

U.S. Department of Energy
Building Energy Codes Program

2024 National Energy Codes Conference
May 7, 2024
Sacramento, CA

Using Tools and Data Analysis to Inform Building Policy Adoption and Implementation

AIA Provider # 1014
AIA Course # 24NECC-D1S4



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Course Description

As building codes and building performance standards become more advanced, new tools and insights are critical to help inform their adoption and implementation across the U.S. In this session, we will explore various data-based solutions at the national, state, and local level helping jurisdictions realize savings and achieve their goals.



Learning Objectives

Understand how building energy data and new software tools can support the adoption and implementation of building energy policies.

Learn about novel approaches to analyze and synthesize large building energy use datasets.

Identify opportunities to utilize cost-effectiveness analysis and other policy analysis to support local energy code adoption efforts.

Understand how REScheck and COMcheck will support energy code compliance now and in the future.



Speakers

Anna Stern (Moderator) – US Dept. of Energy, Building Technologies Office

Eric Engelman – Policy Studio

Rob Salcido – Pacific Northwest National Laboratory (PNNL)

Duncan Prael – The City University of New York (CUNY)





Digital Tools
to Accelerate
Decarbonization

California and Beyond: Tool for Accelerating Code Adoption

Eric Engelman | Founder & Managing Director | Policy Studio

Overview

- **My Energy Origin Story**
- **What We Built**
- **Beyond CA**



How did you end up in
energy codes?



My first role in energy policy

Challenges

I always felt like I lacked the understanding, data, and resources to do my job well

Role:

Energy Policy Advisor
to Mayor's Office
City of San Diego

Responsibility:

Accelerate adoption of
clean energy initiatives



Learnings

- 1. Most of the resources designed to be helpful do not save time
- 1. Policy disagreements can often be resolved with the right data
- 1. If you have a good foundation of key knowledge to start with, you can make policies much better and faster

Role:

Energy Policy Advisor
to Mayor's Office
City of San Diego

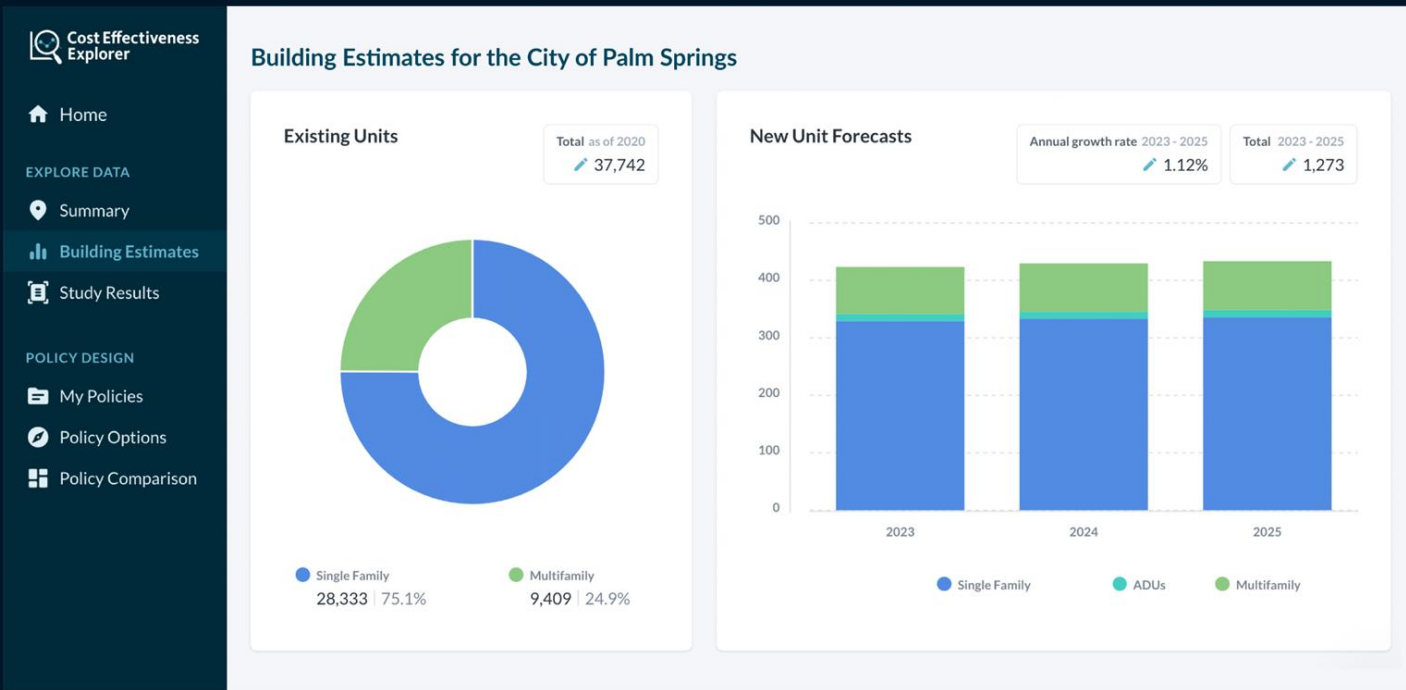
Responsibility:

