

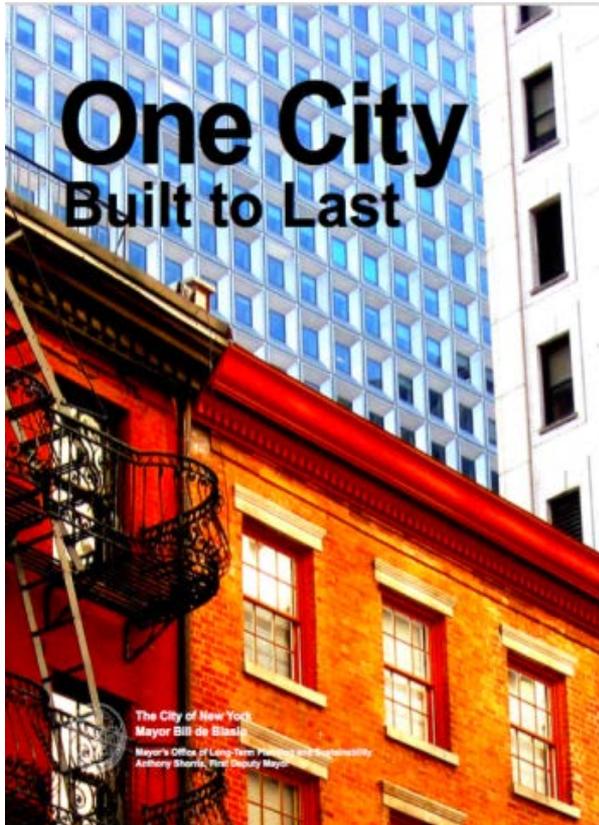


Mind the Gaps: Post-Occupancy Discoveries from Data and Operational Perspectives

Who Has the Edge?

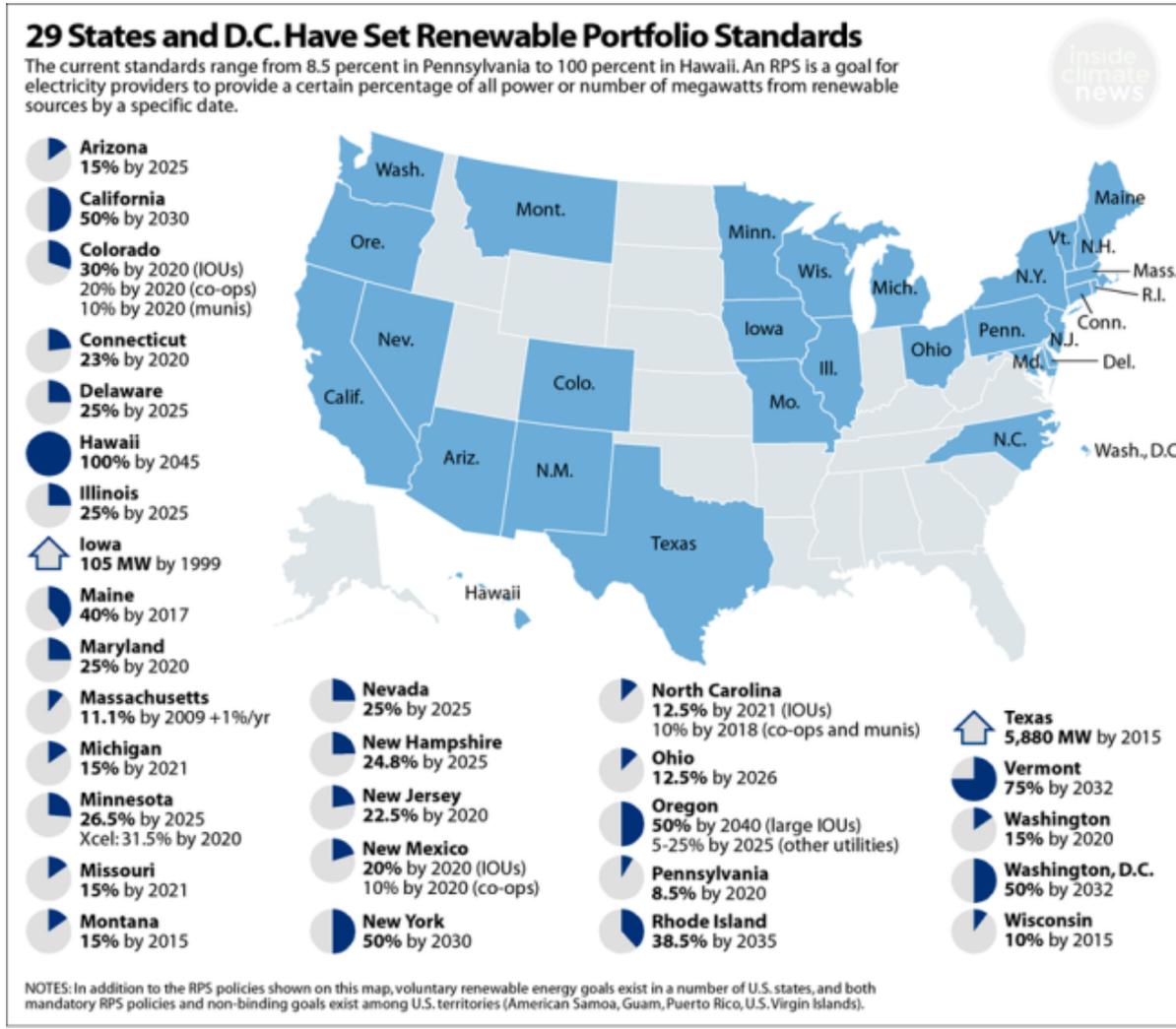


Government Initiatives to Reduce CO₂



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Government Initiatives to Reduce CO₂



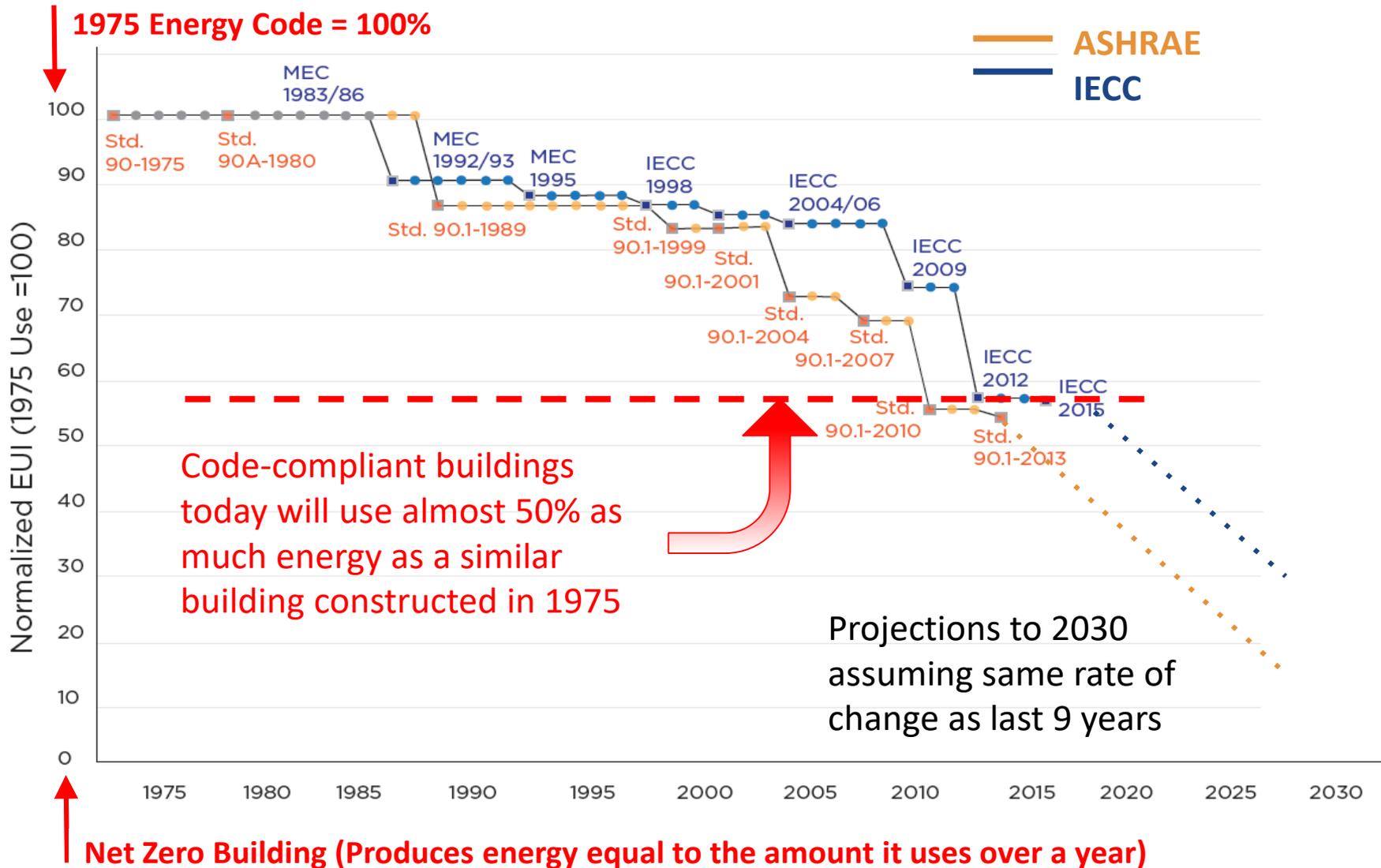
SOURCE: Lawrence Berkeley National Laboratory

PAUL HORN / InsideClimate News

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Efficiencies in the Code?





Performance Based Standard?

- CA net zero residential 2020
- Stretch codes
- Building energy grades
- DOE Asset Score

