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City of Providence Building Energy Code Compliance Process Review

slipstream

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1. EXECUTIVE SUMMARY

This report provides an analysis and evaluation of the compliance status with the current 2012 IECC energy code for the residential and commercial building sector in the City of Providence. This report summarizes the data collection methodology used to determine an energy code compliance rate, key findings from the data collection and finally a set of recommendations for the Providence Department of Building Inspections and Standards (DIS). This report is jointly supported by City Energy Project (CEP) and National Grid Rhode Island.[1]

BACKGROUND

CEP is a joint national initiative of the Institute for Market Transformation (IMT) and Natural Resources Defense Council (NRDC) that is creating healthier and more prosperous cities by improving the energy efficiency of buildings. Each city receives technical and financial assistance to design, plan, and implement a suite of solutions that advance local sustainability goals. In 2016, the City of Providence joined the list of CEP cities. Providence's plan included conducting a code compliance assessment to help ensure that buildings being permitted and constructed today are meeting the state's current building energy code standards. Slipstream was selected by CEP to conduct this assessment study in Providence.

OBJECTIVES AND PROCESS

The objectives of this study were to:

1. Estimate energy code compliance rates for residential and commercial new construction.
2. Estimate potential energy savings from improved compliance.
3. Provide recommendations to the building inspections staff for further improvement in plan reviews and inspections of energy code requirements.

To meet these objectives, Slipstream

1. Interviewed 10 DIS staff.
2. Conducted plan reviews and site visits of a sample of 5 buildings permitted under the residential code (1-2-unit homes) and 8 buildings permitted under the commercial code[2] (including low and high rise multifamily).
3. Developed energy models for the selected residential and commercial buildings to determine the magnitude of energy savings opportunities resulting from non-compliance.

TOP FINDINGS AND RECOMMENDATIONS

The project team believes the following results and ensuing recommendations will contribute the most towards ensuring compliance and increasing energy savings.

Commercial Buildings:

1. **Lack of Sufficient Documentation:** The city should require project teams to upload sufficient documentation before the building is scheduled for inspection. A checklist of all

[1] National Grid supports energy code trainings in Rhode Island as part of their state-wide energy efficiency programs. www.ngrid.com/rienergycode

[2] City of Providence considers 1-2 dwelling units as residential energy code and anything above that as commercial energy code.

necessary documentation can be used to track the required information. Required documentation should be marked as mandatory (where applicable) on the online reporting platform. If the documentation is not uploaded, the building project team should not be allowed to submit the plan without providing an explanation.

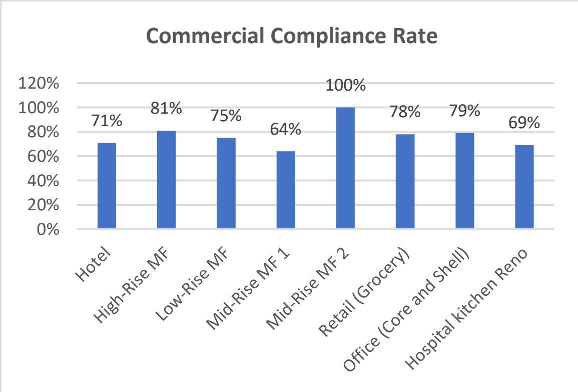
2. **Lack of correct compliance pathways:** The city should require project teams to clearly indicate in the code analysis section which code and which compliance path the project team is using. The compliance path is important as code requirements may be different for specific measures between different compliance paths, and it may change how inspectors evaluate compliance.
3. **Field Inspections:** Focus resources on ensuring compliance with those measures that have a big energy impact. For example, mechanical and lighting controls can have a larger impact on energy savings than envelope insulation measures. Also, make sure that a Sequence of Operations document is available to confirm control settings, especially if not visible or the system is not operational on site.
4. **Trainings:** Additional training of DIS staff is needed on verifying commercial building HVAC controls, and how to make the calculations necessary to determine compliance if supplemental calculations are not provided by the building project teams.

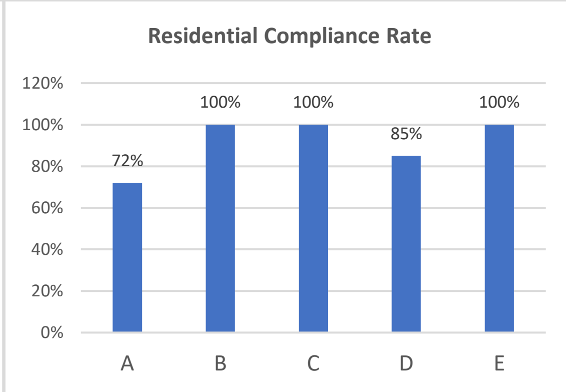
Residential Buildings:

1. **Lack of Sufficient Documentation**: Require plans to identify the type of heating and cooling systems and location of any ductwork. Exterior ductwork triggers the need for duct-leakage testing. Alternatively, require builders to certify that a home is exempt from the duct-leakage testing requirement because the home has no ductwork outside the thermal envelope.
2. **Duct and air leakage tests:** Require air-leakage and (when applicable) duct-leakage test results to be uploaded to the on-line reporting platform prior to issuing a Certificate of Occupancy. Although current code does not require builders to meet a specific air-leakage threshold, thresholds are likely to be included in coming code cycles: beginning to enforce testing now will help build testing infrastructure and inform builders about changes in construction practices that they'll need to adopt.
3. **Field Inspections:** Inspections should focus on ceiling insulation defects in single-family projects. Inspect the home after all attic work is complete to ensure adequate attic insulation and to identify any insulation disturbances related to the installation of bath fans or other ceiling/roof penetrations.
4. **Trainings:** Provide clarity around and train inspectors on air-leakage and duct-leakage testing methods for single family homes so that third-party test results can be evaluated for code compliance, when these become mandatory requirements in next code cycle.

The average compliance rates of the sample commercial buildings was calculated to be **77%**, and that of residential homes was **89%**. Figure 1 shows compliance rates of each of the sample buildings.

Figure 1. Code compliance rates for commercial and residential construction





CONCLUSIONS

The overall compliance for residential buildings was considerably higher (89%) than commercial buildings (77%). It is important to highlight that these compliance rates are based on a combination of a high rate of market readiness/acceptance due to the exceptionally elongated energy code cycle (6 years versus traditional cycle of 3 years), a limited number of site visits and limited site observations due to the stage of construction of the sample buildings. Additionally, we reduced compliance rates for some commercial buildings that didn't show proper documentation in the plan review tool, despite documenting compliance on site. The reason for doing that was to emphasize the importance of proper documentation practices during plan reviews, both for plan reviewers and for building practitioners, especially as new and more stringent codes get adopted in the city.

In 2016, Mayor Jorge Elorza committed Providence to becoming a carbon neutral city by 2050 citing energy efficiency in buildings as one of the most important ways to get to that target. Advanced building energy codes are the most cost-effective way to achieve energy savings and help consumers save energy and money because they capture these savings from the time of construction. They improve efficiency by mandating performance through careful construction and proper selection of building components, including wall and ceiling insulation, windows and doors, heating and air conditioning equipment and system efficiency, and lighting power density and controls.

As a result of not being in full compliance, the city is missing out on energy savings. Lost savings as a result of non-compliance of the sampled buildings translates to cumulative 20 years potential energy savings of 93,000 MWh electric and 8 million therm gas savings for commercial buildings and about 6,400 MWh electric and 1.1 million therm gas savings for residential buildings. With enhanced support from the National Grid energy code support program and the City of Providence, and implementing the recommendations provided in this report, the City of Providence and DIS staff should aim to achieve a goal of fully compliant new construction buildings.

2. INTRODUCTION

Providence participates in the City Energy Project (CEP), a national initiative to create healthier and more prosperous cities by improving the energy efficiency of buildings. CEP is a joint project of the Institute for Market Transformation (IMT) and the Natural Resources Defense Council (NRDC).

