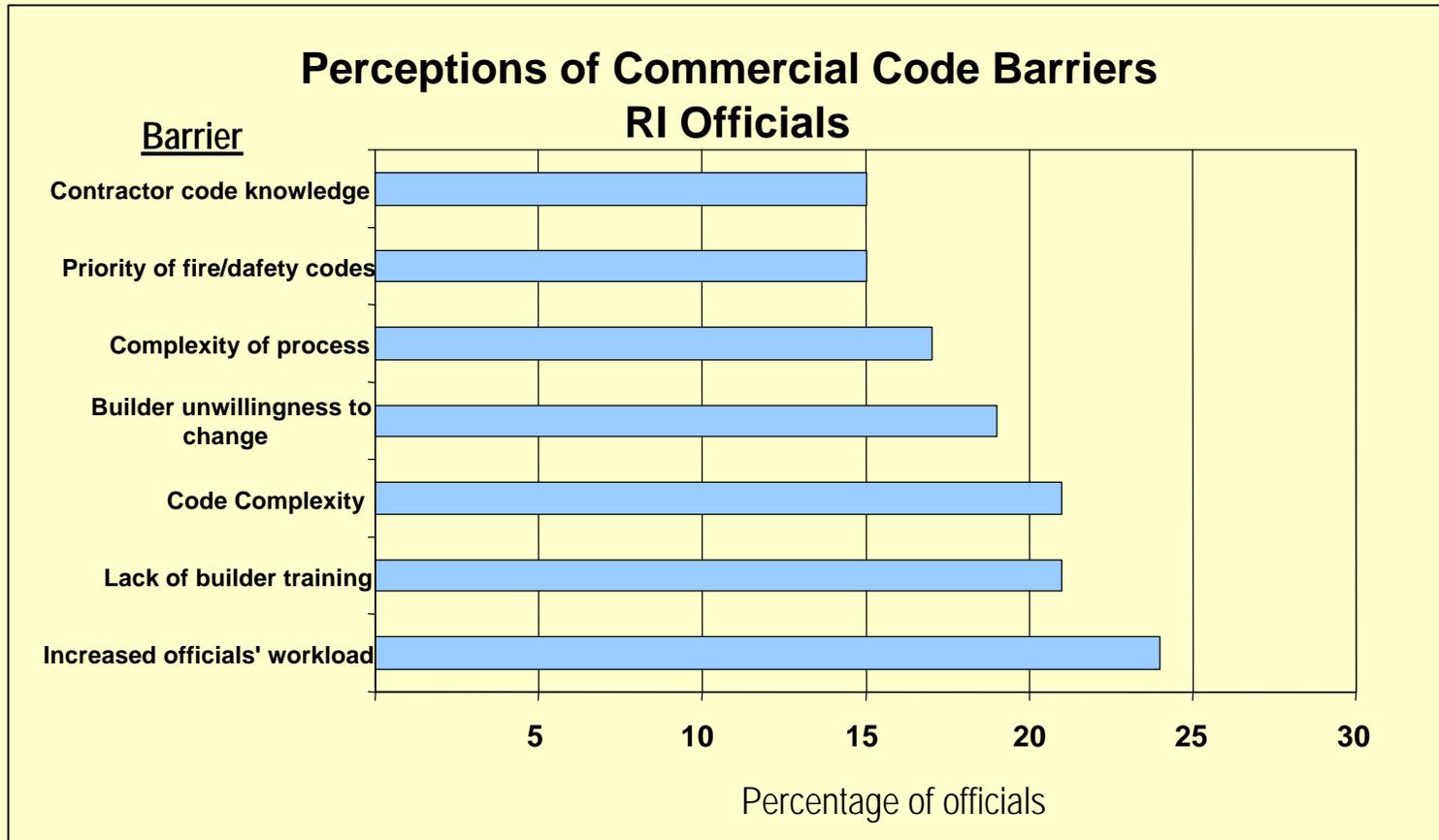


Rhode Island Residential Barriers

Since only three of 29 building code officials interviewed in Rhode Island are part-time officials, there is no opportunity to test for the full-time/part-time differences found in New Hampshire and present the findings for the entire group. Overall, perceived RI barriers are similar to New Hampshire, with increased work load and concerns about builder knowledge and builder unwillingness to change construction practices (residential) rating very high.



Rhode Island Commercial Barriers



Top 5 Rhode Island Barriers

For commercial and residential code compliance in Rhode Island, the top five perceived barriers are very similar. The Top 5 lists of the two states are also very similar, not only in content but in order, focusing on builders, increased time demands and complexity of the code and process.

<i>Top 5 Barriers to Rhode Island</i> <i>Residential and Commercial Code Compliance</i>		
	Residential	Commercial
1	Lack of builder training opportunities	Code complexity
2	Increased code official workloads	Increased code official workloads
3	Builder unwillingness to change practices	Lack of builder training opportunities
4	Lack of builder knowledge	Complexity of the process
5	Code complexity	Lack of contractor knowledge



3.5 Assessment of Code Officials' Knowledge of the Energy Code

We asked officials to rate their own knowledge of the energy codes and then that of other players in the residential and commercial construction industry

- ✓ Full-time code officials know the NH commercial energy code much better than part-time officials do. Knowledge of the residential code is essentially the same for both NH groups

NH Code Knowledge			
	<i>Residential</i>	<i>Commercial</i>	
		<i>Full-Time</i>	<i>Part-Time</i>
Not Very	7%	21%	43%
Some	52%	57%	49%
Very	41%	21%	9%