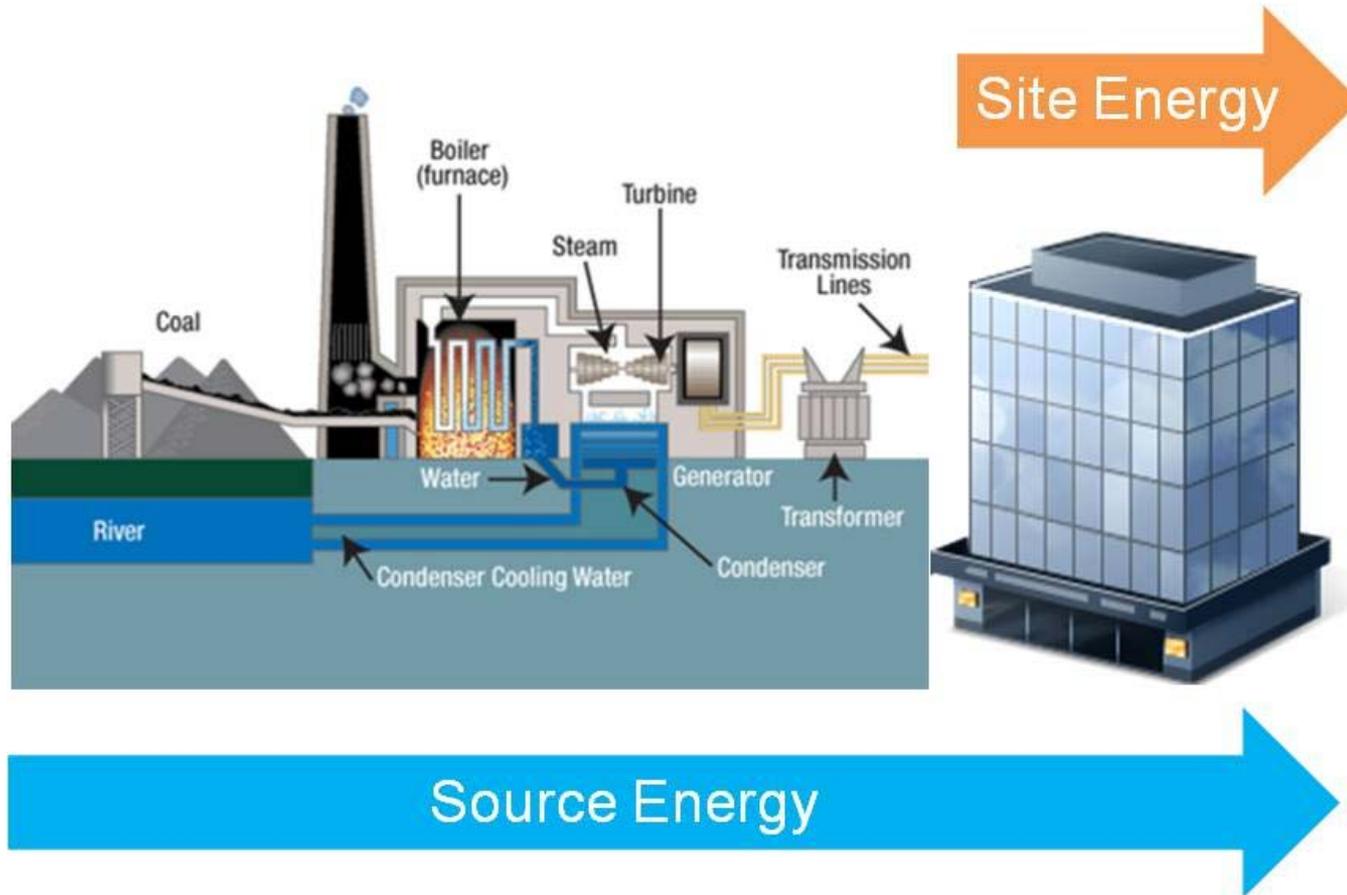


Key Metrics: New Multifamily

Metric	Unit	Significance
Benchmark (EUI)	kBtu/SF	Whole-building <u>source</u>
Heating	Btu/SF/HDD	Owner-paid
Domestic Hot Water	kBtu/SF	Owner-paid
Fuel	kBtu/SF	Owner-paid
Electric	kWh/SF	Owner-paid
ENERGY STAR Score	1-100	Relative to similar buildings nationwide



Site vs. Source





Data Challenges

- Utility bill tracking
 - Master-metered
 - Sub-metered requires assistance from Owner
 - Direct-metered
 - Aggregate data
 - Commercial tenants receive “free” heat from central system, but also supplement their own
- Square footage discrepancies
 - Source: NYC DOF, DOB, OASIS
 - Parking garage
 - Cellar, sub-cellar not counted SF by DOF
 - Commercial space (provide heat, not electricity?)
- Renewables

ENERGY STAR Multifamily: Shifting Design



Design	Circa 2007	Now
Walls	Insulation Placement	Reduce Thermal Bridging
Windows	Aluminum vs. Fiberglass	Aluminum vs. uPVC
Ventilation	Code changes	Unitized exhaust/ERV
Heating	Boilers: Condensing?	Boilers vs. VRF
Distribution	Baseboard	PTAC
Cooling	Window vs. Sleeve AC	PTAC vs. Heat Pumps
DHW	Boilers with Indirect Storage	Same + HPWH?
Lighting	Fluorescents and Sensors	LED
On-site Power	Micro-cogeneration	Solar PV/cogen/batteries
Controls	Basic, Local	Smart
Modeling	ASHRAE 90.1 - 2004	ASHRAE 90.1 – 2013

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Results

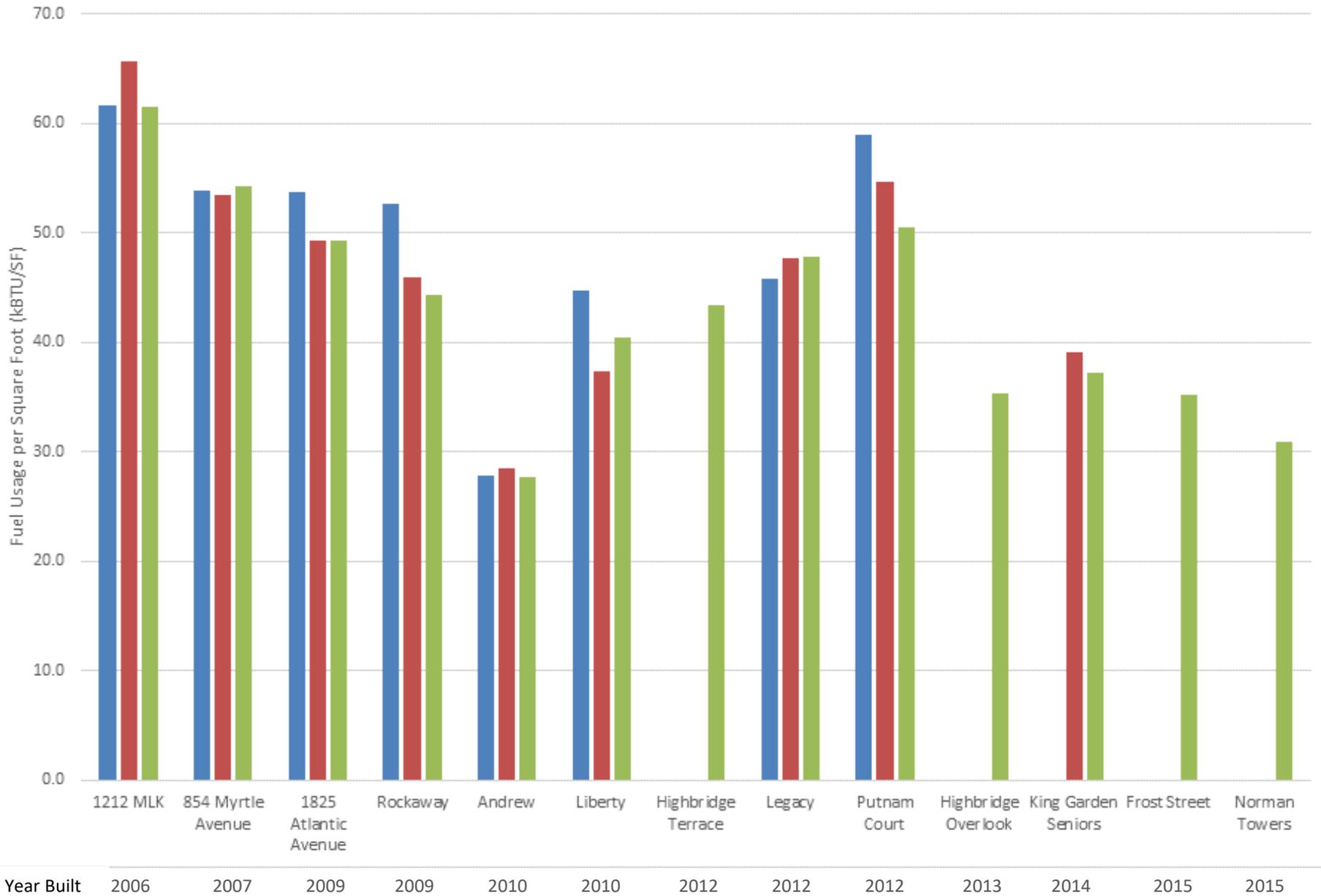
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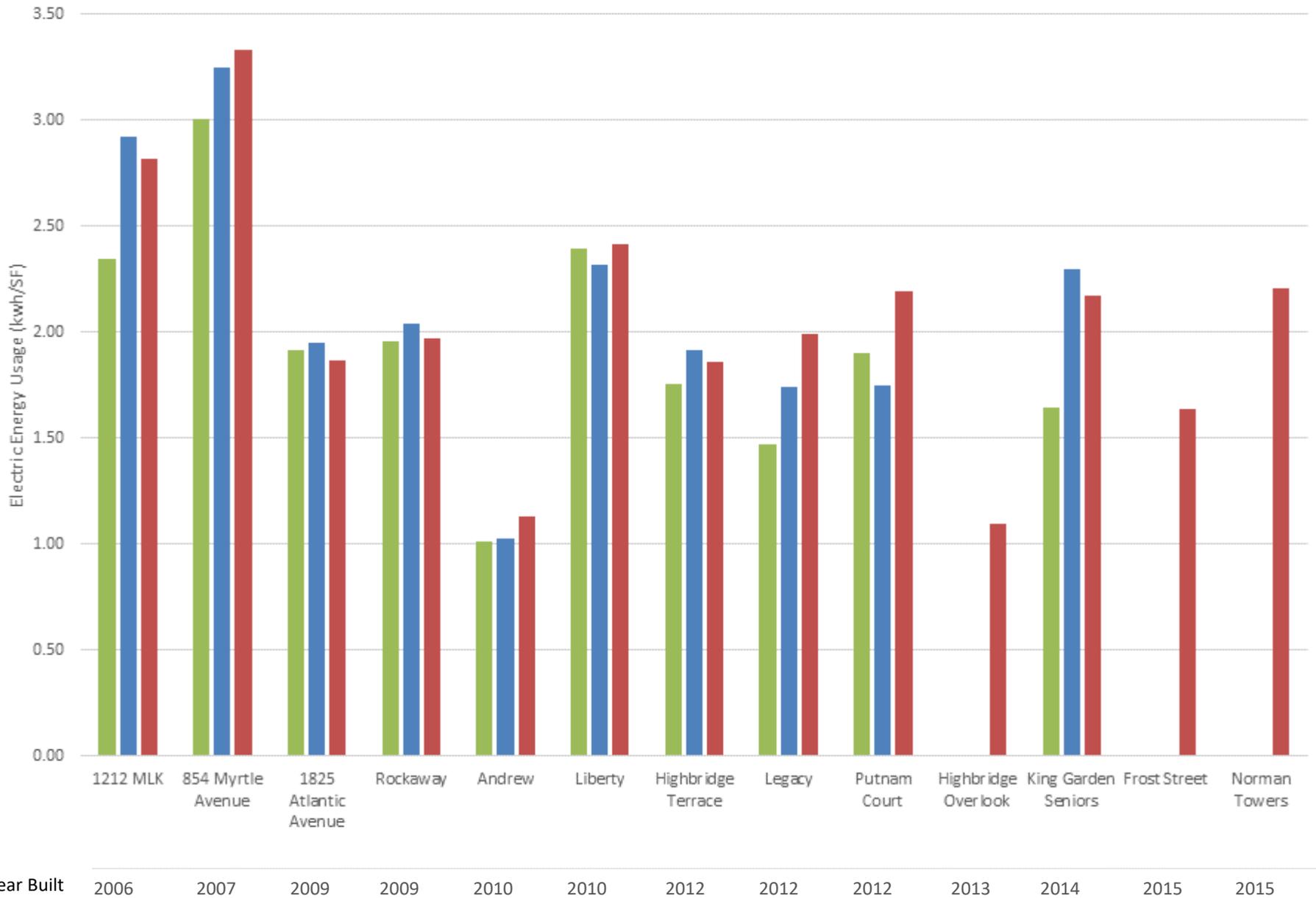
Comparison of Annual Fuel Usage: Heating & Domestic Hot Water