Building energy codes are a fundamental component for ensuring a base level of energy efficiency in a city's building stock. Providence undertook a study to assess both residential and commercial compliance rates with its building energy code. The results from this study will be used to identify opportunities for increasing compliance with the energy code.

Slipstream, an organization with deep roots in building energy efficiency research, conducted the energy code compliance assessment for the current code (2012 IECC) in effect in Providence. This report summarizes the data collection methodology used to determine energy code compliance rates for residential and commercial buildings in Providence, key findings from the data collected and presents a set of recommendations for increasing compliance with building energy codes.

2.1 BACKGROUND

CEP was launched in 2014 to empower participating cities to implement locally designed energy efficiency strategies and foster peer-to-peer sharing of knowledge and best practices. Each participating city receives technical and financial assistance to design, plan, and implement a suite of solutions that advance local sustainability goals. CEP also provides dedicated staff assistance to work onsite within each city. In 2016, Providence Mayor Jorge O. Elorza set a goal for Providence to become a carbon neutral city by 2050. With the understanding that 70 percent of citywide greenhouse gas emissions come from buildings, the city successfully applied for and joined the CEP. Part of Providence's plan included conducting a code compliance assessment to help ensure that buildings being permitted and constructed today are meeting the state's building energy code standards.

In 2018, IMT and National Grid, one of Rhode Island's energy providers,[3] engaged Slipstream to assess building energy code compliance in Providence.

2.1.1 Rhode Island State Energy Code

In Rhode Island, the Building Code Standards Committee promulgates, adopts, and administers the state building code. It formally adopted the Rhode Island State Building Code on July 1, 2013, incorporating the provisions of the International Energy Conservation Code, 2012 edition, as published by the International Code Council, Inc. (ICC), together with amendments. Since 2013, the code hasn't been updated. Rhode Island is currently updating the code to incorporate the 2015 International Energy Conservation Code provisions (with amendments). As a result,

[3] National Grid supports energy code trainings in Rhode Island as part of their state-wide energy efficiency programs. www.ngrid.com/rienergycode

the 2012 version has been the energy code for the last six consecutive years instead of the typical three-year cycle.

The State Building Commissioner enforces the code for all state buildings and buildings built on state-owned property. Compliance is determined through the building permit and inspection process by local building code officials and the State Building Commission. The link to the state energy conservation code is provided here:
https://sos.ri.gov/assets/downloads/documents/SBC8-RI-state-energy-conservation-code.pdf

2.1.2 City of Providence Application of the IECC

The City of Providence applies the residential energy code only to one- to two-dwelling unit buildings when determining which code (residential or commercial) a project should comply with. They apply the commercial energy code to residential buildings with more than two dwelling units. This interpretation deviates from the IECC which includes multiple single-family dwelling unit projects (triplexes, R-2, R-3 or R-4 buildings) that are three stories or less in height in the residential energy code. As a result, our assessment of commercial energy code compliance in Providence includes low-rise multifamily buildings.

3. CODE COMPLIANCE ASSESSMENT

The objectives of this study were to generate a rough estimate of code compliance rates based on the CEP Assessment Methodology for Code Compliance in Medium to Large Cities[4] for residential and commercial new construction and estimate potential energy savings from improved compliance using Equest modeling protocols.[5] To meet these objectives, Slipstream

- Interviewed DIS staff
- Conducted plan reviews and site visits of a sample of residential and commercial buildings
- Developed energy models for residential and commercial buildings to determine the magnitude of energy savings opportunities resulting from non-compliance

Prior to conducting interviews and site visits, we reviewed previous code compliance studies for Rhode Island[6] and survey instruments and data collection forms created for CEP.[7] We were able to modify the CEP instruments to suit the Providence study, referred to as CEP Survey Instrument and CEP Data Collection Form throughout this document.

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[4] https://www.cityenergyproject.org/resource-library/policy-and-programs/codes/

[5] http://www.doe2.com/equest/

[6] National Grid has funded several state-wide code compliance and related studies which we reviewed to understand the state-level data and its applicability to Providence.

[7] IMT has developed a set of data collection forms and survey instruments for CEP participants to use to benchmark building energy use and efficiency. The data collection forms include calculations for measuring code compliance rates.

3.1 DEPARTMENT OF INSPECTIONS AND STANDARDS STAFF INTERVIEWS

Slipstream staff conducted interviews with plan reviewers and field inspection staff to determine their depth of understanding of the building energy code and to determine what problems and issues they have in enforcing the energy code.

Our discussions with the Chief Building Official gave us an understanding of the basic process for plan review and field inspection of commercial and residential buildings. We used this information to modify the CEP survey instruments to meet our requirements for Providence.

We conducted interviews with nine building plan reviewers and inspectors. The interviews took place in-person at DIS and covered four main categories: administrative process; trainings; plan review process; and building inspection process. A summary of the interview results is provided in Appendix D.

3.2 PLAN REVIEW AND SITE SELECTION

Slipstream worked with DIS to identify an initial set of buildings to include in this study. DIS provided a list of 20 potential projects for plan review and site visits. We eliminated five of those projects because they were deemed unsuitable for this study. In order to get a larger list of buildings to draw from for our site visits, we used their online permit tool, Viewpoint,[8] to access project details and plan review notes. The criteria for including a project in our study was based on several factors including the availability of inspectors/project site coordinators and whether the project had undergone enough stages of inspections. From this deeper review of project plans we were able to identify a suitable pool of building projects to contact for site visits.

Slipstream received architectural, mechanical, electrical, and plumbing plans for most of the commercial building projects we reviewed, and for all residential projects. For each building, we used the CEP Data Collection Form to verify that an energy efficiency measure had been implemented and document code compliance. Code items not shown on the building plans were marked as "non-compliant": sufficient documentation in plans is a key requirement in code enforcement. For commercial buildings, window-to-wall ratio, interior lighting power density and exterior lighting power calculations were conducted separately to determine compliance. See Appendix E for detailed residential and commercial plan review findings.

3.3 SITE VISITS

Slipstream staff visited 13 buildings to assess their envelope (roof, walls, windows, slab and exterior floor), lighting, and mechanical system compliance with the energy code. Five sites were single family homes, four were multifamily buildings, and the others were an office, hotel, retail (grocery) and a hospital kitchen renovation. The residential energy code applied to the five single family homes while the commercial energy code applied to all the other projects. Our intention was to visit 15 sites (10 residential buildings and 5 commercial buildings) but four scheduled visits were either inspector or contractor no-shows resulting in one less non-

[8] http://www.viewpointcloud.com/

residential commercial building than we planned. And, because Providence applies the commercial code to multifamily buildings, our five single family homes were short of the ten sites we hoped to include in the residential code compliance analysis.

3.3.1 Commercial Projects

We completed site visits at eight commercial new construction and major renovation projects. Construction progress at the time of the site visits ranged from a pre-insulation framing stage to fully operational and occupied. Table 1 provides details on these sites. The kitchen renovation project is an outlier among the eight project sites as the scope of the project only included new makeup air units and kitchen exhaust fans, the envelope was untouched, and the lighting renovation was mostly relocating existing fixtures; we did not do an energy model of the kitchen renovation project.