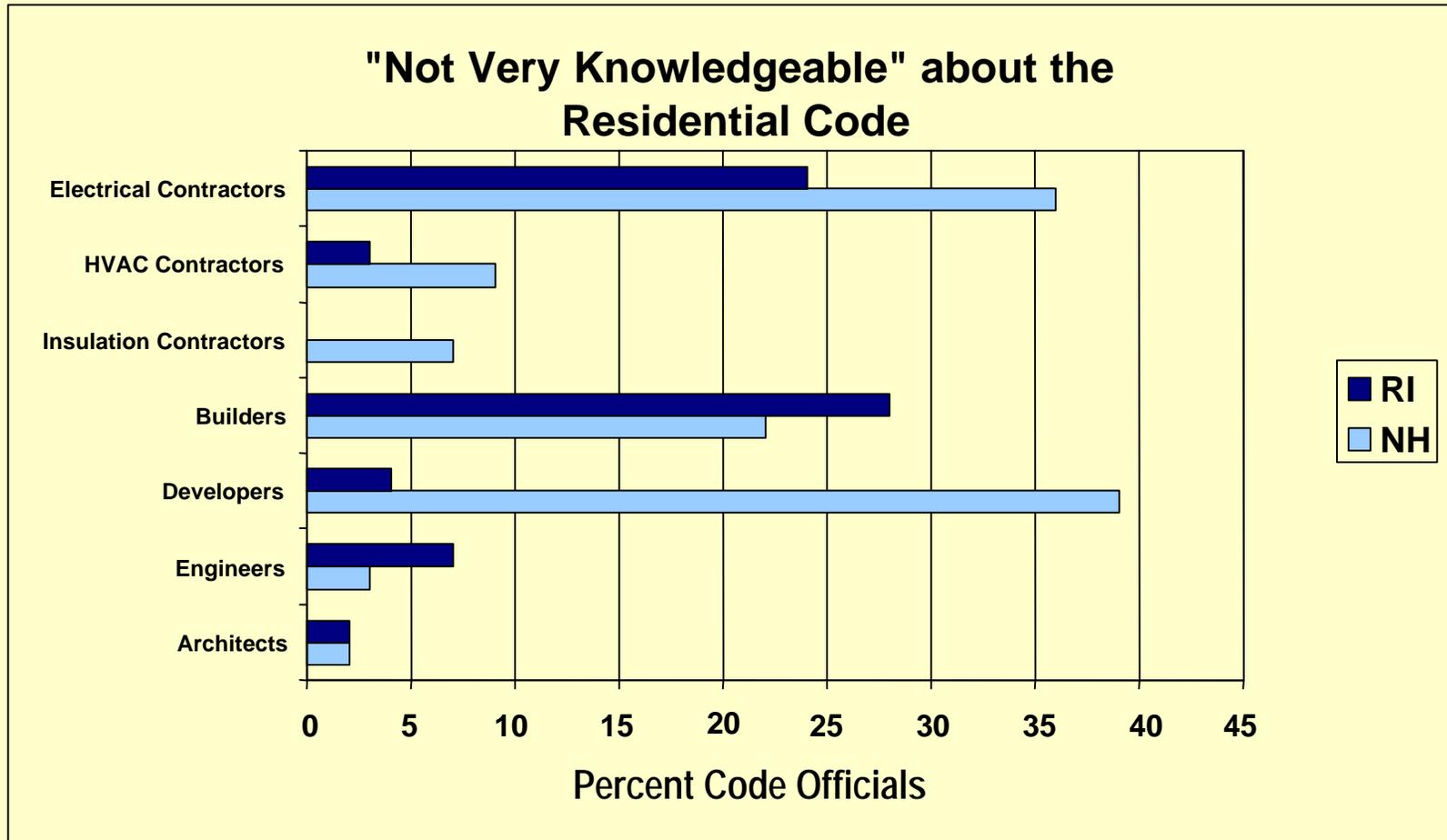
- ✓ Rhode Island officials know the residential energy code much better than they know the commercial energy code, as indicated by the majority's shift from "Very" to "Some"

RI Code Knowledge		
	<i>Residential</i>	<i>Commercial</i>
Not Very	3%	10%
Some	35%	62%
Very	62%	28%



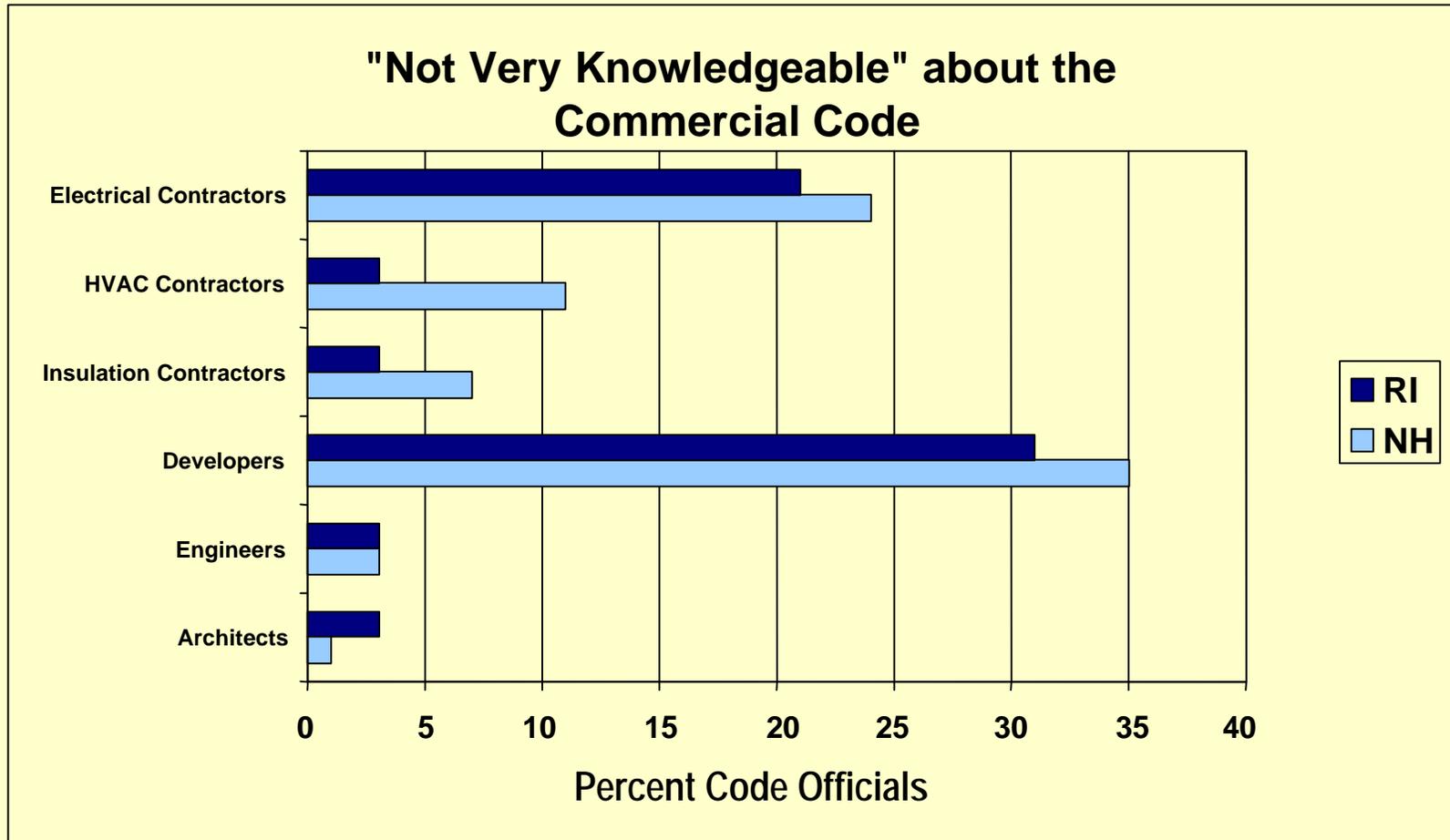
Others in the Building Trades - Residential Code

We asked officials to rate knowledge of other players in the construction trades and present their assessments of those who are "Least Knowledgeable", i.e., the groups that might benefit most from additional training. In general, the assessments agree, except those regarding developers. NH officials consider them less knowledgeable than RI officials do.