■ 2014 Fuel EUI
 ■ 2015 Fuel EUI
 ■ 2016 Fuel EUI

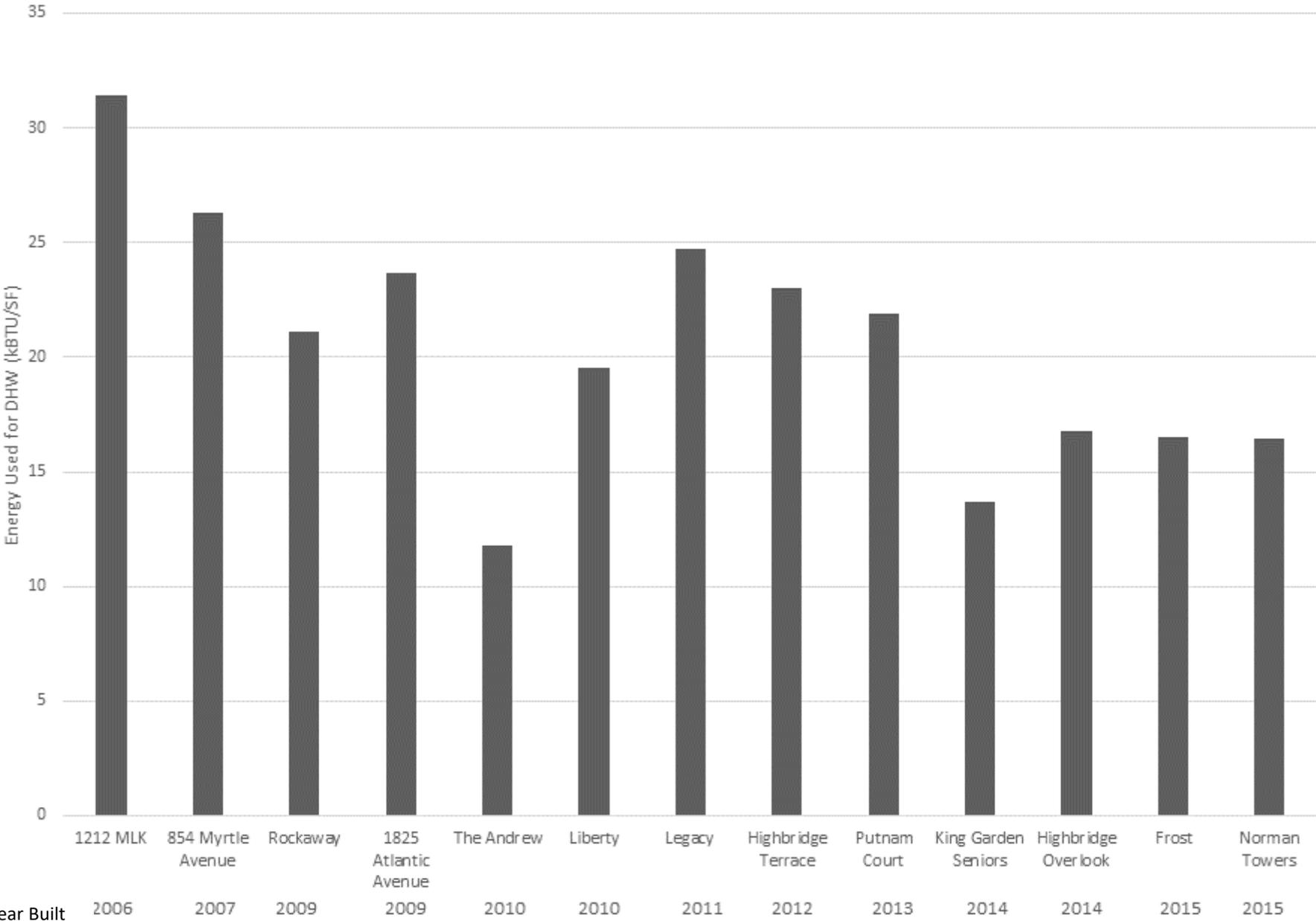


Comparison of Annual Electric Usage: Owner Paid

2014 Elec 2015 Elec 2016 Elec



Comparison of Energy Used for Domestic Hot Water Heating

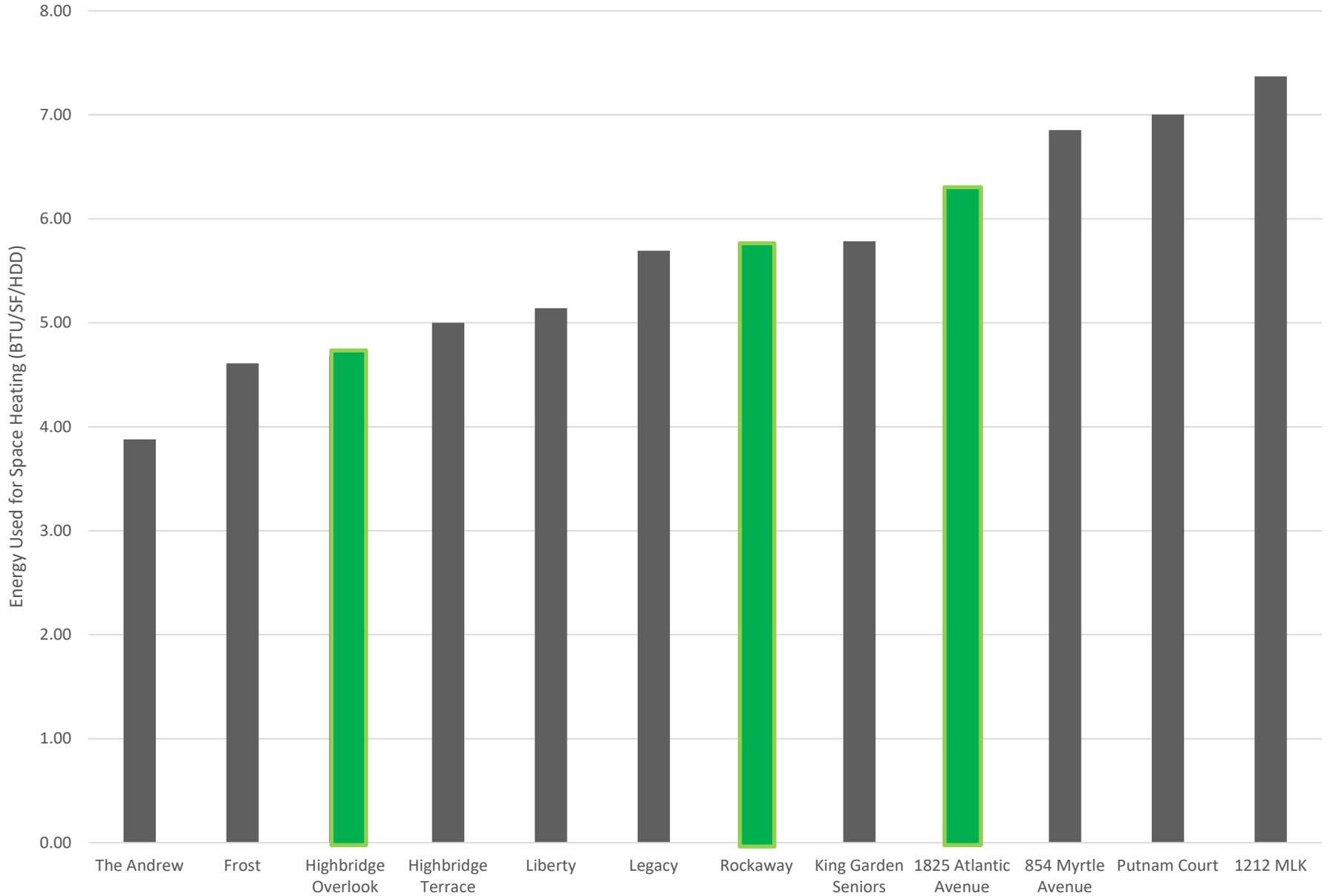




All of these buildings have hot water space heating distribution systems.

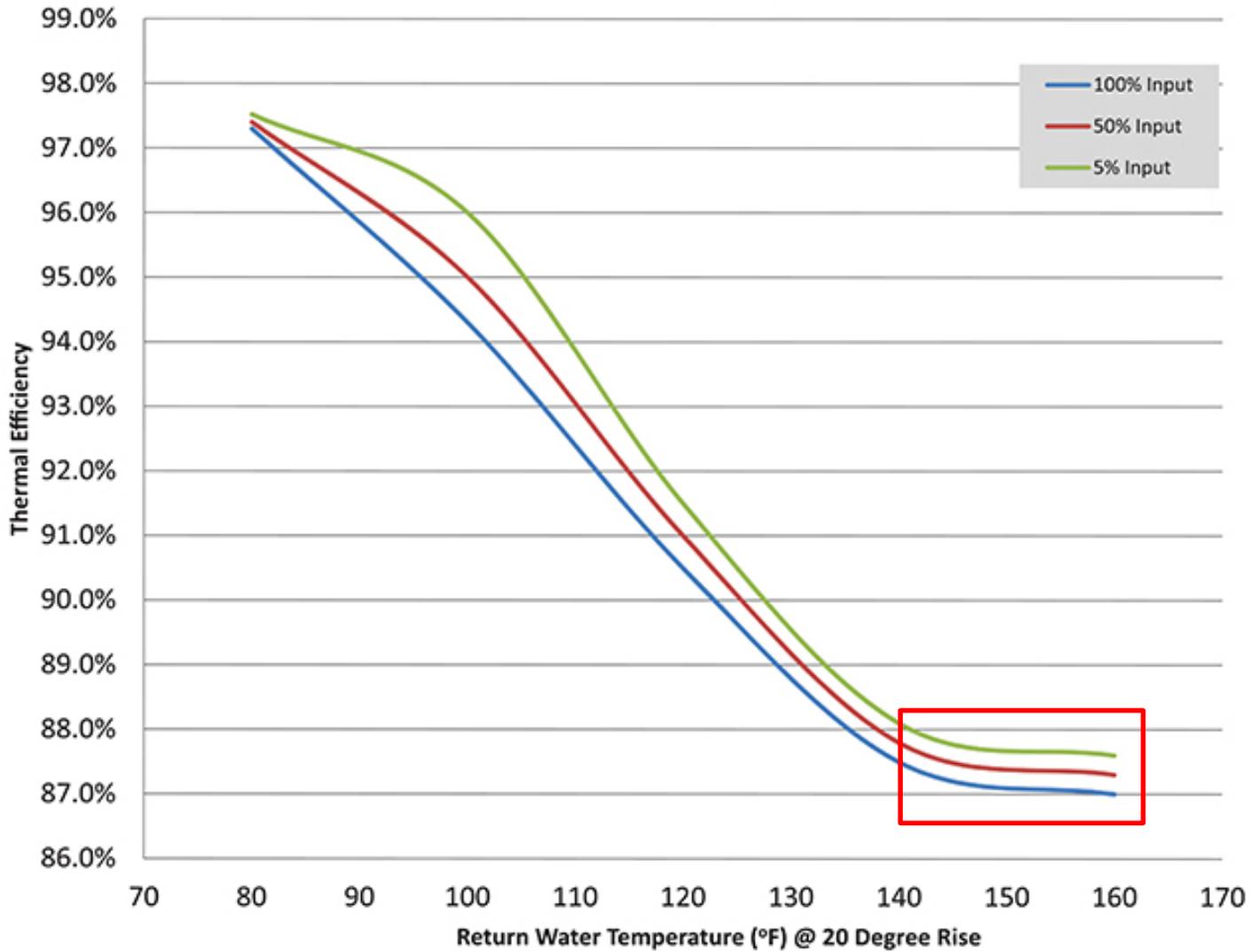
Which buildings do you think have condensing boilers?