Table 1. Commercial Projects Selected for Site Visits

Project Code	Building Type	Total Area	No. of Stories	Mechanical Equipment	Stage of construction
H	Hotel	107,948	8	Guest room: PTHP; 1st and 2nd floor common areas: VRF heat pumps; 1st floor underfloor radiators served by boiler; ERV providing Outside Air (OA)	80% complete
M-1	High-Rise Multifamily	255,934	6	In-unit: Fan coil units w/ boiler supplying space heat and domestic hot water; Common areas: Split AC with gas furnace heat, and air source heat pumps serving smaller areas	80% complete
M-2	Low-Rise Multifamily	75,341	3	In-unit: VRF ductless mini-split heat pump in each room; Common areas: Gas-fired rooftop units	Fully operational and occupied
M-3	Mid-Rise Multifamily	33,075	4	In-unit: Ductless mini-split heat pump in each room, with energy recovery	Pre-insulation
M-4	Mid-Rise Multifamily	8,693	4	Mechanical drawings not available, unknown	Insulation
R	Retail (Grocery)	8,370	1	Gas fired RTUs and split system heat pumps	100% complete, tenant not moved in
O	Office (Core and Shell)	13,540	4	Base building: Air source VRF heat pumps, rooftop ERV	50% complete
K	Kitchen Renovation within a Hospital	18,000	1	Kitchen makeup air unit connected to central heating and cooling	Kitchen hood/exhaust installed, remodeling at 70%

3.3.2 Residential Projects

We completed site visits at five single-family new construction projects. Construction progress at the time of the visits ranged from a pre-insulation framing stage to complete and occupied. Two of the five projects (B and C in Table 2) were identical homes (next door to one another) being constructed by the same builder but were at slightly different stages of construction at the time of the visit. We were able to conduct blower door tests of air leakage for three of the five homes and performed duct-leakage testing at two sites.

Table 2. Residential Projects Selected for Site Visits

Project Code	Floor area (ft^2)[a]	Stories above grade	Mechanical equipment	Stage of Construction	On-site testing performed	
					Air leakage?	Duct leakage?
A	2,264	2	Minisplit ASHP (2), electric DHW	Finished project	Yes	Yes
B	1,728	2	Nat gas furnaces (2), Central A/C (2), electric DHW	Windows+drywall install	Yes	Yes
C	1,728	2	Nat gas furnaces (2), Central A/C (2), electric DHW	Finished drywall	No	No
D	5,216	1	Nat gas furnace, Central A/C, electric DHW	Occupied project	Yes	No
E	2,664	2	Nat gas furnaces (2), Central A/C (2), electric DHW	Framing+windows	No	No
[a]Includes conditioned basement, when present						

3.4 ENERGY MODELING

The rate (percentage) of code compliance is a useful indicator of the effectiveness of code enforcement activities but does not help us to prioritize the importance of energy saving opportunities by magnitude. Building energy models allow us to quantify the energy savings opportunity and document energy efficiency performance impacts. We developed energy models for each of the five homes, and four prototype commercial buildings that reflect the building types that we audited (as noted earlier, project K in Table 1 was not modeled).

3.4.1 Commercial Buildings

Annual potential energy savings for fully compliant commercial buildings were modeled using DOE2-based whole building energy simulation. These models were used to calculate the differences in energy usage for compliant and non-compliant buildings based on our findings from the site visits. Using industry standard modeling techniques, we created 2012 IECC based prototype energy models in eQuest 3.649 to reflect Providence's base code and local building practices, such as typical glazing area. The prototype energy models were created for each major building type, including retail, office, hotel and residential multifamily. Scaling was used to handle individual characteristics of the building stock investigated in the field. The multifamily energy model was based on the average or typical properties of the four multifamily buildings that were visited. Parametric simulations were conducted to quantify potential energy savings from non-compliance measures. The annual potential energy savings was then extrapolated out 20 years to estimate the cumulative 20-year energy savings lost for the current floor area under construction for each occupancy type. Table 14 in Appendix C provides descriptions of each prototype building that was modeled.

3.4.2 Residential Buildings

Slipstream staff developed a REM/Rate™[10] model of each of the five homes that we visited. These models were assessed against a minimally-compliant code-baseline home. Energy savings from addressing specific non-compliance items was then assessed and extrapolated to future-construction housing stock. Cumulative, 20-year potential energy savings for fully compliant residential buildings was derived from REM/Rate™ models for each visited home.

4. STUDY FINDINGS

4.1 COMPLIANCE RATE

As mentioned in the previous section, we used the information gathered during plan review and site visits to populate the CEP Data Collection Form that provided the compliance rates for the sampled buildings.

Commercial Buildings

Based on the plan reviews and site visits, the overall compliance rate (sum of building envelope, mechanical and lighting systems) for commercial buildings is 77%. Code items were marked as non-compliant if they were not observable (because the construction stage precluded it or because the equipment had not yet been installed) and were not shown as compliant on the building plans. Table 3 shows compliance rates for the individual commercial properties visited. Note that the small sample sizes make the average compliance-rate estimate a particularly uncertain indicator of citywide compliance with commercial code. However, it still allowed us to

[9] http://www.doe2.com/equest/

[10] http://www.remrate.com/

present some actionable qualitative feedback to the city on what areas they could focus on, and how their process could be improved.

Table 3. Commercial Code Compliance Rates, by property and overall.

Project Address	Building Type	Overall Compliance				
		Meets Requirements?		Not Observable	Not Applicable	Compliance Rate
		Yes	No			
H	Hotel	90	36	20	79	71%
M-1	High-Rise Multifamily	104	25	11	85	81%
M-2	Low-Rise Multifamily	80	26	25	94	75%
M-3	Mid-Rise Multifamily	56	32	28	109	64%
M-4	Mid-Rise Multifamily	59	0	0	24	100%*
R	Retail (Grocery)	94	26	32	73	78%
O	Office (Core and Shell)	81	22	9	113	79%
K	Kitchen Renovation within a Hospital	20	9	0	113	69%
Total	**-**	**584**	**176**	**125**	**690**	**77%**

**The 100% compliance rate for M-4 is purely based on it meeting 100% compliance only for envelope.*

Compliance rates by building envelope, mechanical and lighting systems were calculated for each project site. Project M-4 did not provide mechanical and electrical drawings, so the compliance rate was only calculated for envelope items. Project O was a core and shell building hence the lighting measures were mostly out of scope. Project K did not have envelope modifications in the scope of work. Table 4summarizes compliance rates by each system: envelope, mechanical and lighting. A much more detailed set of compliance rate tables can be found in Appendix B.

Table 4. Commercial Compliance Rates by Envelope, Mechanical, Lighting System

Project Address	Building Type	Envelope Compliance Rate	Mechanical Compliance Rate	Lighting Compliance Rate
H	Hotel	55%	73%	100%
M-1	High-Rise Multifamily	69%	84%	100%
M-2	Low-Rise Multifamily	58%	77%	86%
M-3	Mid-Rise Multifamily	44%	82%	25%
M-4	Mid-Rise Multifamily	100%	-	-
R	Retail (Grocery)	50%	95%	79%
O	Office (Core and Shell)	69%	86%	100%
K	Kitchen Renovation within a Hospital	-	70%	67%
Total	**-**	**68%**	**82%**	**83%**

Residential Buildings

Energy-code compliance for the five residential properties ranged from 72 to 100 percent, with an overall average of 89 percent (Table 5). Again, due to the small sample size, this is a highly uncertain indicator of citywide compliance with residential code. It should also be noted that only three compliance items could be reviewed for one home (E) that was only at the framing stage of construction.

Table 5. Residential Code Compliance Rates, by Property and Overall.

Property	Number of code-compliance items				Compliance rate
	Meets Requirement?		Not observable	Not applicable	
	Yes	No			
	A	B	C	D	A/(A+B)
A	21	8	20	39	72%
B	23	0	25	40	100%
C	25	0	22	41	100%
D	17	3	17	51	85%
E	3	0	45	40	100%
Total	89	11	129	211	89%

4.2 NON-COMPLIANT MEASURES

The following tables highlight non-compliant measures that have potential energy saving implications.[11] Table 6 is a comprehensive list of commercial energy code measures that were either: 1) not in compliance, or 2) not verifiable due to lack of documentation, restricted access, or some other reason that suggested a compliance issue.[12]

[11] For some code items the building exceeded code minimum requirements could possibly compensate for some of the non-compliance code items. However, as this is beyond the scope of work for this study, we did not investigate further on the 'above-code' items.