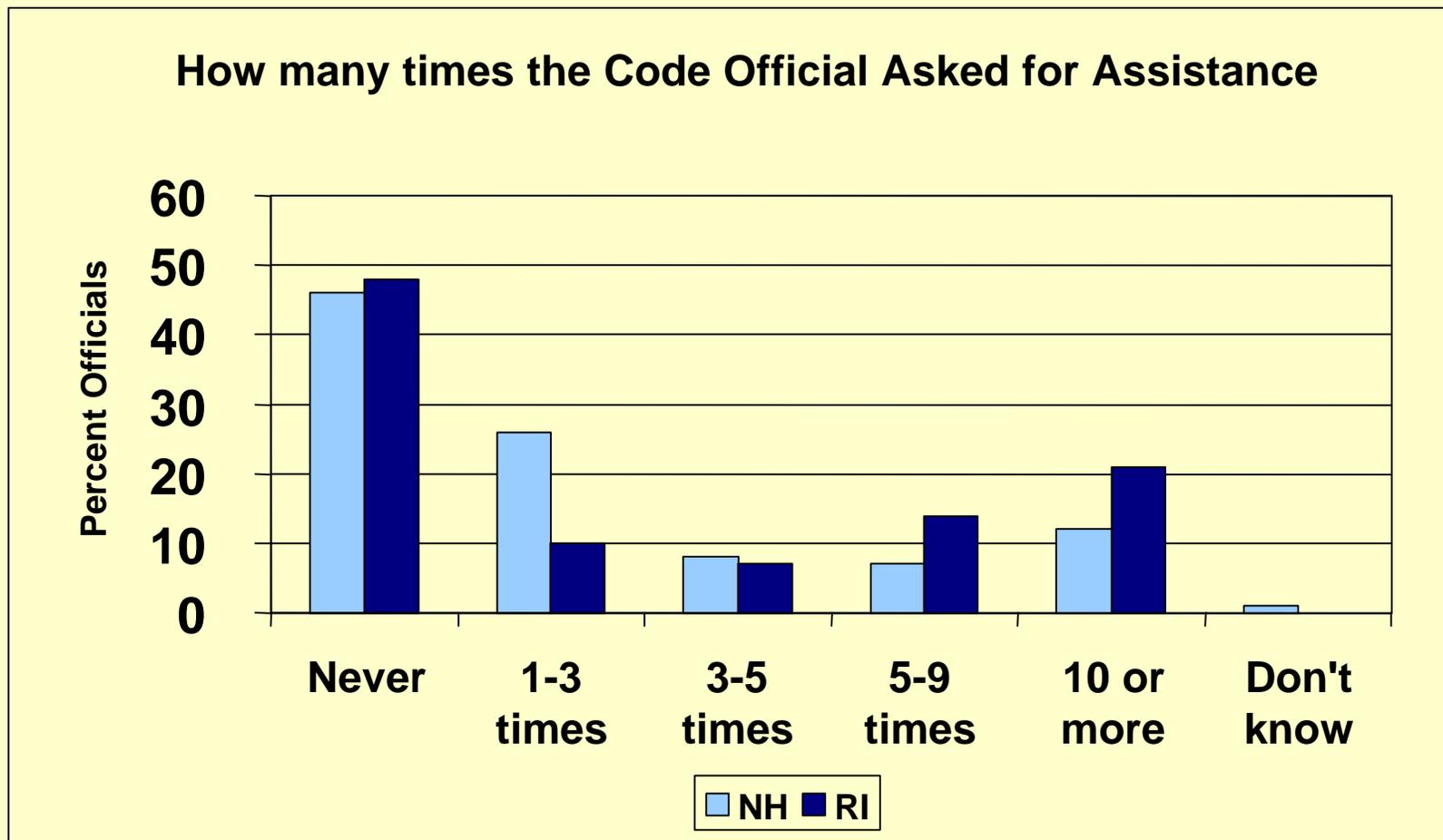
Others in the Building Trades - Commercial Code

RI and NH assessments of player knowledge match even more closely with respect to the commercial energy code than residential energy codes. The relatively high rating of electrical contractors as "Not Very Knowledgeable" may be significant for the design of lighting systems in small commercial projects.



3.6 Technical Assistance

In this section we asked officials about their experience with technical assistance from their respective state code authorities. We asked them roughly how often they had requested technical assistance in the past two years and their assessments of the responsiveness and quality of the assistance they received. Of those who did not ask for assistance, we also inquired about their reasons for not making requests.