Comparison of Energy Used for Space Heating





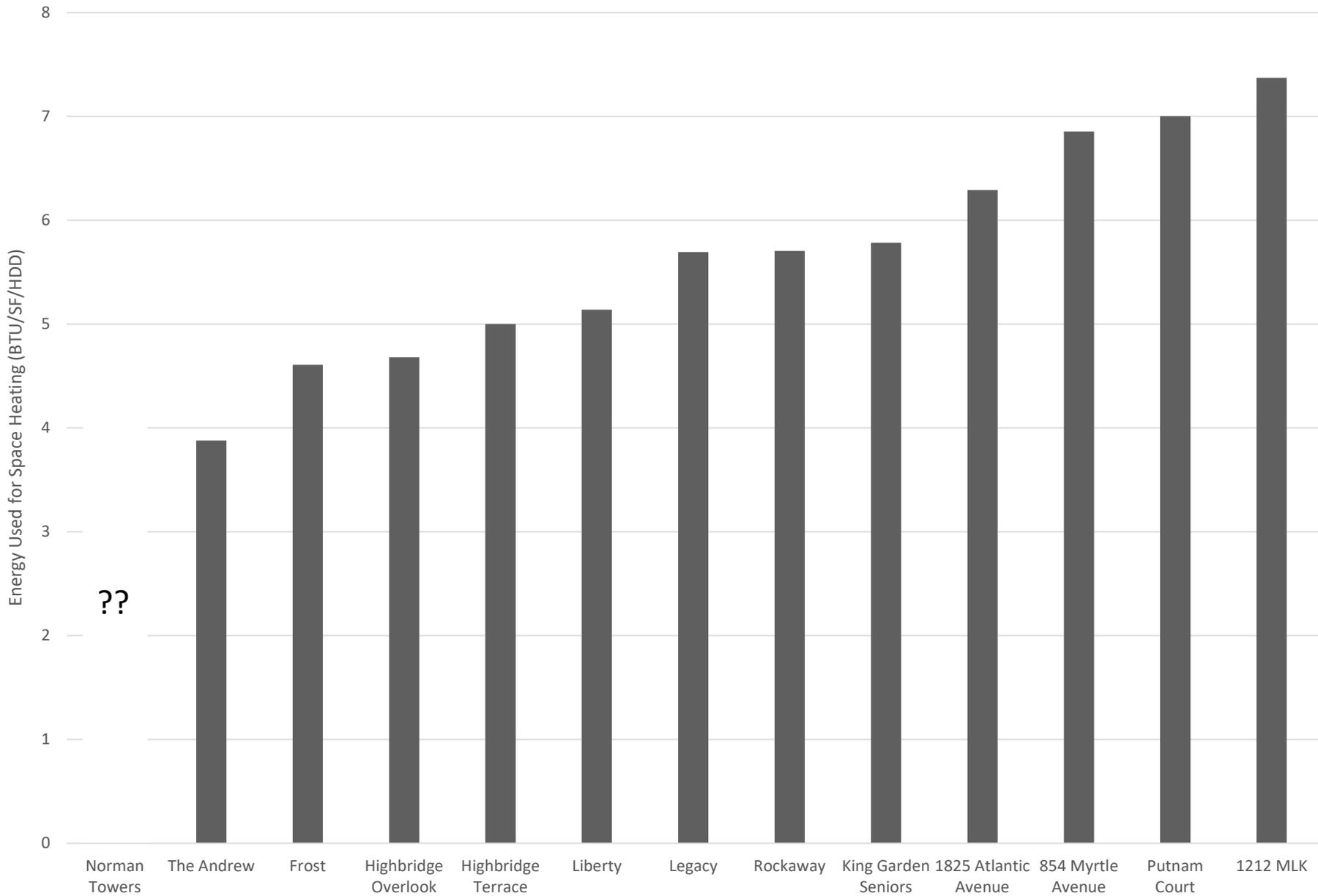
Thermal Efficiency Curves



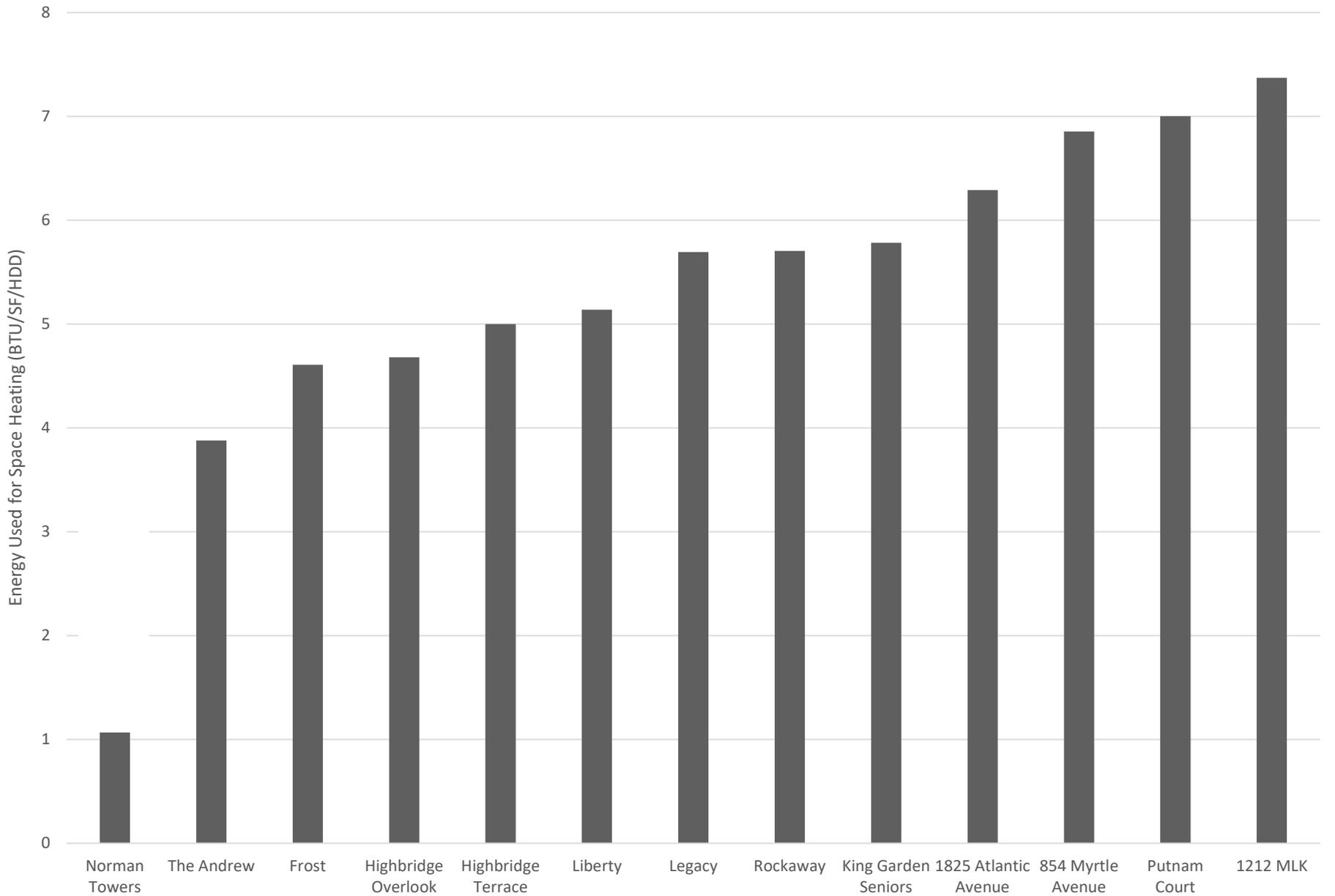
Let's add the heat pump project.



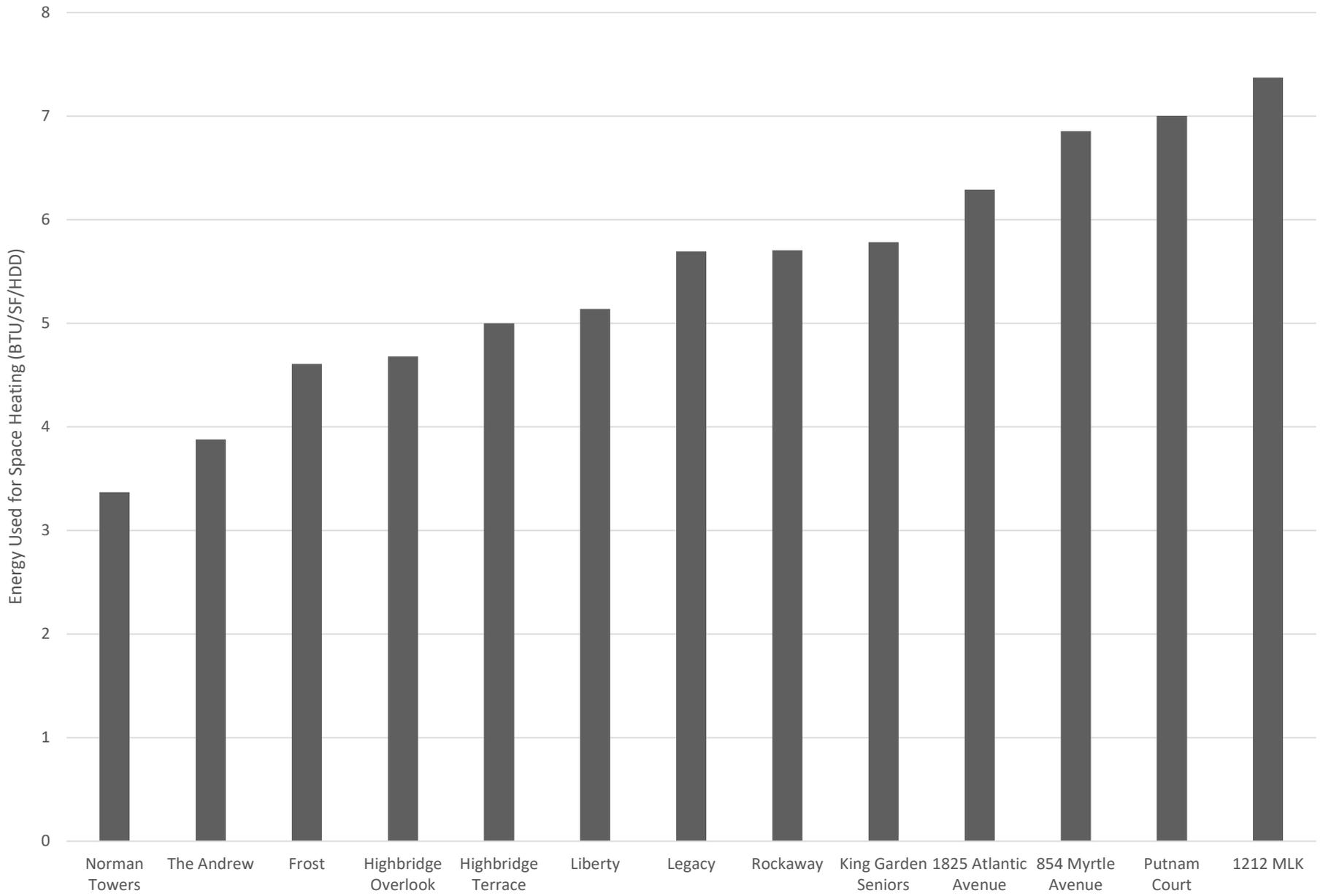
Comparison of Energy Used for Space Heating