[12] Reasons that measures ended up in this category include lack of documentation in the plan review suggesting the item may not have been considered, demonstrated lack of compliance in the 2016 RI Code Compliance Study, or other engineering judgement suggesting that some of these may not have complied.

Table 6. Noncompliant/Unverifiable Measures in Commercial Building Site Visits

Non-compliance Measures[13]	Description
Envelope	
Window Properties (U-value and SHGC[14], leakage requirements)	Six out of the eight commercial buildings did not have window properties documented on the drawings or provided additional documentation to demonstrate window U-value and SHGC compliance. So we marked the window measures as non-compliant in the CEP Data Collection Form for those six projects, as sufficient documentation is a key requirement during plan review. Buildings H and the four multifamily buildings had factory-built windows, but the NFRC[15] labels were no longer visible at the time of the site visit for M-1, M-2 and H. We could not confirm if this was due to the project team removing the stickers after the City's inspection, as inspection records could not be found to verify this. It should be noted that M-2 was already fully occupied for several months so we did not expect to see the NFRC stickers still present. For custom made storefront windows, as NFRC labels are not required or available, there was no way to confirm compliance on site without additional documentation. The 2016 RI statewide code compliance study[16] indicated that window properties are very difficult to confirm on site without the manufacturer labels, hence our observations were in line with the statewide study.
Window-to-Wall Ratio	All sampled buildings were permitted under 2012 IECC prescriptive path, which limits the Window-to-Wall ratio to 30%. However, one project site had a WWR[17] of 35%, which did not meet 2012 IECC prescriptive path code. There was no indication of use of ASHRAE 90.1 at the time of the inspection. We reached out to the project team a few weeks later after the site visits and confirmed that the intent was indeed to use ASHRAE 90.1 Prescriptive path (which would have allowed 40% WWR under the prescriptive path), however 90.1 Prescriptive is not allowed in RI per amended section C401.2 in the RI State Energy Code[18].
Opaque Door U-Value	No additional documentation was provided to verify opaque door properties.
Exterior Floor R-Value	Building H did not meet exterior floor insulation requirements.
Stair and elevator shaft vents have motorized dampers that automatically close	Unable to verify either on plans or on site.
Mechanical	

[13] Including measures that lack documentation in building plans and/or not observable on site.
[14] Solar Heat Gain Coefficient
[15] National Fenestration Rating Council
[16] Rhode Island Commercial Energy Code Compliance Study, October 25, 2016, National Grid
[17] Window to Wall Ratio
[18] https://sos.ri.gov/assets/downloads/documents/SBC8-RI-state-energy-conservation-code.pdf#page=10

Non-compliance Measures[13]	Description
Duct and Pipe Insulation R-value	Insulation was observed on site, however for some sites the R-value could not be confirmed as it was not documented on the drawings.
Thermostat Deadband	Could not be verified for most projects due to the mechanical system not being operational at the time of the site visit.
Air Economizer Shutoff Controls	Cooling system air economizer controls could not be verified for some projects due to no clear indication in drawings and unable to observe on site.
Energy Recovery Where Required	Energy recovery on outside air systems requirement was not met for M-2, which had two 100% OA units.
Heat Pump Supplemental Heating Requirement	Could not verify the operation sequence for the heat pump supplemental heating from the plans.
Mechanical Commissioning	Could not be verified due to lack of documentation for most project sites. Only verbal confirmation was made through discussions with construction crew on site.

Table 7 summarizes noncompliant measures found at the five residential site visits. Additional details about these can be found in Appendix A.

Table 7. Noncompliant measures from residential site visits

Non-compliance Measures	Description
Attic Insulation	• Poor insulation coverage observed at one home where 16-inch batts were installed in an attic with 22-inch truss spacing leaving large gaps between batts. • Attic insulation was disturbed when a bath fan was installed at one home and was not corrected. • Attic access hatch was uninsulated at one site.
Duct Leakage	• Tests on two sites with ducts running outside the thermal envelope found that one site did not meet the requirement of total leakage less than 8 CFM25 per 100 ft^2.
Air Leakage	• While air tightness testing is required, there is no requirement to meet a specified threshold. However, none of the homes tested would meet the requirement in the 2018 residential IECC. • A missing air barrier was observed between a bathtub and the outside wall at one site. Unsealed recessed lighting was observed at two sites.

4.3 POTENTIAL SAVINGS FROM ADDRESSING NONCOMPLIANT MEASURES

Energy models were developed to estimate potential savings from non-compliant measures. DOE2 and eQuest were used to model commercial buildings. REM/Rate™ was used for single-family homes.

Commercial Buildings

Based on the non-compliant measures that were found in the field, the following measures with energy implications were modeled for the prototype buildings:

- Window U-Value
- Window to Wall Ratio (for office building only)
- Thermostat deadband
- Economizer High Limit Shutoff
- Energy Recovery
- Roof Insulation
- Daylighting Zones

It should be noted that the roof insulation measure was not explicitly found to be non-compliant in the eight visited sites, but it was mostly not observable due to timing of the site visits, so we were unsure of this measure's compliance status. The daylight control measure was found to be compliant at the retail store, however since that is the only site where this measure was applicable, we did not think it was representative. Additionally, the 2016 RI Commercial Energy Code Compliance Study[19] found these two measures, roof insulation and daylight controls, to have low compliance rates so we included them in our modeling analysis. Energy impacts were calculated on an annual basis, normalized by square footage. More details on the energy modeling for each measure results can be found in Appendix C.

Cumulative 20-year potential energy savings for fully compliant commercial buildings in the City of Providence were extrapolated based on the modeling results of the DOE2-based whole building energy simulation. See Appendix C for complete modeling information. We used Dodge data for 2010-2015 to estimate the average square footage of retail, office, and hotel buildings that are built in the city each year. The Dodge data did not include the multifamily building types, so we used the city's permit database to estimate an annual average square footage for 2015-2018 for multifamily. We then extrapolated the results to 20 years of estimated new construction activity in the City of Providence, based on the following assumptions:

A 4.4 percent new construction growth rate[20]

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[19] The Final Report of the Rhode Island Commercial Energy Code Compliance Study, completed by DNVGL for National Grid, dated October 25, 2016.

[20] Based on the Rhode Island Code Compliance Enhancement Initiative Attribution and Savings Study, September 2017.

Providence makes up 80 percent of the total building stock in Rhode Island

38 percent calculated square footage ratio of retail, office, hotel and multifamily to all building types in Providence

This yields cumulative estimated 20-year savings as shown in Table 8. This table shows that cumulative 20 years potential energy savings for fully compliant new construction buildings in the city is approximately 93,000 MWh electric and 8 million therm gas savings for commercial buildings alone. Given the small number of sites from which they are derived, these estimates are of course very approximate. They also only account for new construction activity, and do not consider energy savings potential related to code compliance for renovation.

Table 8. 20-Year Cumulative Lost Savings, with New Construction Growth Rate of 4.4% for commercial buildings

Prototype Building Type	Non-Compliant Measures Lost Savings		
	MWh	therm	MMBtu
Retail	10,594	1,693,257	205
Office (all electric)	19,030	0	65
Hotel	710	450,740	47
Multifamily	5,492	1,026,638	121
20 year cumulative lost savings for total Building Stock in Providence	**93,308**	**8,257,549**	**1,144**

Residential Buildings

Cumulative 20-year potential energy savings for fully compliant new single-family homes were derived from REM/Rate^{TM} models for each home visited and extrapolated based on estimates of annual new-construction activity. Results are shown in Table 9 and indicate about 6,400 MWh electric and 1.1 million therm gas savings for residential buildings. These estimates do not include energy savings potential related to energy code compliance from renovation projects. More details on the derivation of these estimates can be found in Appendix C.