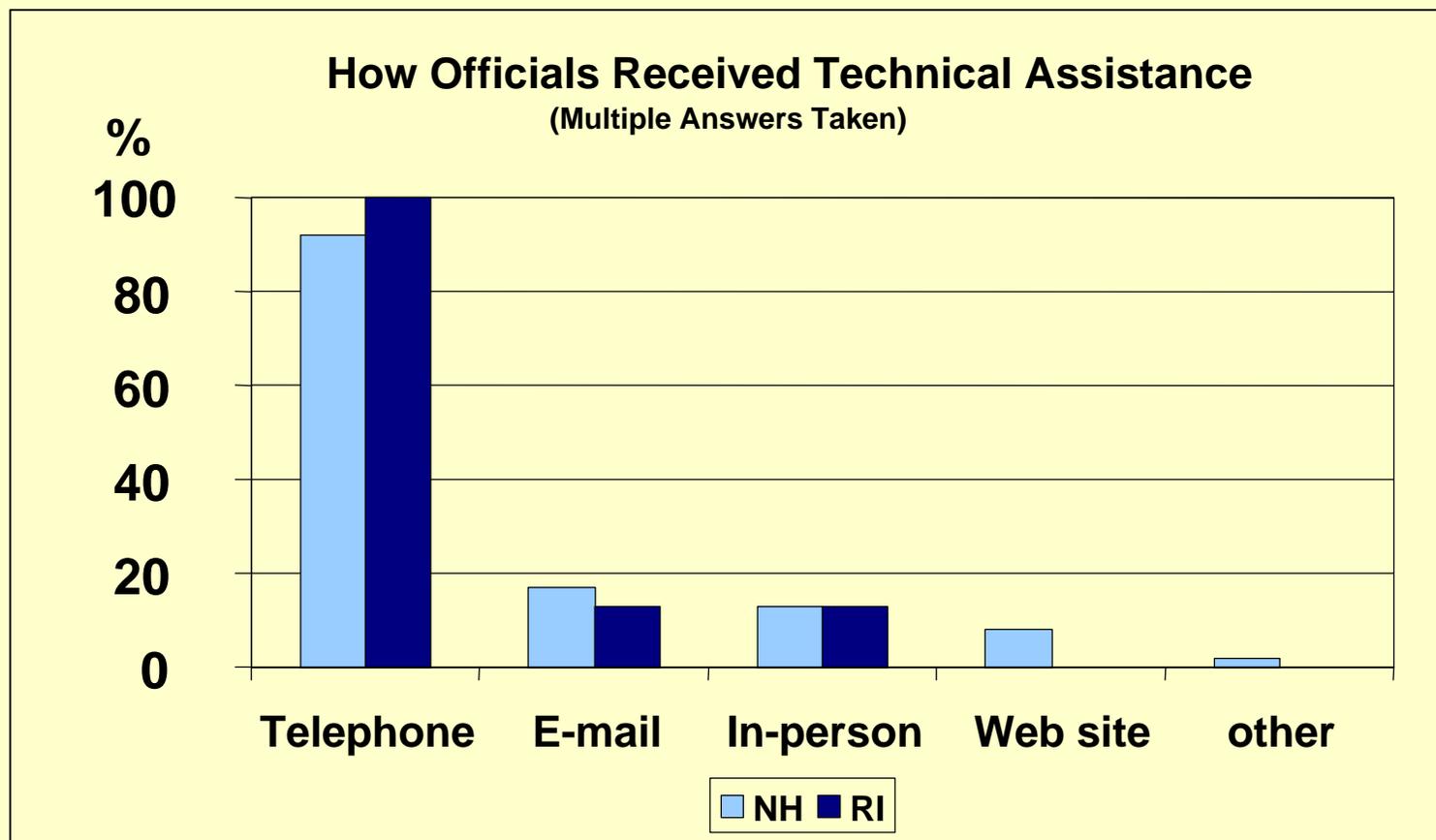


How Officials Received Technical Assistance and Their Satisfaction with It

Telephone contact is by far the most common means of providing technical support. E-mail, in-person visits and Web site contact play minor roles.

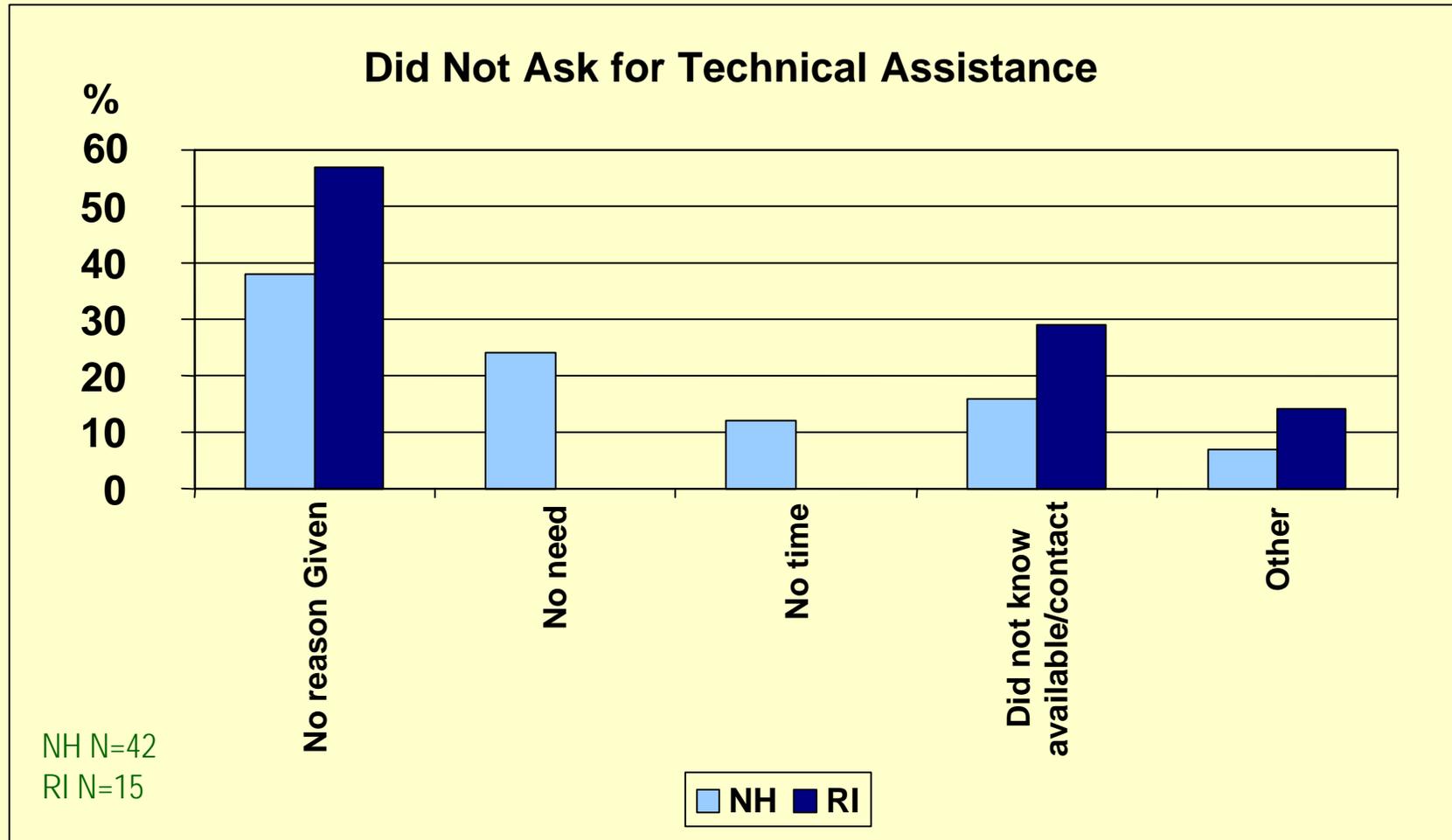
Satisfaction with technical assistance was high in both states:

- ✓ RI "very satisfied" = 67%
- ✓ NH "very satisfied" = 73%



Reasons for Not Asking for Technical Assistance

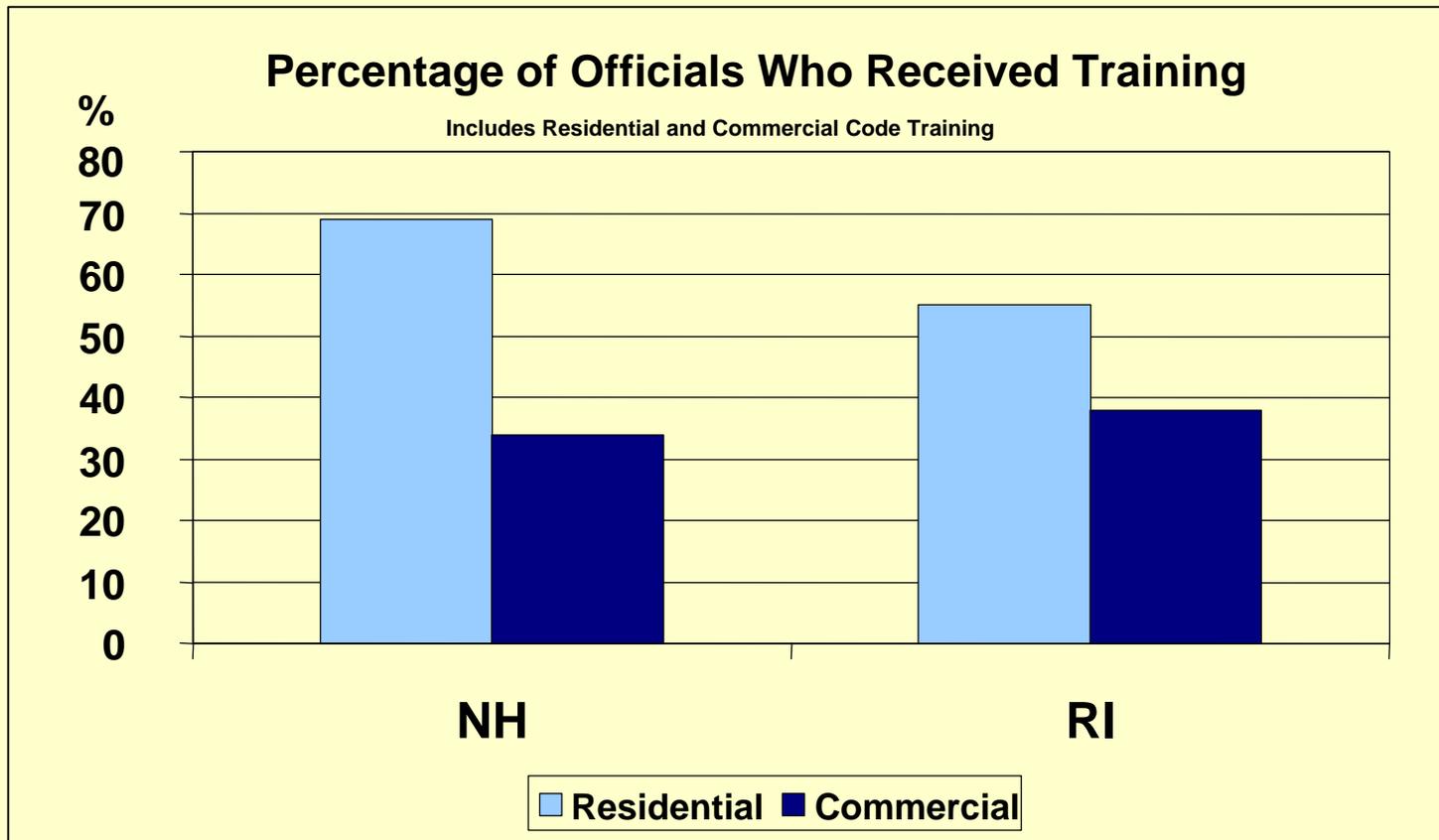
Small groups of officials had similar reasons for not requesting technical assistance. The largest group gave no reasons and may remain a source of useful information. Members of the second largest group either did not know help was available or did not know how to access it. Most officials had requested assistance.



3.7 Training History and Interests

We found some variation in residential code training. Although a smaller percentage of RI officials received residential code training, a larger percentage of them regard themselves “Very Knowledgeable” than do NH officials.

Similar percentages of officials in each state received some commercial energy code training within the last two years. Neither state provided formal commercial code training, but officials may have attended BOCA or AIA sessions.

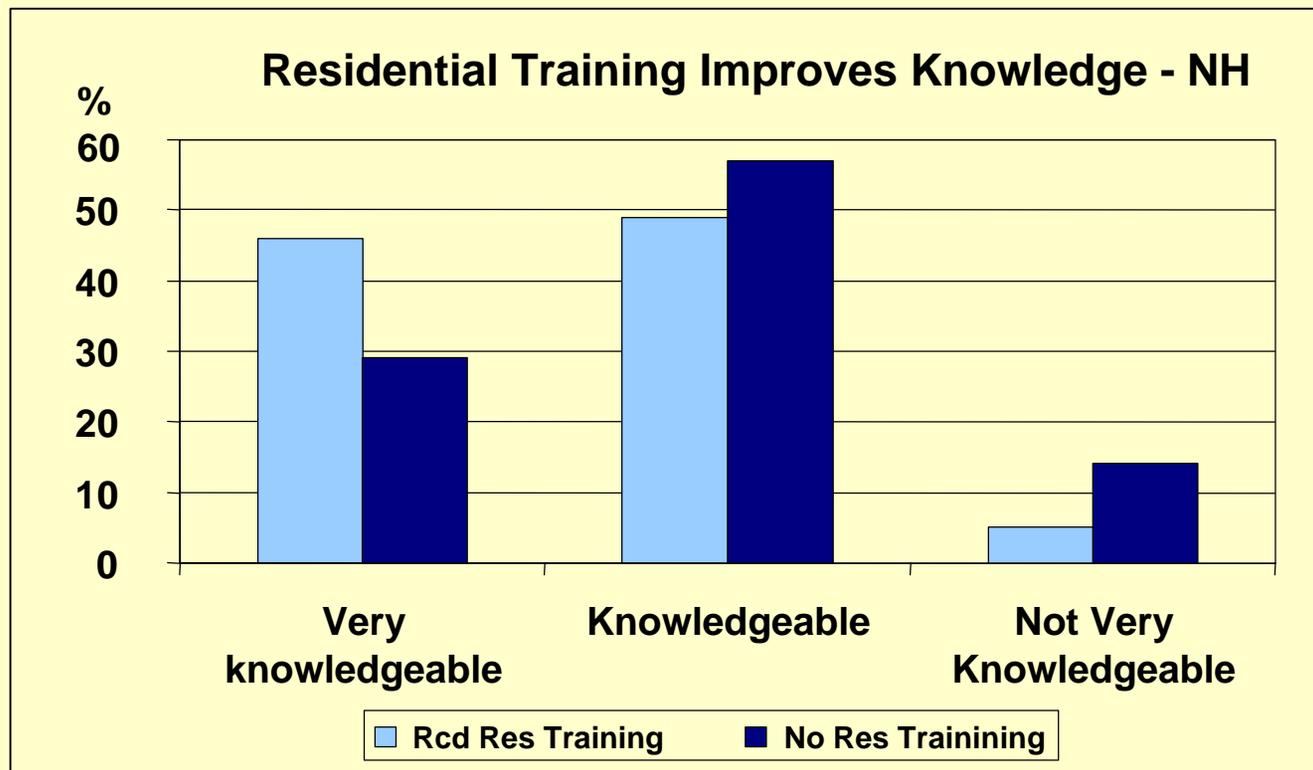


Training and Knowledge of the Energy Code

We asked officials to rate themselves as “Very knowledgeable,” “Knowledgeable” or “Not Very Knowledgeable” with respect to the residential and commercial codes. In the following charts, we compare those self-ratings with participation in residential and commercial training.