Comparison of Energy Used for Space Heating - Site



Comparison of Energy Used for Space Heating - Source

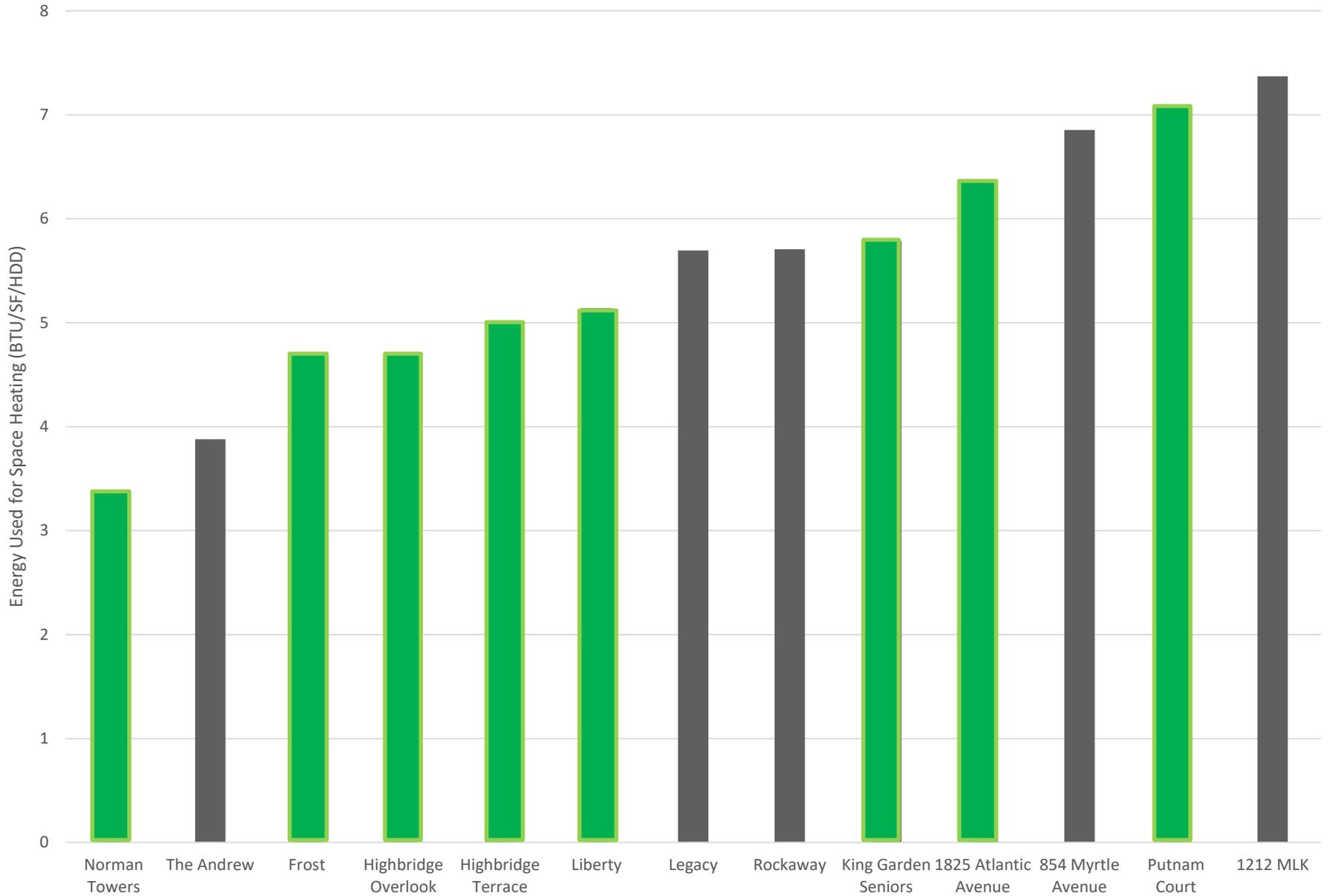




All of these buildings supply fresh air to common area hallways.

Which buildings do you think use ERVs?

Comparison of Energy Used for Space Heating





All of these buildings utilized different strategies to exceed code requirements for wall insulation:

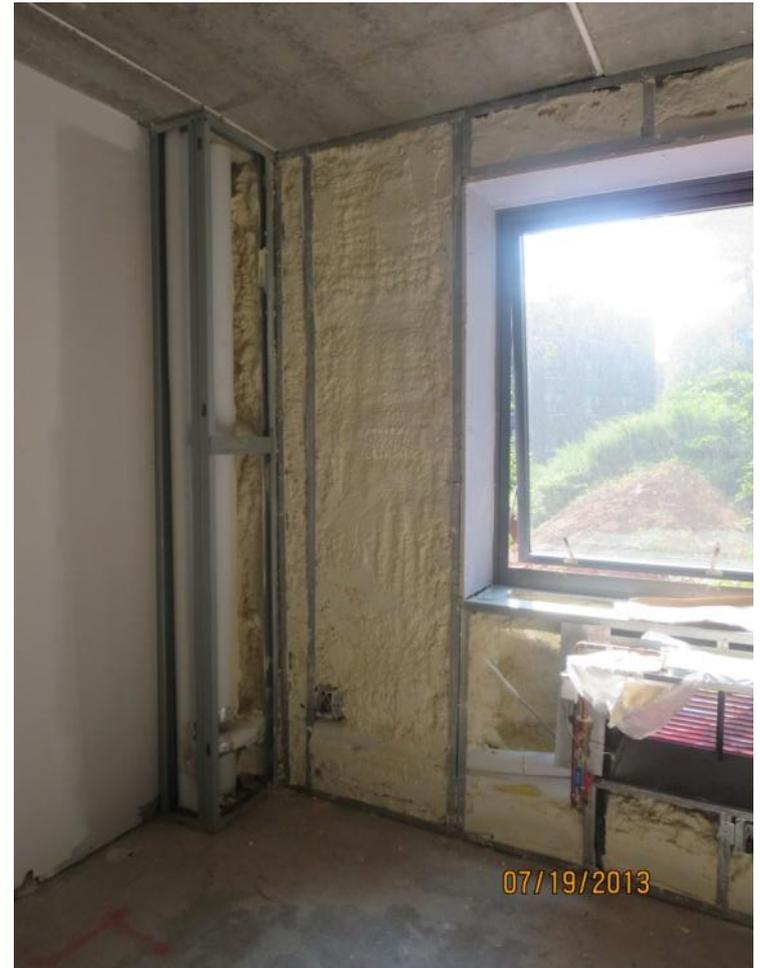
- Interior only
- Exterior only
- Insulated Concrete Form

Which do you think performs best?

Which buildings do you think have interior insulation?