Table 9. Estimated 20-year cumulative lost savings for new single-family homes.

Non-Compliant Measures Lost Savings		
MWh	therm	MMBtu
6,400	1,100,000	1,100

5. RECOMMENDATIONS

Our interviews with DIS staff, plan reviews and site visits provide the basis for these recommendations for improving the code compliance process (see Appendix D). These recommendations fall into three categories: plan review process, inspection process and training needs.

5.1 PLAN REVIEW PROCESS

We found several areas where project documentation could be improved to ensure sufficient information is available for an adequate plan review.

Commercial Buildings

1. Compliance paths. The city should require project teams to clearly indicate in the code analysis section which code and which compliance path the project team is using. The compliance path is important as code requirements may be different for specific measures between different compliance paths, and it may change how inspectors evaluate compliance. For example, if a project team chooses the performance path for compliance, then energy modeling files and supporting documentation will need to be reviewed in addition to the standard documents. We propose two options:

    - Require a narrative document from the project teams detailing their chosen energy code compliance path (to confirm that they did not attempt to use ASHRAE 90.1-2010 Prescriptive). Choose either 2012 IECC Prescriptive path or ASHRAE 90.1-2010 Energy Cost Budget Method Performance path. If 2012 IECC Prescriptive path is chosen, the additional efficiency package option under Section C406 should also be specified.
    - Add a check box to the online tool for the design team to confirm their chosen compliance path.

2. Sufficient documentation. The city should require project teams to upload sufficient documentation before the building is scheduled for inspection. A checklist of all necessary documentation can be used to track the required information. Required documentation should be marked as mandatory (where applicable) on the Viewpoint online reporting platform. If the documentation is not uploaded, the project team will not be able to submit the plan without providing an explanation. Below is an example of the checklist:

    - Permit or construction drawings for architectural, mechanical, electrical and plumbing at a minimum
        - Require that key items are indicated on plans, i.e. lighting fixture wattages, duct and pipe insulation R-values, window U-values and SHGC
    - Project Specifications document
    - Sequence of Operations document

- Mechanical commissioning plan and schedule
- COMcheck[21] files (if the project uses COMcheck to demonstrate compliance)
- Window specification sheets or submittals documenting assembly U-value and SHGC for custom storefront windows
- Interior lighting power density and exterior lighting power baseline and proposed calculations
- Window-to-wall ratio diagram and calculations
- Require supplemental documentation for measures that we've identified as commonly not in compliance.

Residential Buildings

From an overall code-documentation standpoint, the most important information gaps are related to air- and duct-leakage testing. Plans for four of the five residential projects provided adequate information about insulation levels. Most did not specify window U-values, but all met code based on field visits, so this could be considered a lower priority item from a plan-review perspective. Residential heating, cooling and water-heating systems are subject to federal efficiency standards rather than local energy efficiency codes but identifying forced-air systems with exterior duct runs at the plan-review stage is important for determining compliance with duct-leakage testing requirements.

Recommendations for ensuring more complete documentation include:

- Require plans to identify the type of heating and cooling systems and location of any ductwork. Exterior ductwork triggers the need for duct-leakage testing. Alternatively, require builders to certify that a home is exempt from the duct-leakage testing requirement because the home has no ductwork outside the thermal envelope.
- Require air-leakage and (when applicable) duct-leakage test results to be uploaded to the on-line reporting platform prior to issuing a Certificate of Occupancy.
- The sample of homes inspected for this project suggests that a non-trivial fraction of new homes have duct leakage outside the thermal envelope that should be tested per current code.
- Although current code does not require builders to meet a specific air-leakage threshold, thresholds are likely to be included in coming code cycles: beginning to enforce testing now will help build testing infrastructure and inform builders about changes in construction practices that they'll need to adopt.

[21] COM*check* is a software tool that simplifies compliance for building officials, plan checkers, and inspectors by allowing them to quickly determine if a building project meets the code

5.2 BUILDING INSPECTIONS PROCESS

Our site visits indicated there are several ways to improve the building inspection process.

Commercial Buildings

- Document the measures that were not observable on site and follow up with the project team after the inspection to provide additional documentation (i.e. submittals and spec sheets). Verbal confirmation in this case is ideally not acceptable.
- Focus resources on ensuring compliance with those measures that have a big energy impact. For example, mechanical and lighting controls can have a larger impact on energy savings than envelope insulation measures. Also, make sure that a Sequence of Operations document is available to confirm control settings, especially if not visible or system not operational on site.
- HVAC equipment efficiency values have been proved to exceed minimum code requirements for all the sites that we visited (with exception of the two projects where mechanical information was not in scope or not provided). Contractors appear to be very knowledgeable of code minimum efficiency requirements and based on some conversations with them, it is typically the first thing they check. Hence, when short on time, it is recommended that the inspectors only verify a sample of HVAC equipment for efficiency values, and do not need to spend time verifying efficiency for every piece of equipment.

Residential Buildings

Inspectors should focus on ceiling insulation defects in single-family projects. Inspect the home after all attic work is complete to ensure adequate attic insulation and to identify any insulation disturbances related to the installation of bath fans or other ceiling/roof penetrations.

5.3 TRAINING AND ADMINISTRATIVE RECOMMENDATIONS

The DIS staff in general seemed satisfied with the level of trainings they received through the State/City and National Grid code trainings. Based on our plan review and site visits, we see opportunities for both additional training for staff and administrative changes within DIS to ensure greater code compliance.

Training

The recommendations for trainings and education below could be addressed in a few ways. One possible way is for National Grid's existing state-wide energy code trainings to add a dedicated training for the DIS staff to address the components listed below.

- Provide training for building inspectors on verifying commercial building HVAC controls, such as familiarity with Building Automation System and Sequence of Operation files, etc. These are essential in determining operation-related code compliance items and are not always easy to verify on site.

- Provide additional education on interpreting 2012 IECC so building inspectors will better understand code items that are easy to miss, such as economizers and controls, window-to-wall ratio requirements, etc.
- Teach code officials how to make the calculations needed to determine compliance if those supplemental calculations are not provided by the commercial building project team.
- Train inspectors on air-leakage and duct-leakage testing methods for single family homes so that third-party test results can be evaluated for code compliance.
- Provide training on how to interpret/reference the energy code book. Interviews with staff indicated that there are times they find it hard to interpret certain portions of the code book.
- Provide residential contractor training on quality installation of insulation.
- Educate DIS staff on the importance of reviewing a commissioning plan and schedule because mechanical commissioning cannot be visually verified on site.

Administrative Changes

Based on building inspection staff interviews, we recommend the following administrative changes that DIS can make.

- Hire more building inspectors to handle work load.
- Identify another department to take over emergency inspections. A recent administrative change in the beginning of 2018 under ‘minimum housing code enforcements’ generated more work load for building inspectors, in addition to their building code and energy code related inspections. Shedding responsibility for emergency inspections will help reduce this work load.
- Provide clarity around blower door tests and how to conduct the tests and reports

Table 10 summarizes all the above recommendations in a matrix format below.