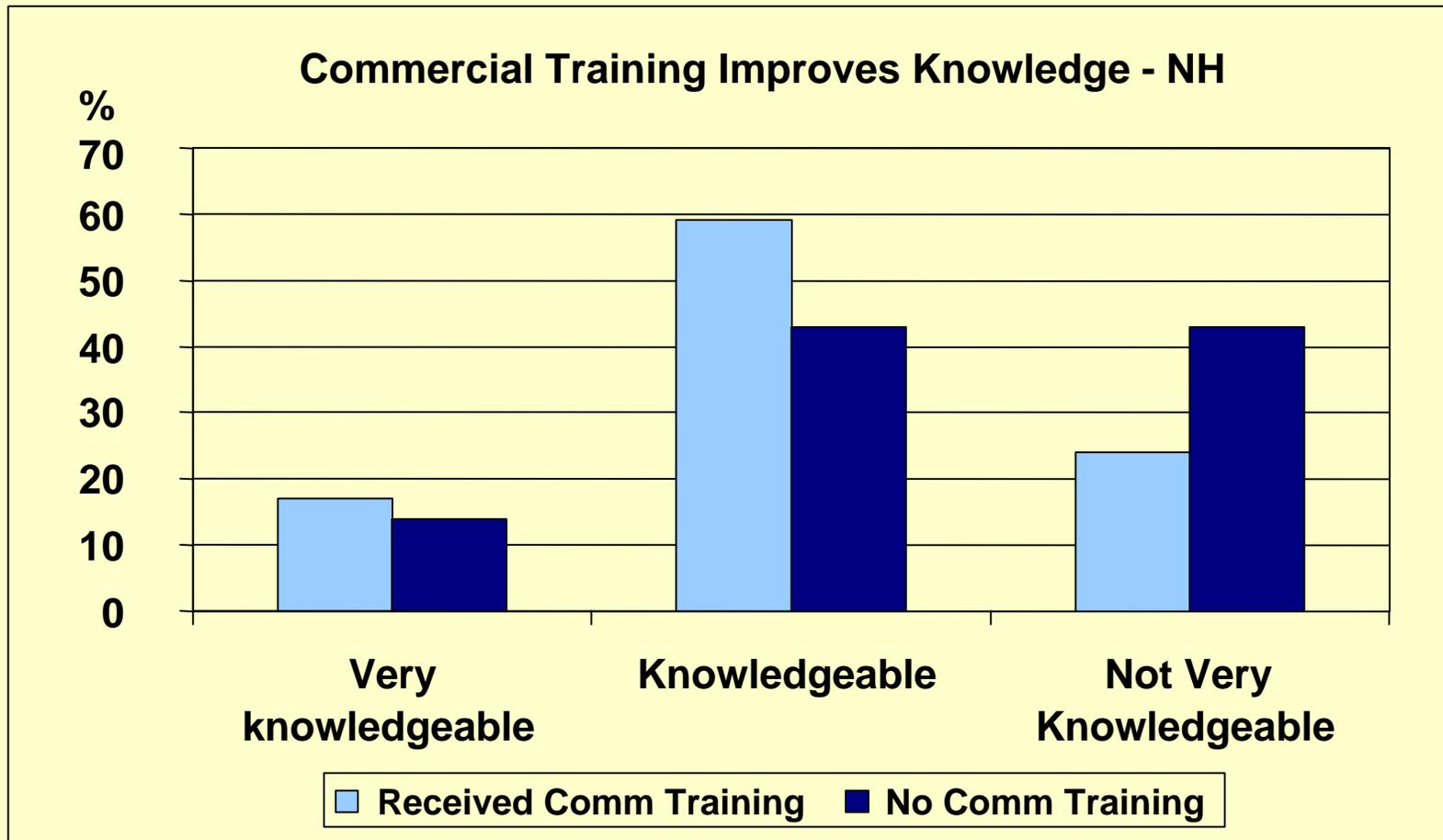
Overall, the ratings are consistent with participation in training. Those trained were more likely to rate themselves as “Very Knowledgeable” or “Knowledgeable” and those not trained were more likely to rate themselves less knowledgeable about the codes.

In NH, residential code training left only a small percentage of officials “Not Very Knowledgeable.” The majority of those “Very Knowledgeable” were trained.



Training and Knowledge of the Energy Code, continued

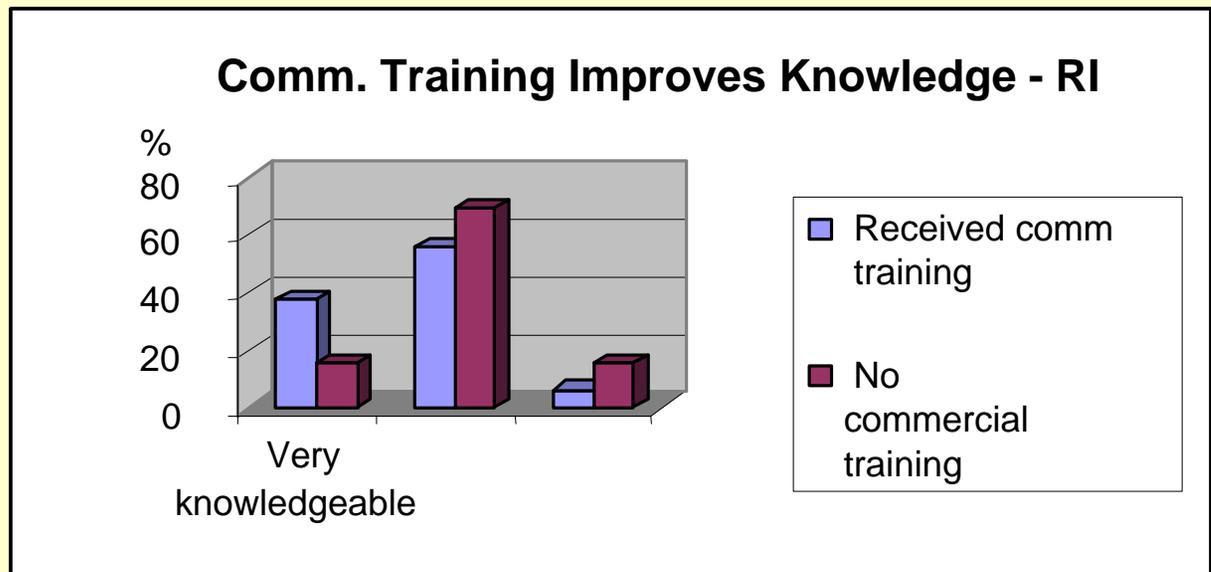
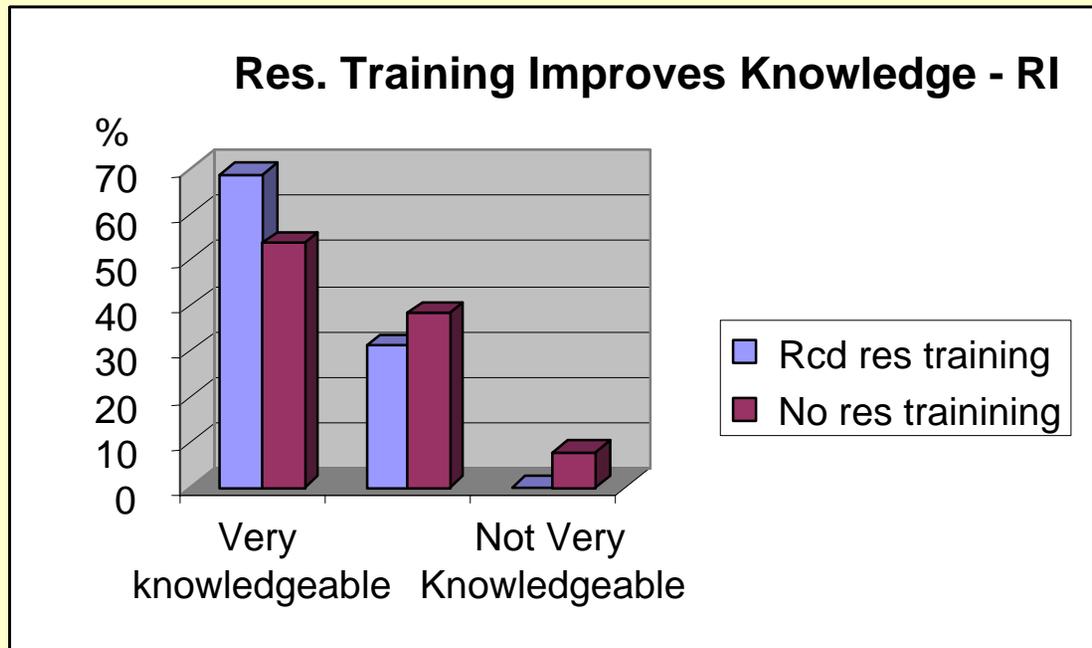
With respect to the commercial code, a correlation between training and knowledge was more evident. The scarcity of such training meant that fewer rate themselves "Very Knowledgeable" and (compared to knowledge of the residential code) only half as many NH officials without training rated themselves "Very Knowledgeable".