Accelerate adoption of
clean energy initiatives

**Since my
first role in
energy policy**



Building Estimates



What we built

Policy Impacts

Cost Effectiveness
Explorer

Home

EXPLORE DATA

Summary

Building Estimates

Study Results

POLICY DESIGN

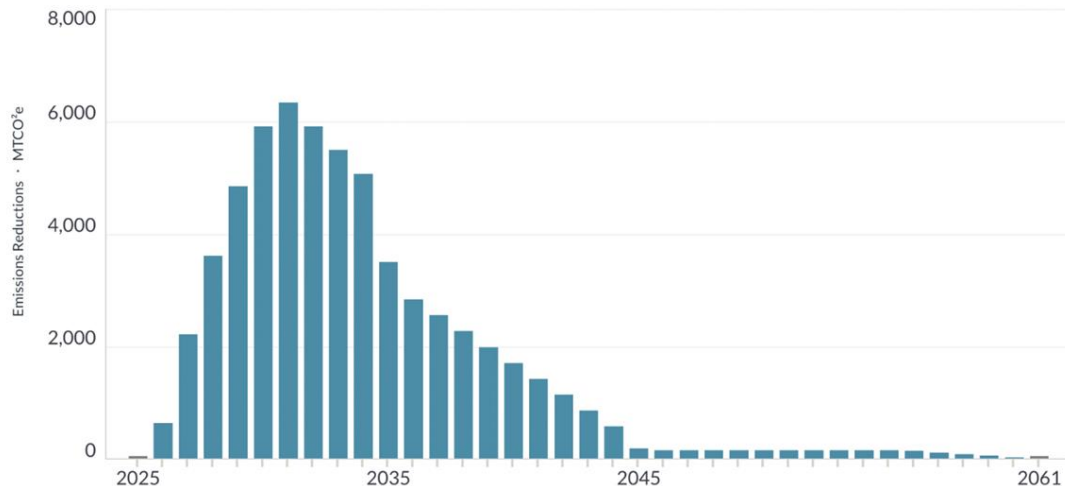
My Policies

Policy Options

Policy Comparison

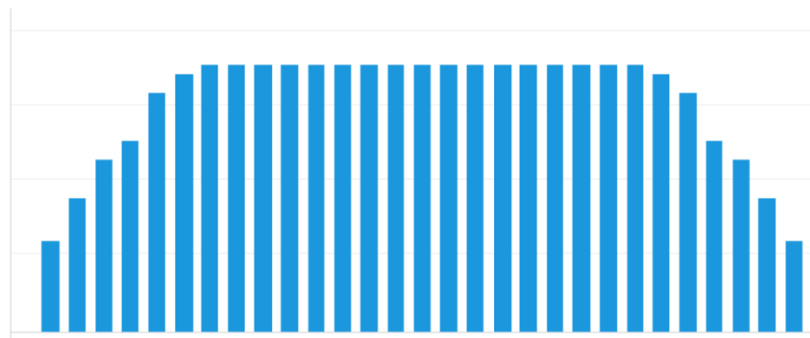
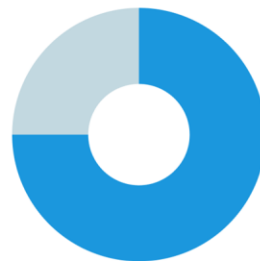
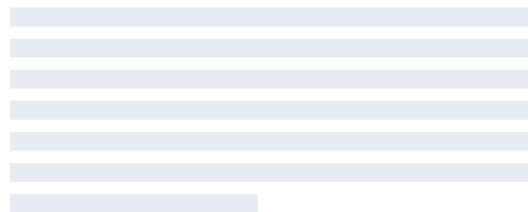
Policy Impact for the City of Palm Springs