Table 10. Matrix Summary of All Recommendations

<table>
<tr><th></th><th>Issue</th><th>Measure</th><th>Recommendation</th></tr>
<tr><td rowspan="5">Commercial buildings</td><td>Lack of correct Compliance Pathways</td><td>Applicable to overall code pathway within documentation</td><td>Require project teams to clearly indicate in the code analysis section which code and which compliance path the project team is using. Compliance path is important as code requirements may be different for specific measures between different compliance paths, and it may change how inspectors evaluate compliance.</td></tr>
<tr><td rowspan="4">Lack of Documentation</td><td>Window Properties</td><td rowspan="4">Require project teams to upload sufficient documentation before the building is scheduled for inspection. A checklist of all necessary documentation can be used to track the required information. Required documentation should be marked as mandatory (where applicable) on Viewpoint. If the documentation is not uploaded, the project team should not be able to submit the plan without providing an explanation.</td></tr>
<tr><td>Opaque Door U-Value</td></tr>
<tr><td>Stair/elevator shaft vents with automatic motorized dampers</td></tr>
<tr><td>Duct/Pipe Insulation R-value</td></tr>
</table>

		Air Economizer Shutoff Controls	
		Mechanical Commissioning	
Residential buildings	Lack of documentation	Type of heating and cooling systems & duct work	Require plans to identify the type of heating and cooling systems and location of any ductwork. Exterior ductwork triggers the need for duct-leakage testing. Alternatively, require builders to certify that a home is exempt from the duct-leakage testing requirement because the home has no ductwork outside the thermal envelope.
	Duct and Air Leakage Testing Results	Air leakage and Ducts	Require air-leakage and (when applicable) duct-leakage test results to be uploaded to Viewpoint prior to issuing a Certificate of Occupancy. Although current code does not require builders to meet a specific air-leakage threshold, thresholds are likely to be included in coming code cycles.
Trainings (Both sectors combined)	Building system verification	HVAC controls, building automation system, sequence of operation files	Provide training to building inspectors on verifying commercial building HVAC controls, such as familiarity with Building Automation System and Sequence of Operation files, etc.
	Code interpretation	NA	Provide training on how to interpret/reference the energy code book, especially items like economizers and controls, window-to-wall ratio requirements, etc.
	Testing and measurement	Air leakage and Ducts	Train inspectors on air-leakage and duct-leakage testing methods for single family homes so that third-party test results can be evaluated.
	Calculations	NA	Teach code officials how to make the calculations needed to determine compliance if those supplemental calculations are not provided by the building project team.
	Installation	Quality insulation installation	Provide residential contractor training on quality installation of insulation.
Administrativ	Limited staff		Hire more building inspectors to handle work load. Identify another department to take over the emergency inspections
	Clarity around blower door test		Provide clarity around City's requirements around blower door tests

CONCLUSION

The overall compliance for residential buildings was considerably higher (89%) than commercial buildings (77%). It is important to highlight that these compliance rates are based on a combination of a high rate of market readiness/acceptance due to the exceptionally elongated energy code cycle (6 years versus traditional cycle of 3 years), a limited number of site visits and limited site observations due to the stage of construction of the sample buildings. Additionally, we reduced compliance rates for some commercial buildings that didn't show proper documentation in the plan review tool, despite documenting compliance on site. The reason for doing that was to emphasize the importance of proper documentation practices during plan reviews, both for plan reviewers and for building practitioners, especially as new and more stringent codes get adopted in the city.

In 2016, Mayor Jorge Elorza committed Providence to becoming a carbon neutral city by 2050 citing energy efficiency in buildings as one of the most important ways to get to that target. Advanced building energy codes are the most cost-effective way to achieve energy savings and help consumers save energy and money because they capture these savings from the time of construction. They improve efficiency by mandating performance through careful construction and proper selection of building components, including wall and ceiling insulation, windows and doors, heating and air conditioning equipment and system efficiency, and lighting power density and controls.

As a result of not being in full compliance, the city is missing out on energy savings. Lost savings as a result of non-compliance of the sampled buildings translates to cumulative 20 years potential energy savings of 93,000 MWh electric and 8 million therm gas savings for commercial buildings and about 6,400 MWh electric and 1.1 million therm gas savings for residential buildings. With enhanced support from the National Grid energy code support program and the City of Providence, and implementing the recommendations provided in this report, the City of Providence and DIS staff should aim to achieve a goal of fully compliant new construction buildings.

APPENDIX A: SITE VISIT OBSERVATIONS

Slipstream staff completed site visits at 13 buildings (5 residential energy code projects and 8 commercial energy code projects). These site visits were used to observe compliance both with the code generally and to ground truth data from the project plans and building permits.

Commercial Buildings Site Observations

We completed site visits to eight commercial new construction and major renovation projects. Construction progress at the time of the site visits ranged from pre-insulation (framing) stage to fully operational and occupied.

- For projects where building envelope insulation was observable on site, it was generally installed properly (no gaps) and to the minimum required thickness.
- There were some projects where the NFRC labels for factory-built windows were missing. It was unclear if the stickers were removed after the building inspection.
- Areas where we could observe duct and pipe insulation reflected good installation and no tear or gaps.
- Installed mechanical and plumbing equipment (RTUs, ductless mini-split units, water heaters) generally match the drawings with efficiency values exceeding code minimum. One multifamily building installed different units than designed but still went above and beyond code minimum efficiencies.
- For most projects, HVAC controls either could not be observed or could not be verified due to a lack of Sequence of Operations. One building was at 100 percent construction completion stage, but as the tenant has not moved in yet, the thermostat controls were set to the personal preferences of the contractors on site, and may not reflect actual operation once the tenant moves in.
- For the fully operational buildings, we tested the interior lighting occupancy and vacancy controls and they worked as designed. Some HVAC controls could be site verified (i.e. thermostat deadband, setback and fan night cycle settings), but other HVAC controls (i.e. economizer shutoff settings) could not as they would require additional documentation.
- For pre-insulation stage projects, no energy code items could be verified during site visits, as no envelope, lighting and mechanical code items have been installed yet. This is one building (M-3) only among the eight sampled sites.

Residential Buildings Site Observations

As noted in Table 2, the five residential site visits were at various stages of construction, ranging from framing stage to complete and occupied. The electronic plan reviews and comments of building inspectors/plan reviewers for all projects appeared to match with conditions found on site. Key compliance observations are as follows:

- The most significant single non-compliance item noted was poor attic insulation coverage at Home D, where 16-inch batts were installed in an attic with 22-inch truss spacing, leaving large gaps between batts (Figure 2. As detailed in Appendix B, modeling results suggests that correcting this deficiency would reduce heating and cooling consumption by more that 30 percent.22

Figure 2. Large ceiling-insulation voids at Home D

- Attic insulation issues were also observed at Home A, where it appears that the installation of a bath fan left an area of disturbed attic insulation that was not corrected. The attic-access hatch for this home was also uninsulated.

Figure 3. Disturbed attic insulation in the vicinity of a bath fan (Home A)

- Three of the four homes with installed ductwork had duct runs outside the thermal envelope of the home. Rhode Island code requires such systems to have total leakage of less than 8 CFM25 per 100 ft^2 of conditioned floor area. Of the two systems that we

22 We also note that this home was certified for occupancy in late October 2018, and as of late January 2019, an attic access stairwell had not been installed, leaving a large hole in the ceiling. We treated this item as “not observable” on the assumption that the access stairwell will eventually be installed.

tested for duct leakage, one passed (4.0 CFM25/100ft2) and one failed (15.6 CFM25/100ft^2) the duct leakage test.[23]

- We observed no issues with installed above-grade wall insulation. In all cases, this was paper-faced, R-21 fiberglass batts.
- The three homes that we tested had air leakage rates of 3.3, 4.2 and 7.9 air-changes per hour @ 50 Pa (ACH50).[24] While air-tightness testing is required by Rhode Island code, there is no requirement to meet a specific air-leakage threshold. As a point of reference, none of these homes would pass the air leakage requirement for the latest IECC residential code (2018), which establishes a threshold of 3 ACH50 for air leakage. The air-leakage rates for the homes in the sample are in line with measurements made for 39 Rhode Island homes in a 2018 statewide baseline study, which revealed a range from 0.8 to 10.4 ACH50 with an average of 5.3 ACH50.
- Rhode Island code does require compliance with a list of envelope air-leakage items. In this regard, two of the homes had recessed ceiling lights that were not adequately sealed at the ceiling, and thus presented an air-leakage pathway.
- All windows and patio doors were observed to be LowE.
- For one project (Property B) with a bathtub located on an outside wall, visible framing and wall insulation were observed but air barrier was lacking.
- Ceiling can lighting was observed in several homes; these were rated as air-tight but were observed to have unsealed ceiling penetrations in one case.
- In situations where heating systems (furnace) were in attic, 80 percent AFUE rating was observed. For Furnaces located inside thermal boundary, sealed combustion direct vent 90+ AFUE specifications were observed. Residential heating and cooling systems are subject to federal energy efficiency standards and not local code.