Training and Knowledge of the Energy Code, continued

In Rhode Island, residential code training left only a tiny percentage of officials "Not Very Knowledgeable." Most of those "Very Knowledgeable" were trained.

With respect to the commercial code, a correlation between training and knowledge was more evident. The scarcity of training meant that fewer rated themselves "Very Knowledgeable" and, compared to knowledge of the residential code, about 66% fewer officials without training rated themselves "Very Knowledgeable".



Dissatisfaction with Training

Training addressed a number of aspects of the residential and commercial codes

- **Residential** code training included:
 - ✓ Building envelope, including vapor barriers, penetrations and sealing
 - ✓ Building insulation, including continuous, foundation, etc.
 - ✓ Heating and cooling systems
 - ✓ Glazing (windows, percentage of glass area)
 - ✓ Using the MECcheck or NHcheck software
 - ✓ Residential Energy code regulations
- We asked the officials about their satisfaction with each aspect. In general, the responses in both states showed officials satisfied with almost all of the training. Since we are assessing training needs, however, we decided to highlight dissatisfaction to aid identification of areas for additional training. These areas are:

N = 63 16		
<i>Dissatisfaction with Residential Training</i>		
	NH	RI
MECcheck	18%	19%
Residential Heating, Ventilation, AC	13%	19%
Residential Glazing	8%	13%



Dissatisfaction with Commercial Training

We found general satisfaction with most commercial code training topics. From the following list of training topics, the table presents those that most respondents found less than satisfactory:

- ✓ Building Envelope Thermal Performance
- ✓ Glazing
- ✓ Above-grade walls
- ✓ Below-grade walls
- ✓ Roofs
- ✓ Slab edges
- ✓ HVAC
- ✓ Equipment Sizing & Efficiency
- ✓ Duct/Pipe Insulation
- ✓ Operations & Maintenance
- ✓ System Controls/Economizers
- ✓ Interior Lighting Loads
- ✓ Using Comcheck Or ASHRAE Software
- ✓ Commercial Energy Code Regulations

	N= 63 16	
<i>Dissatisfaction w Commercial Training</i>	NH	RI
System controls	9%	36%
O&M	8%	36%
Duct/pipe insulation	4%	27%
Software	4%	27%
HVAC	11%	18%
Interior Light loads	8%	18%
Code regulations	7%	18%
Economizers	4%	18%



Training Needs

We asked officials in both states, both the trained and the untrained, about their interest in particular areas of training in residential and commercial energy code compliance. Many said they would not like any training in residential or commercial code compliance. However, in response to a question asked later, they overwhelmingly said they were very likely to attend residential and commercial training. The more positive later responses may be due to training content and format alternatives presented in the intervening questions.

Among those who said they would like additional training we did not find any differences between New Hampshire full-time and part-time code officials.

New Hampshire Training Interests

New Hampshire residential and commercial energy code training needs have some similarities. *HVAC, Energy Codes* and *Software* are among the top four needs in both categories.

<i>Measure</i>	<i>NH - Residential</i>
None	48%
HVAC	34%
Code Regs	33%
Software	29%
Glazing	24%
Bldg Envelope	24%
Bldg Insulation	23%

<i>Measure</i>	<i>NH-Commercial</i>
HVAC	51%
Ltg & Controls	50%
Code Regs	47%
Software	44%
Bldg Envelope	43%
Glazing	41%
Bldg Insulation	40%
None	37%



Rhode Island Training Interests

Rhode Island officials provided very similar lists of interests. Excluding *None* and *Don't Know*, the residential codes areas of most interest are *HVAC*, *Code Regulations* and *Software*. In the commercial list, *Other*, *HVAC*, *Software*, *Building Envelope* and *Code Regulations* are the leaders, with other some other areas not far behind.

Measure	RI-Residential
Don't Know	45%
None	35%
HVAC	31%
Code Regulations	31%
Software	28%
Glazing	24%
Building Envelope	24%

Measure	RI-Commercial
Other	45%
None	41%
HVAC	41%
Don't Know	38%
Software	34%
Building Envelope	34%
Code Regulations	31%
Building Insulation	28%



Training Aids and Formats

We asked respondents which types of training aids would be most helpful to them, from very practical, everyday tools such as checklists to background materials such as training manuals for code compliance in each type of energy code. Interest in the suggestions was high in both states, somewhat higher in NH, where officials were more oriented to checklist materials. The strongest preferences of RI officials were for training manuals in building types. There were no real differences between preferences of full-time and part-time officials in NH.

Question: "Which of the following types of aids do you think would be helpful to you in fulfilling your energy code compliance responsibilities?"

<i>Training Aid Interests</i>	<i>NH</i>
Checklist: residential permit	90%
Checklist: commercial permit	88%
Checklist: residential inspection	87%
Checklist: commercial inspection	85%
Manual for commercial buildings	82%
Manual for residential buildings	81%
FAQ mail/email	70%
FAQ on web	68%

<i>Training Aid Interests</i>	<i>RI</i>
Manual for commercial buildings	80%
Manual for residential buildings	72%
Checklist: residential permit	59%
Checklist: commercial permit	59%
Checklist: residential inspection	59%
Checklist: commercial inspection	59%
FAQ mail/email	59%
FAQ on web	59%



Likelihood of Attending Training

We asked officials about the likelihood they would attend training on the energy codes and related energy efficiency concerns if the states provided it. A majority of officials expressed interest. However, the part-time officials would be less likely to attend than full-time officials. Note that results shown in bold are statistically significant differences.