Total Emissions Reductions: 60,837 MTCO₂e



What we built

Policy Documents



Cost-Effectiveness Explorer

Launched in 2021

Free for all cities and counties

Provides customized data for each jurisdiction

Supports learning

Supports policy development

Enables collaboration



Outcomes

Cost-Effectiveness Explorer



150

CA Cities/Counties



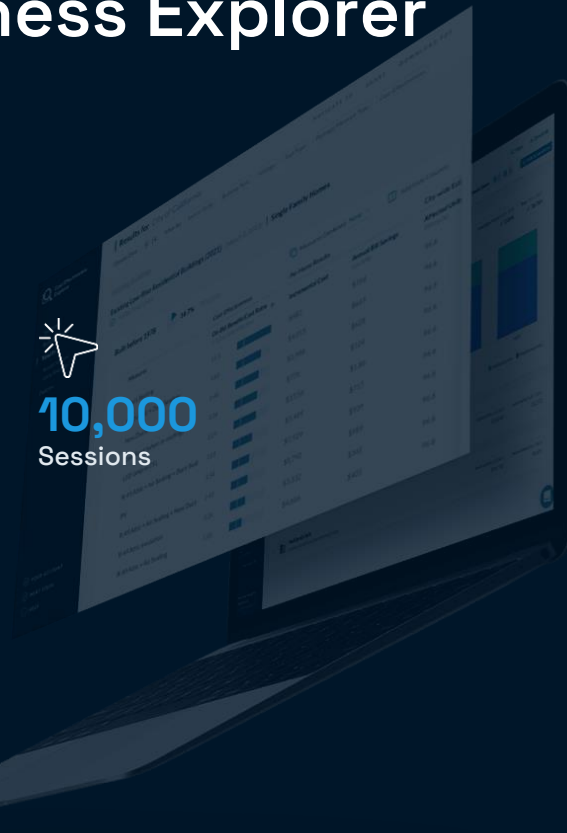
600

Policies Designed



10,000

Sessions



“Something that used to take me 3 weeks to do by hand, I can now produce in 3 minutes.”

California City Policymaker

“I used to spend all my time helping California cities. Now with the Explorer tool in place for California, I just direct cities there and know their needs are taken care of—so I can now spend my time supporting cities in other states across the country.”

Decarbonization Policy Advocate



Where is the need for a similar tool?

Local Gov Code Adoption Authority	Local Govs	States		Need	States
Type 1: None	11,000	25	Maybe	Help local governments understand code impact?	Connecticut, Delaware, Florida, Hawaii, Idaho, Illinois, Indiana, Iowa, Kentucky, Louisiana, Michigan, Minnesota, Montana, Nebraska, New Hampshire, New Jersey, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, Utah, Virginia, Washington, Wisconsin
Type 2: Adopt stretch codes beyond state code	7,000	16	Yes	Help local jurisdictions adopt stretch codes	Alabama, Arkansas, California, Georgia, Maine, Maryland, Massachusetts, Nevada, New Mexico, New York, Oklahoma, South Carolina, Tennessee, Texas, Vermont, West Virginia
Type 3: Adopt code	4,000	9	Yes	Help local jurisdictions adopt code updates	Alaska, Arizona, Colorado, Kansas, Mississippi, Missouri, S. Dakota, Wyoming

Is it possible to replicate this tool for other states?



Technically Feasible

- Data
- Policy Environment
- Technical Studies



Economically Feasible

- Leverage the investment California made
- Leverage the accumulated team expertise
- Economies of scale for many states

What will it take to make it happen?