23 Note that the home that passed (Home B) had two duct systems, one for the first floor with ducts in an unconditioned basement, and a separate system for the second floor with ducts in the attic. We were only able to test the latter. Also note that the duct system for home that failed (Home A) served only the third floor. The other two floors for that home are served by ductless minisplit heat pump systems.

24 Note that Home B had no basement door installed at the time of testing, so the (unconditioned) basement was included in the air leakage (and home volume) calculations.

APPENDIX B: COMPLIANCE RATE CALCULATIONS

Table 11. Commercial Compliance Rates by Building Envelope System

Project Address	Building Type	Building Envelope System				
		Meets Requirements?		Not Observable	Not Applicable	Compliance Rate
		Yes	No			
H	Hotel	23	19	17	24	55%
M-1	High-Rise Multifamily	35	16	8	24	69%
M-2	Low-Rise Multifamily	11	8	25	39	58%
M-3	Mid-Rise Multifamily	11	14	22	36	44%
M-4	Mid-Rise Multifamily	59	0	0	24	100%
R	Retail (Grocery)	17	17	26	23	50%
O	Office (Core and Shell)	35	16	0	32	69%
K	Kitchen Renovation within a Hospital	-	-	-	-	-
Total	**-**	**191**	**90**	**98**	**202**	**68%**

Table 12. Commercial Compliance Rates by Mechanical System

Project Address	Building Type	Mechanical System				
		Meets Requirements?		Not Observable	Not Applicable	Compliance Rate
		Yes	No			
H	Hotel	46	17	3	44	73%
M-1	High-Rise Multifamily	48	9	3	50	84%
M-2	Low-Rise Multifamily	51	15	0	44	77%
M-3	Mid-Rise Multifamily	42	9	3	56	82%
M-4	Mid-Rise Multifamily	-	-	-	-	-
R	Retail (Grocery)	54	3	6	47	95%
O	Office (Core and Shell)	37	6	9	58	86%
K	Kitchen Renovation within a Hospital	14	6	0	90	70%
Total	**-**	**292**	**65**	**24**	**389**	**82%**

Table 13. Commercial Compliance Rates by Lighting System

Project Address	Building Type	Lighting System				
		Meets Requirements?		Not Observable	Not Applicable	Compliance Rate
		Yes	No			
H	Hotel	21	0	0	11	100%
M-1	High-Rise Multifamily	21	0	0	11	100%
M-2	Low-Rise Multifamily	18	3	0	11	86%
M-3	Mid-Rise Multifamily	3	9	3	17	25%
M-4	Mid-Rise Multifamily	-	-	-	-	-
R	Retail (Grocery)	23	6	0	3	79%
O	Office (Core and Shell)	9	0	0	23	100%
K	Kitchen Renovation within a Hospital	6	3	0	23	67%
Total	**-**	**101**	**21**	**3**	**99**	**83%**

Table 14 List of Modeled Measures

Non-Compliant and Not-Observable Measures	IECC 2012 Prescriptive Requirement	Non-Compliant Parameter	Notes
Window U-Value	Fixed U-0.38, Metal Framing	Metal with thermal break, double pane: U-0.65*	Retail and office prototype models - fixed, metal framing. Multifamily and hotel prototype models - operable, nonmetal framing. No documentation of window properties on building plans for most sites. No NFRC labels for factory-built windows for some sites.
	Operable U-0.45, Nonmetal Framing	Nonmetal double pane: U-0.55*	
Window-to-Wall Ratio (Office Only)	30%	35%	This was found at the office project site. Confirmed that it was permitted under 2012 IECC Prescriptive path, which limits the WWR to 30%. The project team had attempted to use ASHRAE 90.1 Prescriptive path which is not a permissible compliance path in RI. Modeled only for the office prototype model.
Thermostat Deadband	5F	4F	Unable to observe, assumed non-compliant value, 20% violation
Economizer High Limit Shutoff	70F	75F	Unable to observe, assumed non-compliant value, 60% humidity control set in model
Energy Recovery	Yes for all 100% OA systems, with 50% sensible and latent effectiveness	No ERV where required	Confirmed non-compliant for the mid-rise multifamily property site, modeled only for the multifamily and hotel prototypes
Roof Insulation	R-20 c.i., U-0.048	R-12 c.i., U-0.083	Assumed non-compliant based on 2016 RI Commercial Energy Code Compliance Study
Daylighting Zones	Daylight zoned as required, 100% of fixtures under daylight zones are controlled via photocell sensors	50% of fixtures under daylight zones are controlled	Assumed non-compliant based on 2016 RI Commercial Energy Code Compliance Study. Control fraction set to 0.5 in model

*Based on 2012 IECC Table C303.1.3(1) Default Glazed Fenestration U-Factor

APPENDIX C: ENERGY MODELING RESULTS

Commercial Buildings

Table 15. Prototype Buildings

Prototype Building Type	Area	Stories	Window-to-Wall Ratio	HVAC System
Multifamily	50,000	5	29%	Split Heat Pump w/ Gas Fired MAU
Hotel	180,000	10	29%	PTHP w/ Gas Fired MAU
Retail	25,000	1	11%	Gas Fired RTU
Office	50,000	3	30%	Packaged VAV

Modeling results for each prototype building model are listed as follows. Potential energy savings were normalized by square footage for comparison.

Table 16. Retail Prototype Modeled Savings by Measure

Retail Prototype Modeled Measures 25,000 sq-ft	Lost Elec Savings kWh/sf	Lost Gas Savings therm/sf	Lost Savings kBtu/sf
Baseline	-	-	-
Window U-Value	0.06	0.02	2.306
Thermostat Deadband	0.03	0.01	0.781
Economizer High Limit	0.16	0.01	1.864
Roof Insulation R-12	0.25	0.06	6.655
Daylighting Ctrl Fraction	0.45	-0.01	0.752

Table 17. Office Prototype Modeled Savings by Measure

Office Prototype Modeled Measures 50,000 sq-ft All Electric Building	Lost Elec Savings kWh/sf	Lost Savings kBtu/sf
Baseline	-	-
Window U-Value	0.92	3.129
Window-to-Wall Ratio (Office Only)	0.44	1.485
Thermostat Deadband	0.22	0.751
Economizer High Limit	0.09	0.318
Roof Insulation R-12	0.49	1.659
Daylighting Ctrl Fraction	0.26	0.894

Table 18. Hotel Prototype Modeled Savings by Measure

Hotel Prototype Modeled Measures 180,000 sq-ft	Lost Elec Savings kWh/sf	Lost Gas Savings therm/sf	Lost Savings kBtu/sf
Baseline	-	-	-
Window U-Value	0.07	0.00	0.233
Thermostat Deadband	0.08	0.00	0.264
Economizer High Limit	0.00	0.00	0.000
No Energy Recovery	-0.08	0.04	3.951
Roof Insulation R-12	0.06	0.00	0.194
Daylighting Ctrl Fraction	0.02	0.00	0.083

Table 19. Residential Multifamily Prototype Modeled Savings by Measure

Residential Multifamily Prototype Modeled Measures 50,000 sq-ft	Lost Elec Savings kWh/sf	Lost Gas Savings therm/sf	Lost Savings kBtu/sf
Baseline	-	-	-
Window U-Value	0.10	0.00	0.336
Thermostat Deadband	0.09	0.00	0.300
Economizer High Limit	0.00	0.00	0.000
No Energy Recovery	-0.05	0.03	2.364
Roof Insulation R-12	0.15	0.00	0.513
Daylighting Ctrl Fraction	0.03	0.00	0.109

The table below sums up the energy savings impact for the four building types respectively.