Inboard Insulation



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Outboard Insulation



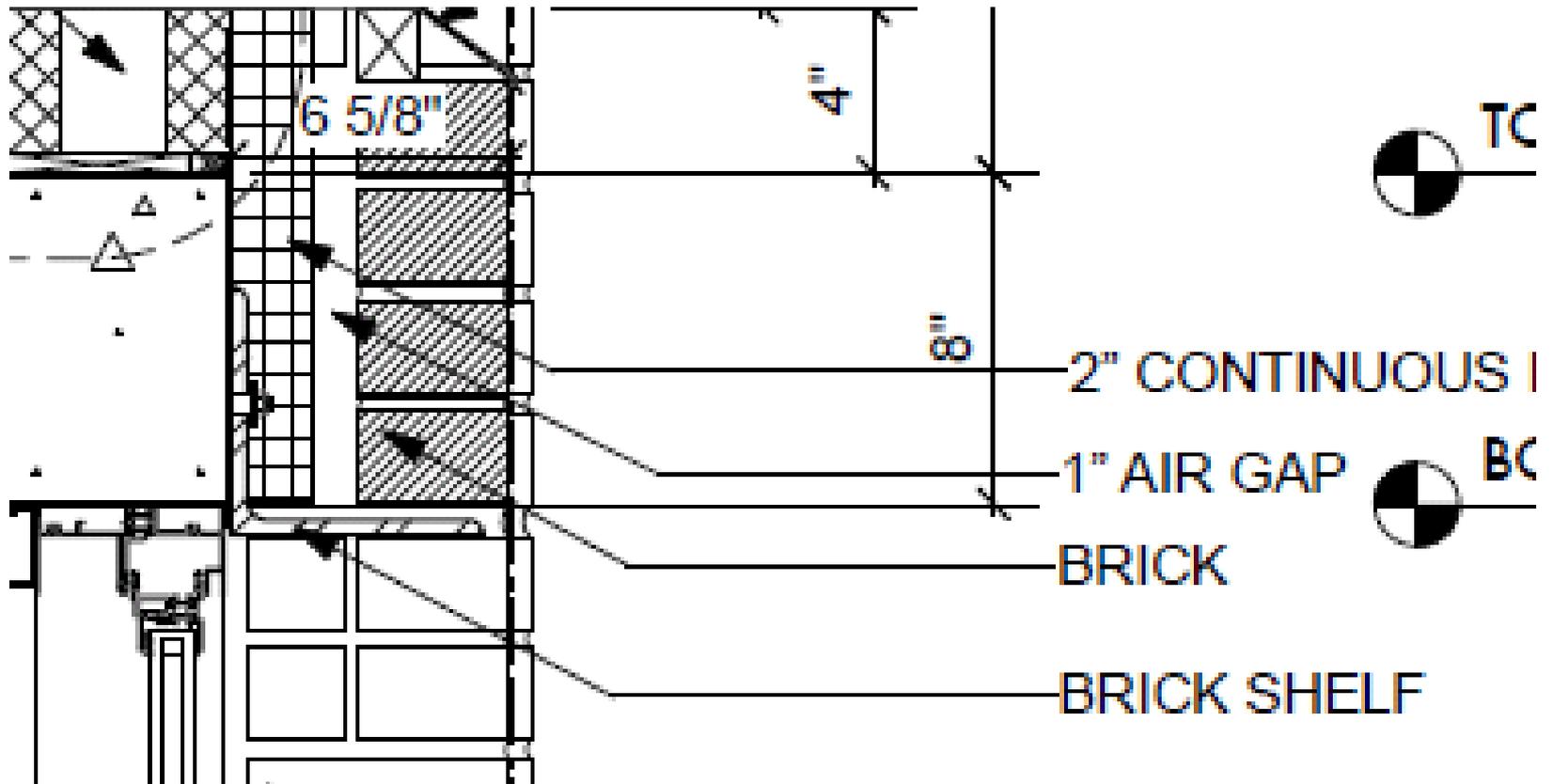


Thermal Bridging Challenges





Thermal Bridging Challenges



HORIZONTAL JOINT
REINFORCEMENT W/
INTEGRAL WALL TIES

RIGID INSULATION

THRU-WALL FLASHING

ADJUSTABLE SHELF ANGLE

WEEP VENT

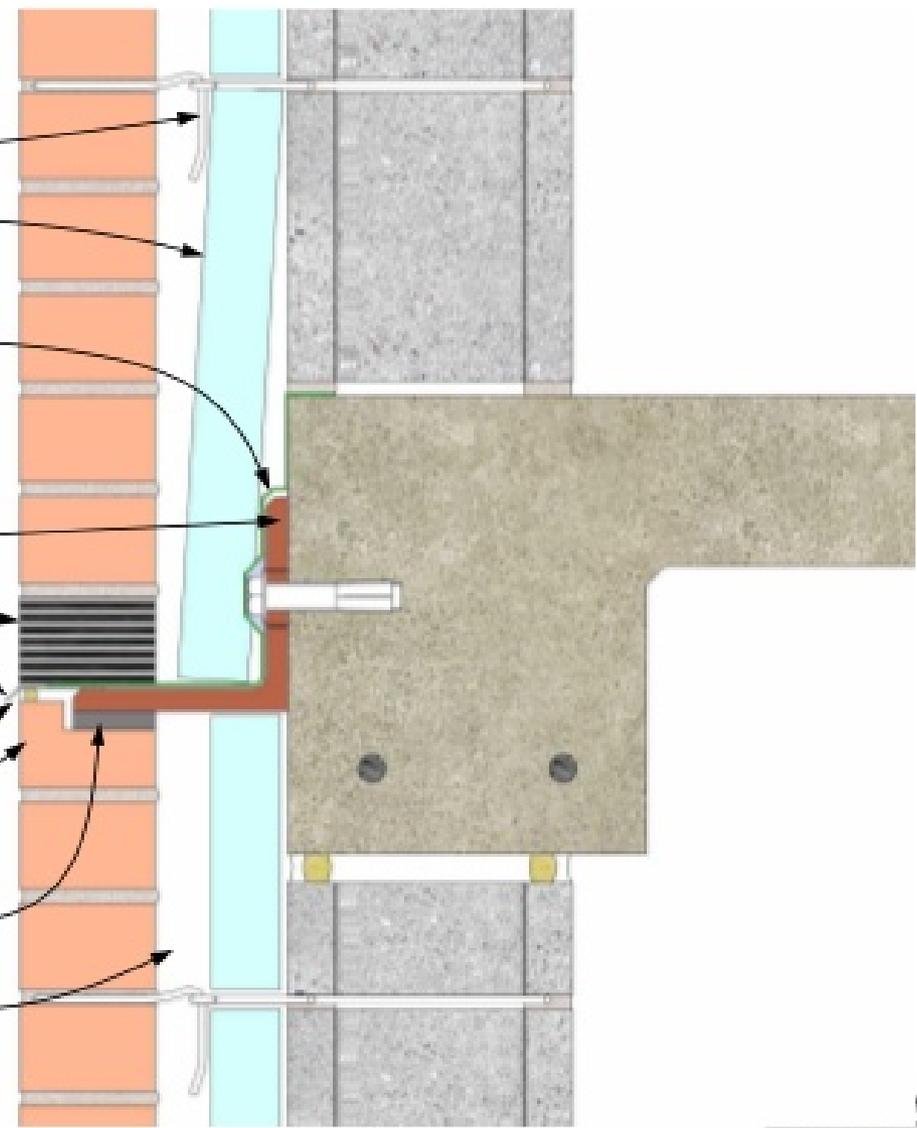
METAL DRIP EDGE SET IN
MASTIC OR SEALANT

SEALANT & BACKER ROD

LIPPED BRICK BELOW
SHELF ANGLE

COMPRESSIBLE FILLER,
OPTIONAL

2" AIR SPACE RECOMMENDED;
1" MIN. REQ'D FOR DRAINAGE
WALLS



SHELF ANGLE DETAIL

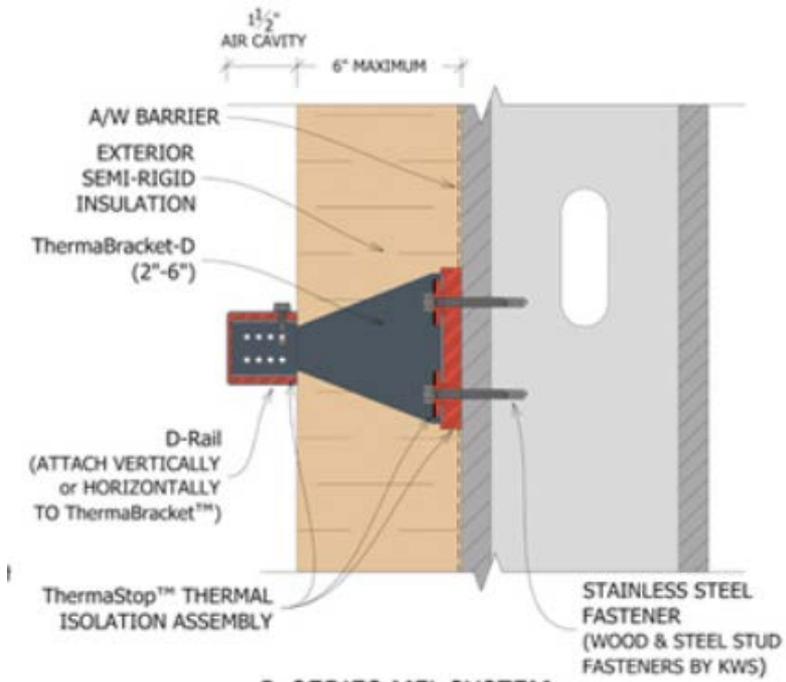
LIPPED BRICK

DETAIL 01.030.0702.2D

REV. 10/14/07



Thermal Bridging Challenges



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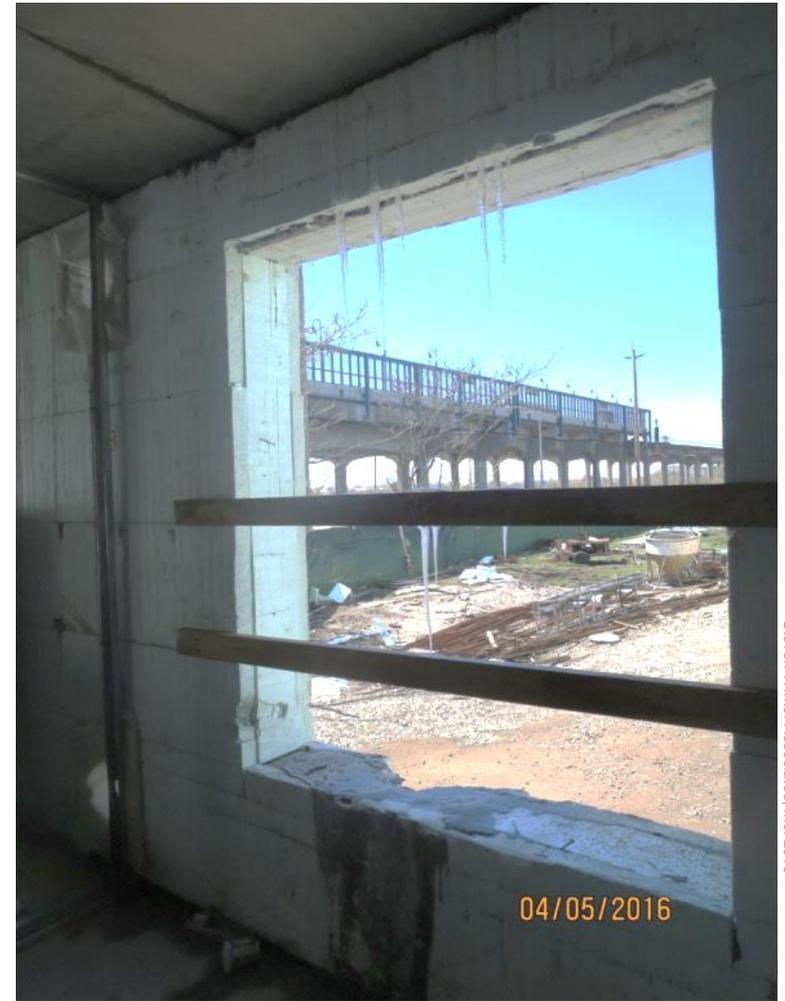
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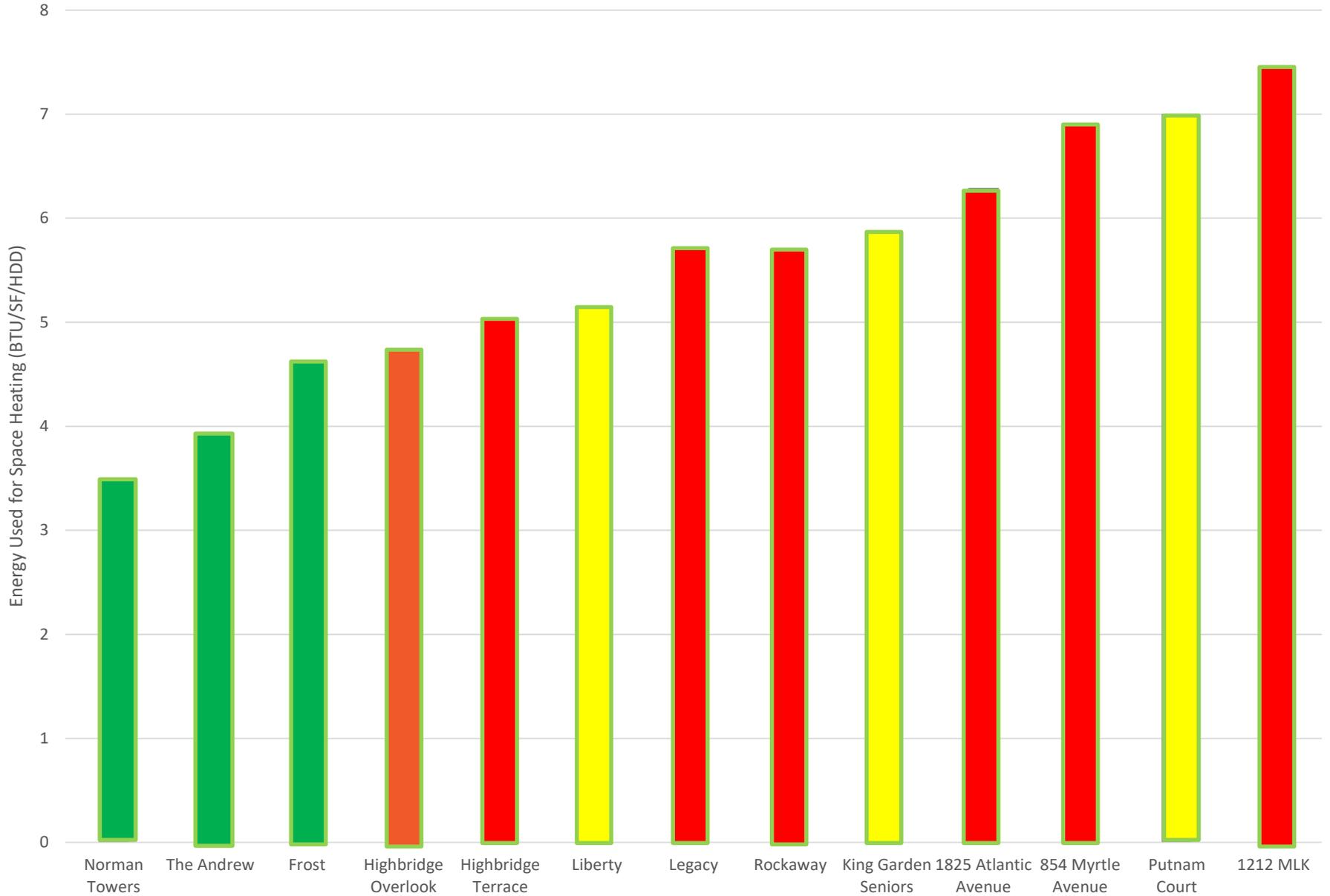
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Insulated Concrete Form