Collaboration and Partnerships

- Advocates
- State partners
- Regional partners
- Local partners
- Technical partners



Funding

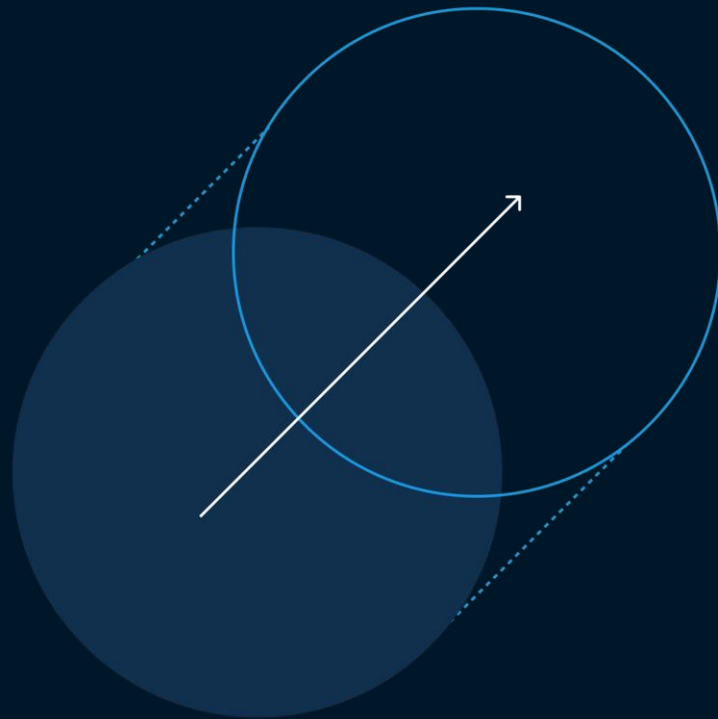
- Development costs
- Ongoing maintenance costs



Digital Tools
to Accelerate
Decarbonization

Thank you

eric@policystudio.co
818.917.3425



Learn more at explorer.localenergycodes.com and policystudio.co



REScheck and COMcheck Updates

2024 Department of Energy National Energy Codes Conference
Building Energy Codes Program

May 7, 2024

V. Robert Salcido
Senior Engineer



PNNL-SA-197898

PNNL is operated by Battelle for the U.S. Department of Energy



Overview of Check Tools



- **REScheck**

- ✓ REScheck-Web
- ✓ REScheck-Desktop (Phase out plan)

- **COMcheck**

- ✓ COMcheck-Web New (April 2024)
- ✓ COMcheck-Web Legacy (Phase out plan)
- ✓ COMcheck-Desktop (Phase out plan)

- **The Check Tools clarify and simplify energy code compliance with the IECC, ASHRAE Standard 90.1 or state-specific energy codes.**

REScheck & COMcheck Energy Codes



- **National, state and local energy codes (approved by DOE)**
 - ✓ **ASHRAE 90.1 Standard editions**
2007/2010/2013/2016/2019/2022
 - ✓ **IECC editions**
2006/2009/2012/2015/2021/
2024 in 2024
 - ✓ **Local Jurisdictions** - Boulder, Washington DC, Denver, Chicago, New York, Ontario
 - ✓ **State Energy Codes** – Florida, Massachusetts, Minnesota, New York, Puerto Rico, Utah, Vermont

Overview of Check Tools



▪ DOE software policy for state energy codes

- ✓ The Energy Conservation and Production Act (ECPA) directs DOE to provide technical assistance to improve and implement state building energy codes
- ✓ DOE's Building Energy Codes Program (BECP) provides residential (REScheck) and commercial (COMcheck) energy code compliance software to facilitate code adoption
- ✓ DOE will not provide a custom version of REScheck or COMcheck for state/local energy codes that provide less energy savings than the current versions of the national model energy codes.