Table 20. Summary of Modeled Lost Savings

Prototype Building Type	Non-Compliant Measures Lost Savings		
	kWh/sf	therm/sf	kBtu/sf
Retail	0.26	0.04	4.95
Office (all electric)	1.67	0.00	5.68
Hotel	0.07	0.04	4.45
Multifamily	0.14	0.03	3.00

Table 21. New Construction Activity 2010-2015

Year	Retail	Office	Hotel	Multifamily*
Annual Average New Construction sq-ft: 2010-2015 (from Dodge data)	140,933	38,800	36,267	137,365*

*Multifamily data was not provided in Dodge data, used information on the City's permit database instead.

Residential Buildings

A REM/Rate model of each home was developed and assessed against a minimally-compliant code-baseline home. We estimated energy savings from addressing seven specific non-compliance items in two homes that were observed to have energy-related non-compliance items (Table 22). The most significant of these is the ceiling insulation gaps observed for Home D, for which the modeling indicates large implications for both space heating and cooling.

Table 22. Modeled Energy Savings for Correcting Key Non-compliance Items

Property	Compliance item	Gas savings*		Electricity savings		kBtu/yr
		therms/yr	%	kWh/yr	%	
A**	Slab insulation			785	3.4%	2,680
	Duct leakage			595	2.6%	2,030
	Ceiling insulation			195	0.8%	670
	Attic hatch			30	0.1%	100
	Air sealing			165	0.7%	560
D	Ceiling insulation	415	31.9%	670	7.5%	43,790
	Air sealing	5	0.40%			500

*for heating and/or cooling
**all-electric property

APPENDIX D: SUMMARY OF BUILDING DEPARTMENT INTERVIEWS

Slipstream staff conducted interviews with plan reviewers and field inspection staff to understand their knowledge of the residential and commercial building energy codes and identify barriers to enforcing the codes. Following are the primary observations from these interviews.

Administrative Process

The funding for building permit department comes through the State of Rhode Island.

- Plan reviewers and inspectors who do envelope measures don't do HVAC, electrical or plumbing. There are separate ones for these 3 components. Some staff (about 3-4) do both residential and commercial plan reviews and inspections. Some staff does only inspections (residential or commercial or both)
- A recent administrative change in the beginning of 2018 under 'minimum housing code enforcements' generated more work load for building inspectors, in addition to their building code and energy code related inspections. The inspection staff is now responsible for conducting emergency inspections under this change. This includes violation complaints they receive from tenants who don't have heating in their apartments. When that happens, they have to inspect the home, provide a report to owner to install heating and sometimes have to go to court to testify as witness. They do 8-10 such inspections per day during the fall/winter seasons. This takes away their time from doing building inspections in a more detailed way.
- All of them responded that they 'rarely' use the energy code book for reference. Only hard copy is available to them.
- All of them responded that they 'always' use the other building codes for every project.
- As noted in the introduction section 2.3 above, during the interviews with the building inspectors, we were informed that the Providence City building department interprets 1-2 dwelling units as residential buildings and use the residential energy code for code compliance purposes. Any residential building above these number of units refer to the commercial energy code. This interpretation is different from the definitions provided in the 2012 IECC.[25]

Trainings

- Most of the respondents felt that they received sufficient training to do their work (medium to high range), for all building codes

[25] It is beyond the scope of this study to assess how this code interpretation by the City would impact energy performance of those multifamily buildings that may be impacted by this.

- They have all attending National Grid trainings[26] on energy code and that seems to be the predominant education they receive on energy codes.
- DIS staff interviewed stated they could benefit from the following additional trainings or improvements to trainings:
  - Add In-field trainings with real world examples
  - Focus on quality insulation installation
  - How to use and refer to the energy code book
  - An infield checklist for energy code related measures
  - Contractor trainings
  - A combined gathering of building departments and building community to interact and understand each other's work, to build relationships

Plan Review and Inspection Process

- The most common method of compliance path (more than 70 percent) chosen by building permits are the prescriptive method of compliance.
- Plan reviews time specific to energy code range anywhere from half hour to an hour, making up 10-20 percent of their overall time in plan reviews
- Field inspections specific to energy also range from 20 minutes to an hour, making up 10-25 percent of overall inspections per day.
- There is no checkbox indicating energy code compliance in their software tool. Most plan review approvals are done via direct contact with owners or emails. Notes are made on plan reviews online but not updated all the time.
- Residential inspections related to energy are typically done at four to five stages: foundation, rough framing, dry wall, attic/roofing times. For windows they typically look for sticker with specifications along with manufacturer specification sheets. Most on-site issues are around insulation levels being incorrect or installed incorrectly. This occurs mostly in retrofits and less so in new construction.
- Commercial inspections can vary depending on size of project. On average, inspections can range from seven to fifteen visits per large project. Inspectors don't typically observe non compliance in the field during commercial projects inspections because these are mostly done by professional design, engineering and contractor teams. The inspectors don't get involved in commissioning reviews at all. They expect the owners to conduct commissioning through their third-party agent.
- There is no checkbox on their online permit software to approve inspections. After every inspection, they update the online system with notes indicating inspections are approved. If they see any problem, they communicate directly with project team and try their best to update the notes online.

[26] Since 2013, National Grid has been conducting energy code trainings through the State energy efficiency program funding. The Code Compliance Enhancement Initiative (CCEI) is an effort sponsored by National Grid Rhode Island to improve code compliance among residential and commercial new construction projects. https://www.nationalgridus.com/ProNet/Technical-Resources/Trainings-Events

APPENDIX E: PLAN REVIEW OBSERVATIONS

Slipstream staff reviewed documents filed with the Department of Inspections and Standards to identify projects to include in this study. A thorough review was conducted of plans for the buildings selected for the project. Following are observations based on those reviews.

Commercial Buildings

- Sufficient documentation was not always provided on Viewpoint. We were only able to get permit drawings or construction drawings. Specifications, submittals and Sequence of Operations documents were not always available. If the project used COMcheck to document compliance, the COMcheck files were not provided. Window specifications were also not provided for projects that have custom made storefront windows. For one project, only architectural drawings were provided, no MEPs were available. This missing information was not followed through and we were not able to determine compliance for multiple measures.
- Energy code was referenced as 2012 IECC on the drawings but was not always followed. It was found later that one project was attempting to use ASHRAE 90.1-2010 prescriptive compliance path, which is not a permissible compliance path in RI.
- The permit drawings do not always include all necessary information to determine compliance for certain code items. Some examples as follows:
  - The drawings do not clearly indicate if mechanical commissioning is part of the project.
  - Pipe insulation R-values were not always indicated.
  - Lighting fixture details were not always provided. For some multifamily projects it was up to the Owner to select the fixtures and therefore were not documented on permit drawings.

Residential Buildings

For residential properties, key plan code-compliance indicators are the location and R-value of insulation and the U-value of windows. The filed building plans for the residential sample provided insulation R-values in four of five cases but listed window U-values for only two projects.

None of the project plans provided details about heating and cooling systems but energy efficiency aspects of these are mostly covered by federal standards and not local codes. In terms of code compliance, the key piece of information needed is whether a central forced-air system will be installed, as this will trigger the need for a duct-leakage test if any ducts are outside the thermal envelope. We were able to ascertain type of heating system from the work description field for mechanical-permits pulled for the five sites in hand—but in general, this may not be a reliable indicator of the presence of a forced-air system, since it is an open-ended description.