Comparison of Energy Used for Space Heating

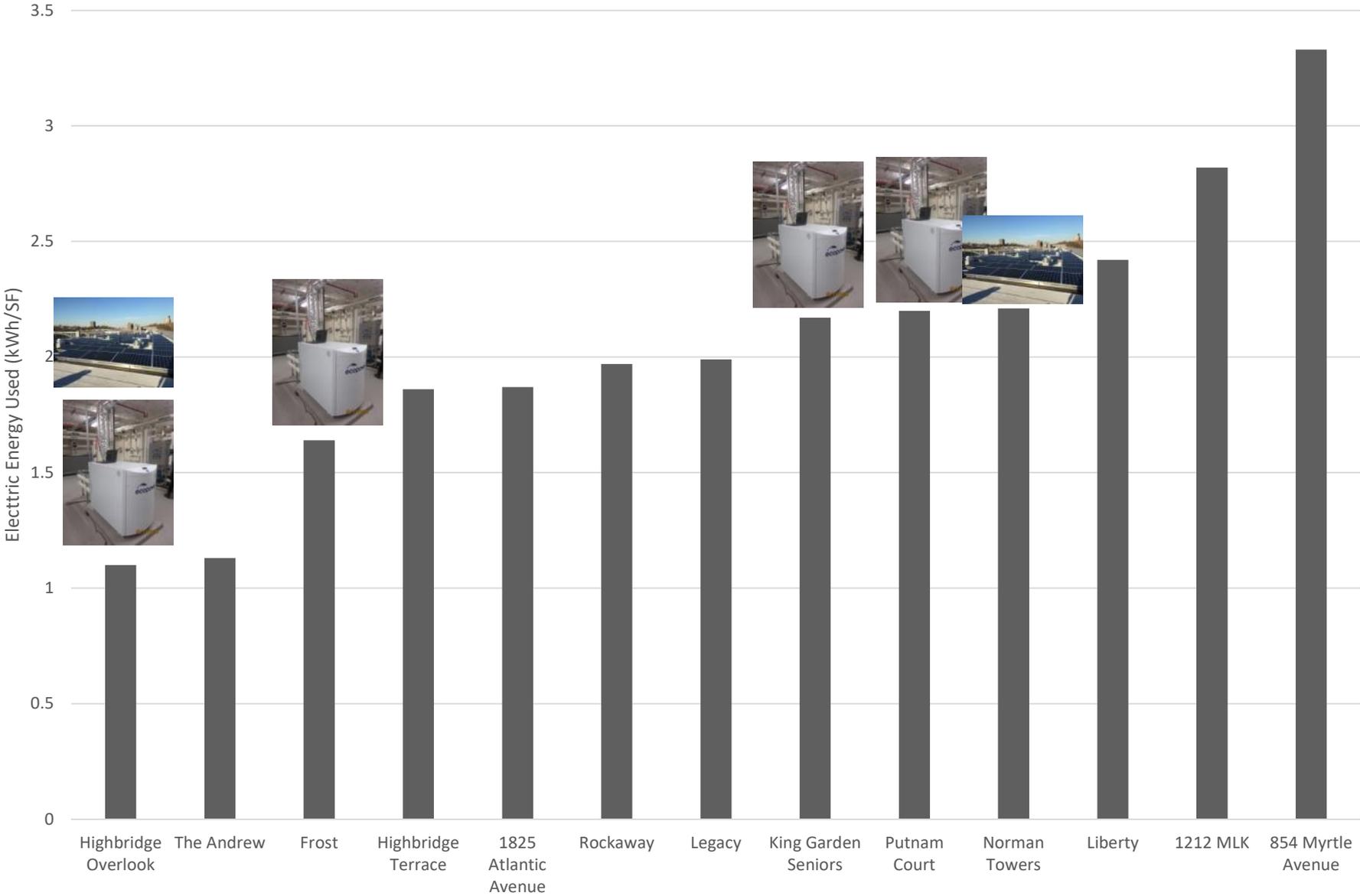




What About Onsite Generation?



Comparison of Energy Used for Common Area Electric





Owner Paid Electric: Other Factors

- Apartment Exhaust Ventilation
 - Central versus unitized
- Booster pumps
- Heating circulator pumps



The Andrew: Keeping it Simple

- Unitized exhaust ventilation
- Heating circulators
- Booster pumps





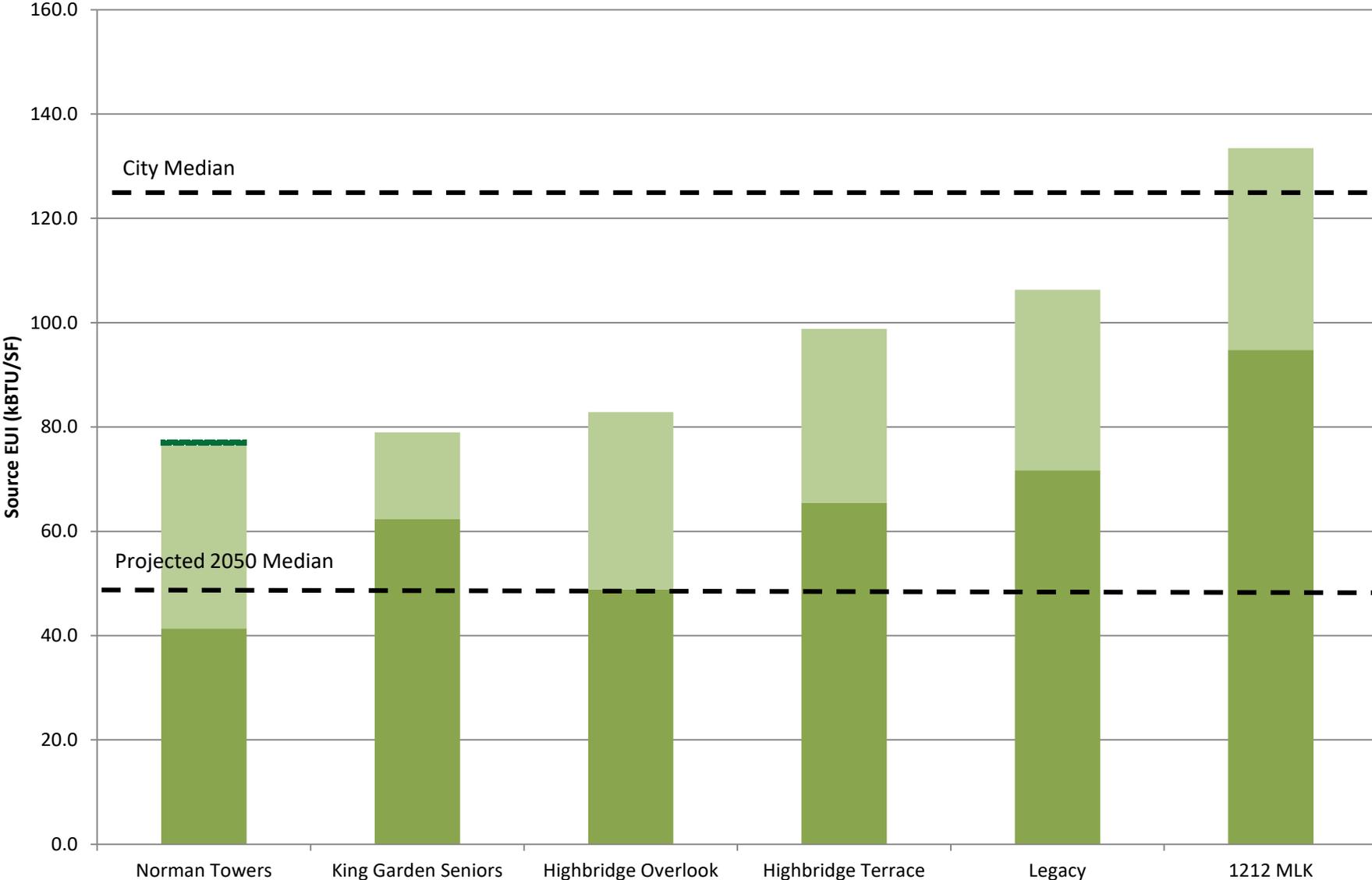
Whole Building EUI

- What about the rest of these buildings?



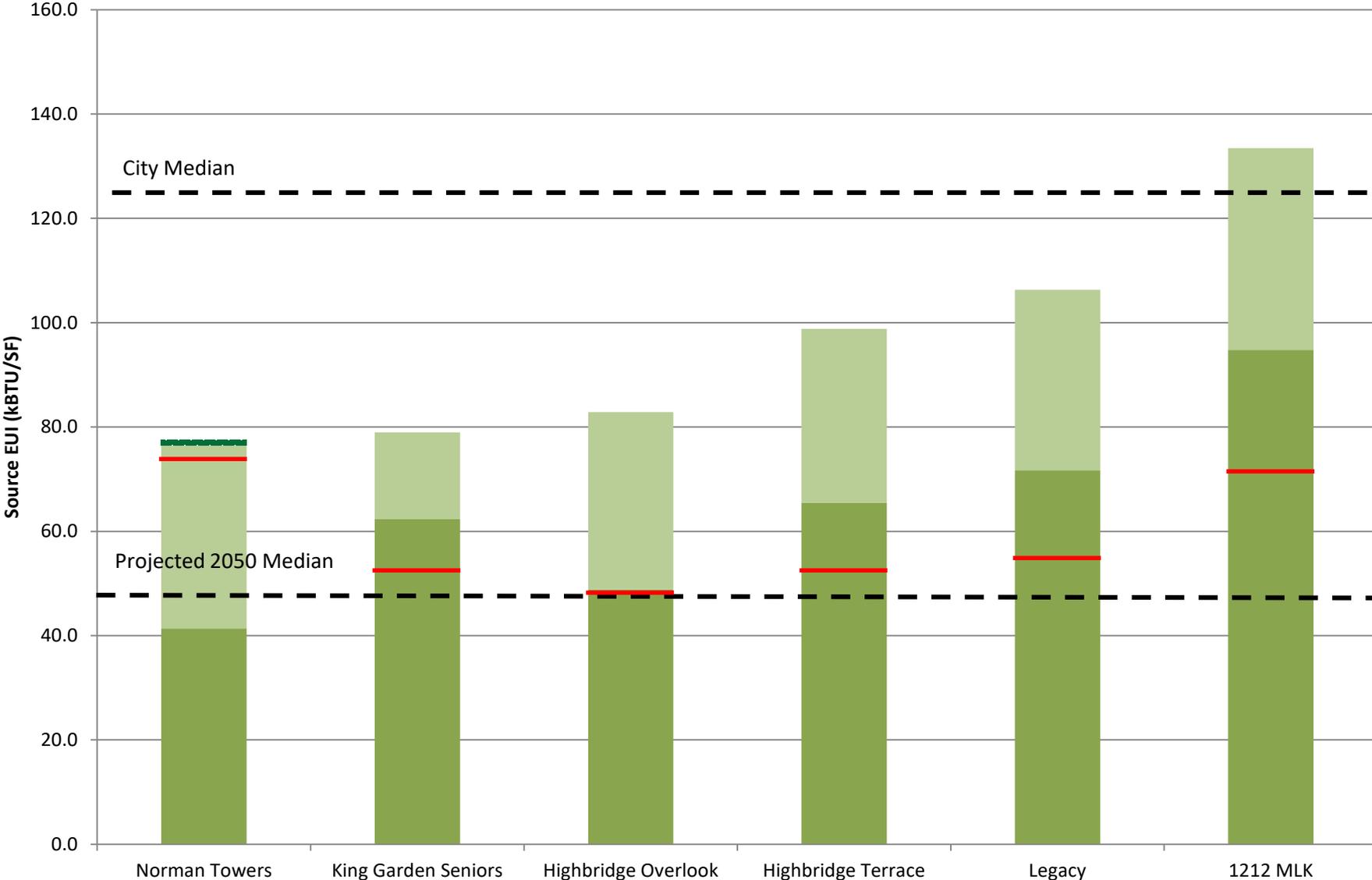
Comparison of Whole Building Source Energy Use