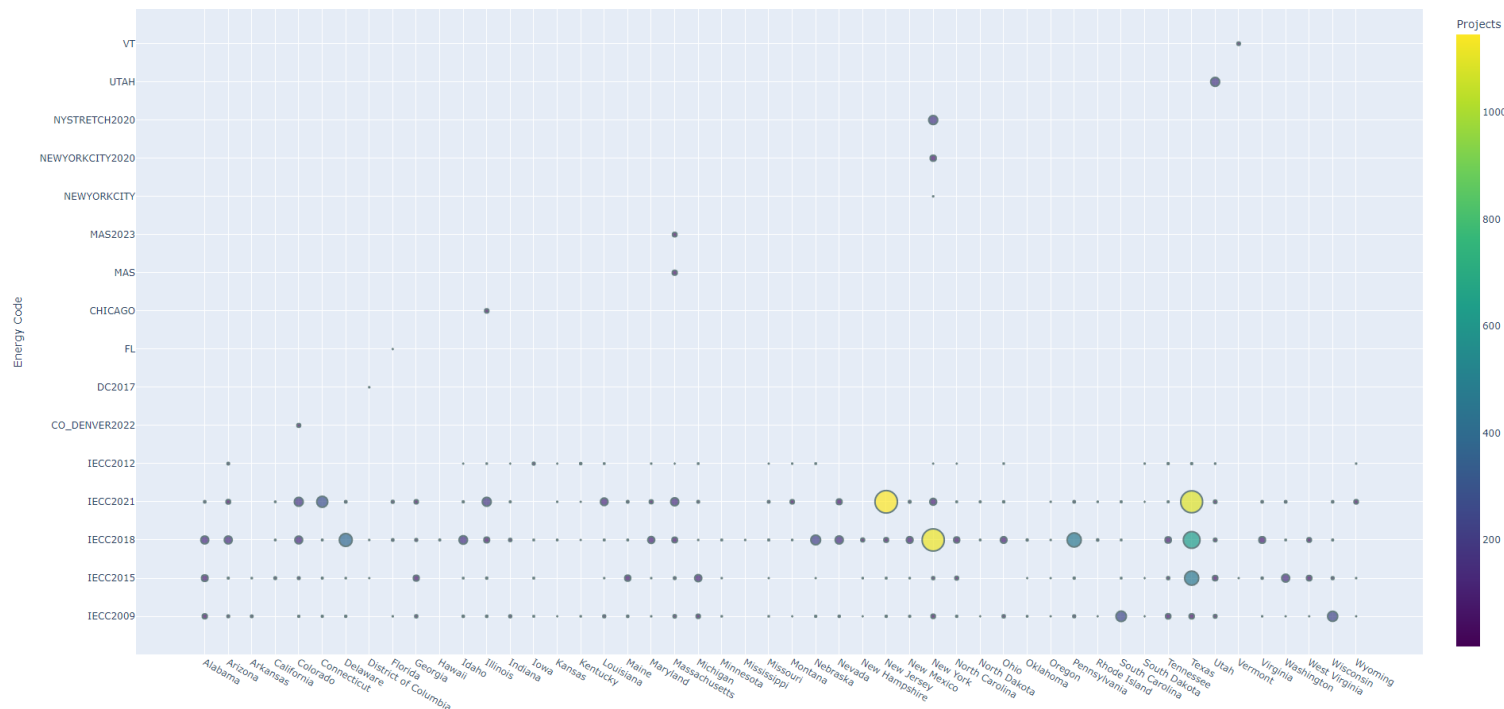
▪ Priorities of Check Tool development

- ✓ Current national model energy codes
- ✓ State or local codes based on current national energy codes with or without amendments that increase energy savings
- ✓ Current versions of state or local codes not based on or fundamentally diverging from the model codes with energy savings equal to or greater than the current national model code.
- ✓ DOE also releases regular updates of REScheck and COMcheck for maintenance and enhancement.