<i>Likely to attend?</i>	<i>NH - Residential</i>	<i>NH Commercial</i>	
		<i>Full-Time</i>	<i>Part-Time</i>
Very	64%	62%	42%
Somewhat	29%	21%	34%
Not Likely	7%	4%	23%
Don't Know	1%	0%	3%

RI officials expressed a slightly stronger inclination to attend training than that of NH officials

<i>Likely to attend?</i>	<i>RI</i>	
	<i>Residential</i>	<i>Commercial</i>
Very	79%	72%
Somewhat	10%	10%
Not Likely	3%	7%
Don't Know	3%	7%



Participating in Training Design

More than half of the survey respondents (52% in NH, 59% in RI) said they would be interested in participating with the state in designing further training for the local level. Virtually all of those who responded “yes” to that question gave permission for release of their names to the states for that purpose.

End of Section 3.



4. Conclusions and Recommendations

Providing additional training and tools in both states, particularly in commercial code compliance would be worthwhile for the following reasons:

- ✓ 43 % of part-time code officials in New Hampshire have been on the job for five years or less
- ✓ In Rhode Island, almost half of the officials we surveyed said they had not received any energy code training during the last two years and only about a third had been to a commercial energy code training session
- ✓ In New Hampshire, about two-thirds of officials had been to residential energy code training in the past two years but only one third had been to a commercial training session
- ✓ Code officials in both states cited Checklists and Manuals as the most useful training aids
- ✓ In both states, the complexity of the commercial energy code ranked among the top barriers to code compliance
- ✓ For the residential energy code, officials in both states rated vapor barriers, heating system efficiency and duct systems "Not Very Difficult" to inspect in the field. However, officials in both states said they typically do not inspect them.

Officials in both states believe training should also address the construction community, especially builders



4. Conclusions and Recommendations (continued)

Officials in both states express very similar levels of interest in specific building measures

- **In New Hampshire, the top residential codes issues are:**

- ✓ HVAC (sizing and efficiencies for both states & all building types)
- ✓ Code regulations
- ✓ Software (effective use of modeling programs – both states & all building types)
- ✓ Glazing
- ✓ Building envelope (sealing penetrations, continuous insulation, vapor barriers - both states & all building types)

- **In New Hampshire, the top commercial training interests are:**

- ✓ HVAC
- ✓ Lighting and controls
- ✓ Code regulations
- ✓ Software
- ✓ Glazing
- ✓ Building envelope



4. Conclusions and Recommendations (continued)

- **In Rhode Island, the top residential training measures are:**

- ✓ HVAC
- ✓ Code regulations
- ✓ Software
- ✓ Glazing
- ✓ Building envelope

- **The top Rhode Island commercial training measures are:**

- ✓ HVAC
- ✓ Code regulations
- ✓ Glazing
- ✓ Building insulation
- ✓ Software

- In addition to the specific areas that officials place high on their lists, data derived from the Practices sections indicates there are also needs for training in:

- ✓ Duct construction, insulation and sealing
- ✓ Vapor barriers

These measures have substantial effects on energy use, but officials in both states indicate they infrequently inspected them

- We also suggest training in:

- ✓ New building techniques
- ✓ New control and HVAC technologies coming into use
- ✓ Ventilation for moisture control and indoor air quality concerns



Training Methods and Aids

- Survey respondents in both states prefer workshops as the training format, followed by one-on-one instruction. We found scant interest in self-study programs posted on Web sites.
- Software training should stress its practical uses. It is possible that officials make very little use of the software because they do not perceive the value they can get from the building modeling programs in the limited time they have to assess permit applications.
- We found very strong interests in checklists as a training aid, particularly in New Hampshire. We believe that checklists have practical day-to-day value beyond their use as training tools, and recommend developing checklists that address permit application processes and on-site inspections for both residential and commercial code compliance in both states.
- Rhode Island officials indicated strong interest in manuals for code compliance. The energy efficiency provisions of the Rhode Island building code are not set out in distinct sections as they are in New Hampshire, but a manual could compensate through typography and/or structure. Further, the building codes are generally written in language that is not “user friendly” to officials who have to work with them daily. New Hampshire officials are interested in training manuals as well.
- Officials in both states show a high degree of interest for involvement in training design. We suggest both states explore the resources and insights that local officials can offer, possibly by developing small working groups.



Additional New Hampshire Considerations

- Many communities in NH, generally in central and northern areas, do not have officials responsible for energy code compliance at the town level. Our experiences indicate a number of communities have no one with the appropriate expertise in the energy codes (other aspects of building codes are enforced), or there is a local inability to fund this aspect of compliance activity.
- In NH, almost 40 percent of the officials we surveyed work part-time. We would expect to find at least that percentage of part timers among the 46 communities that have energy code officials but did not participate in the survey (98 NH communities have no code official responsible for energy code enforcement). Many part-time officials appear to be inspectors, and may be local contractors who hire out on a per job basis, rather than serving as regular town employees.
- Officials and Peregrine's own experience suggest that getting part-time officials to attend training workshops may be considerably more difficult than getting full-time employees to attend. Working schedules of the part-timers who have other responsibilities probably have little slack. Payment for time in training (or losing income that would have been earned during training time) may be another major barrier to participation in training by part time local code officials.
- We advise more exploration of working conditions and needs of part-time officials, possibly in guided discussion/focus group format. Training part-time officials is particularly important because in several areas they appear less experienced and knowledgeable and less likely to make use of state training and technical assistance resources than full-time code officials.
- The New Hampshire PUC is considering a proposal to engage a "circuit rider" energy code official to circulate among towns that have only part time or no energy code official, providing both training and consultation on pending applications. This idea has merit and is worth trying on a pilot basis, with appropriate evaluation of its effectiveness.



Further Investigation

Prescribing the best way to provide training to part-time officials requires a deeper understanding of their situations than we could develop in this study. We recommend that the Project Advisory Group sponsor some in-depth interviews and/or focus groups (depending on the feasibility of assembling these) during the winter months when building activity is slower. The sessions could develop a more complete profile of the part-time officials and support recommendations for best improving their skills.



7. Resources

We used the following resources as background for this study or recommend them for further reading:

1. *Energy Code Outreach 1999 –2000*, New Hampshire Governor's Office of Energy and Community Services, June 15, 2000.
2. *Impact Analysis of the Massachusetts 1998 Residential Energy Code*, Prepared for Massachusetts Board of Building Regulations and Standards, by Xenergy Inc., April 16, 2001.
3. *Creating Airtight and Healthy Homes*, Bruce Small, Home Energy Magazine, November/December 2001
4. *Can Duct Tape Take the Heat?*, Max Sherman and Iain Walker, Home Energy Magazine, July/August 1998.
5. *Survey of Commercial New Construction Activities in New Hampshire - Final Report*, provided to the NH Commercial Construction Study Group, prepared by GDS Associates and ENTECH Engineering, May 2000.