2016 Source EUI Resident Paid Source EUI Solar

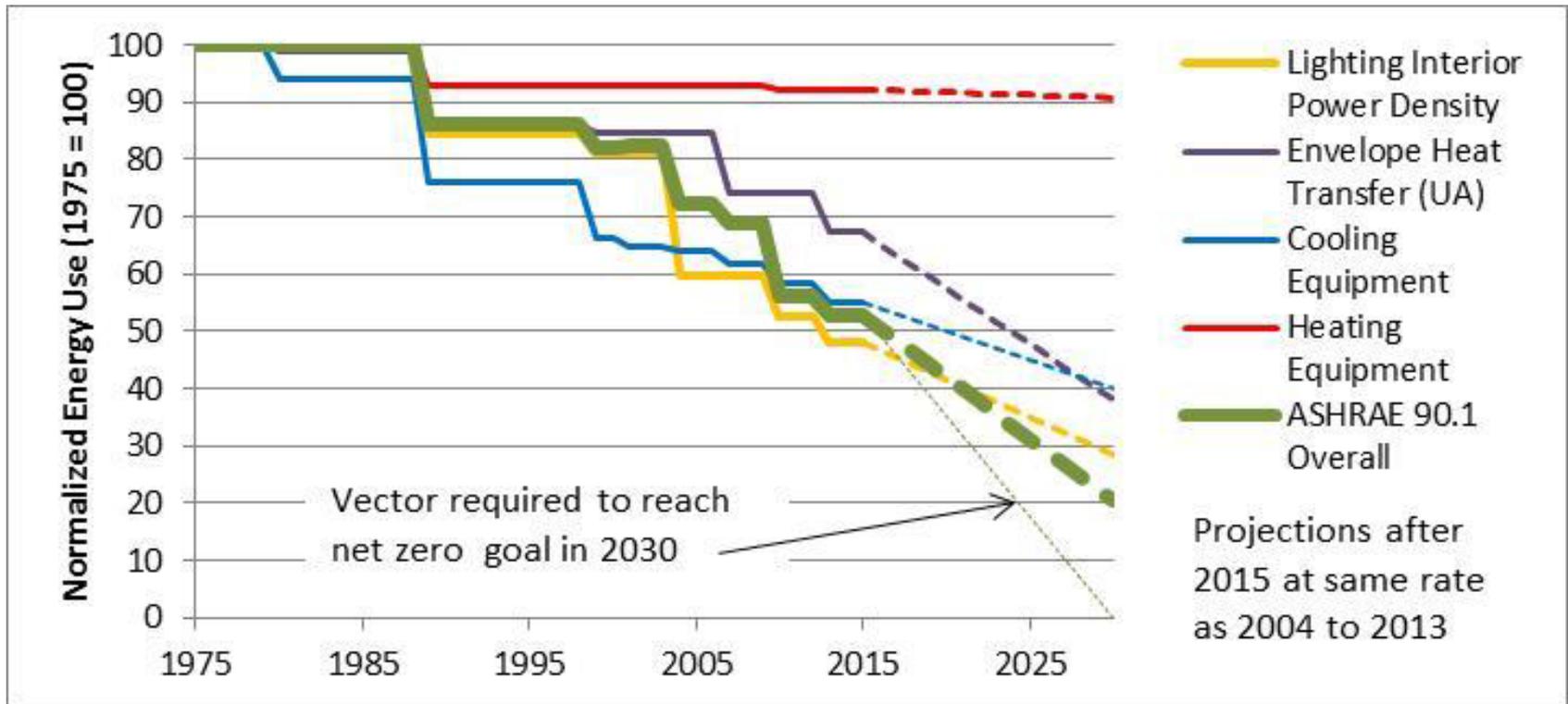


Comparison of Whole Building Source Energy Use

2016 Source EUI Resident Paid Source EUI Solar



Can we get there from here?



Can we get there from here?



PNNL: Roadmap for the Future of Commercial Energy Codes

http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-24009.pdf



Potential Solutions

Code Option	+	-
Predictive Performance with EUI Targets	<ul style="list-style-type: none">• Clear and measurable	<ul style="list-style-type: none">• EUI target challenging• Consistent prediction
Differential predictive performance with a stable baseline (bm)	<ul style="list-style-type: none">• Baseline more reliable• Quality control• Enable software development• Targets for different bldg types	<ul style="list-style-type: none">• Setting appropriate target
Prescriptive Packages	<ul style="list-style-type: none">• Simple turnkey solutions	<ul style="list-style-type: none">• Fed eff regulations• Too many choices?
Outcome based	<ul style="list-style-type: none">• Clear and measurable• Considers all energy used	<ul style="list-style-type: none">• Timing• Setting appropriate target• Undesired consequences

. 2018



Retro-Commissioning Findings



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Boiler & Controls





Insulation





Pump Performance





Gauges





Outdoor Air



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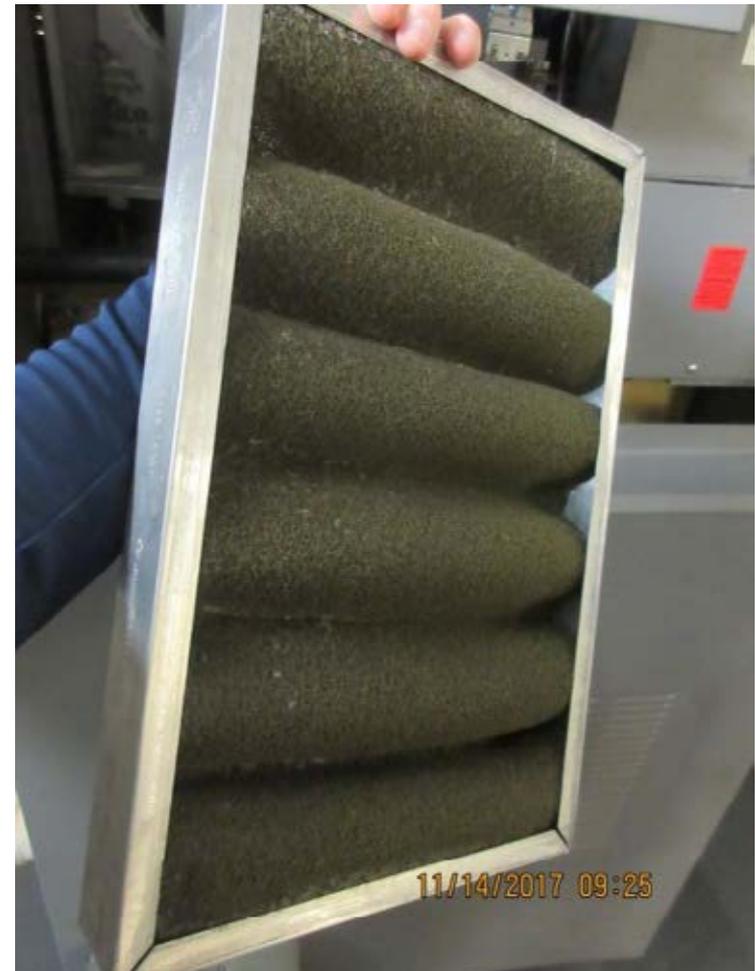


Rooftop Fans

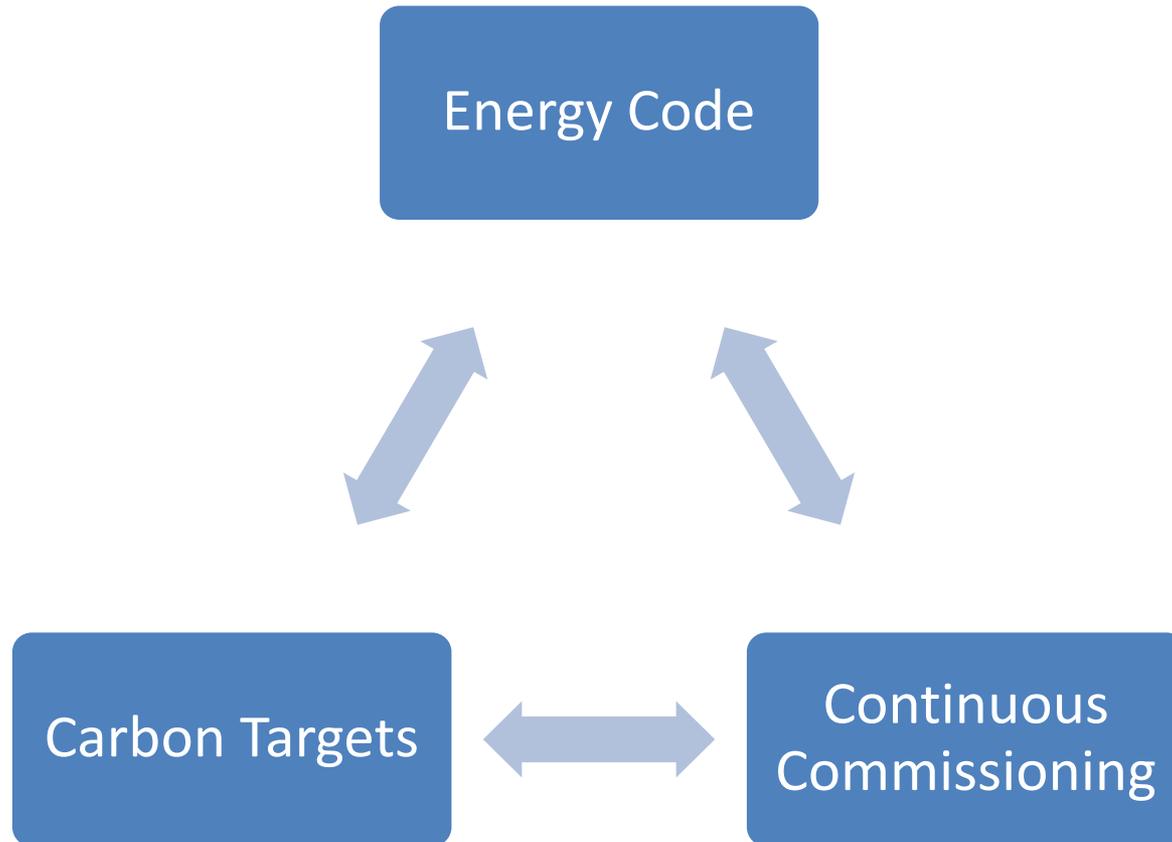




Dirty Coils and Filters



Conclusion





Questions?

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