REScheck Activity



Number of Projects by State and Energy Code - Residential



**REScheck
March 2024**

**11,360 New
Residential
Projects**

**16 Energy
Codes**

**IECC 2018:
4,534 IECC
2021: 3,742
IECC 2015:
1,302**

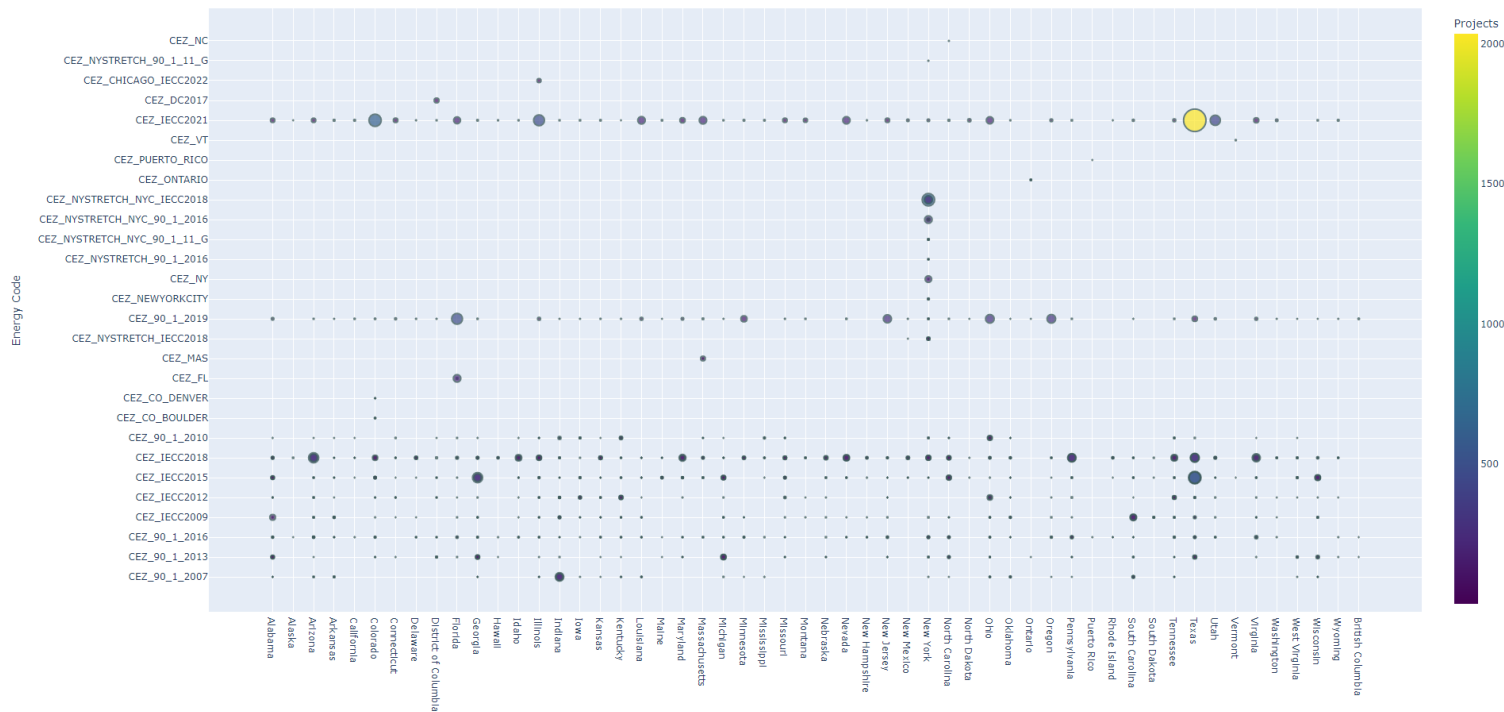
**Annual New
Projects**

**124,316 New
Residential**

COMcheck Activity



Number of Projects by State and Energy Code - Commercial



**COMcheck
March 2024**

**20,970 New
Commercial
Projects**

**28 Energy
Codes**

**IECC 2021:
5,623 IECC
2018: 4,939
IECC 2015:
2,795**

**Annual New
Projects**

**286,900 New
Commercial**

2024 COMcheck / REScheck



2023 Development Plan – Objectives from DOE for the Check Tools

- Convert Check Tools to modern cloud-based applications
- Mobile friendly UI/UX
- Stakeholder workshops on enhanced features
- Digital compliance workflow – permitting, compliance verification and reporting
- Basic and advanced navigation/usability
- Support for wizard-based workflows
- Customizable preferences for states and local jurisdictions
- Compliance process around advanced technologies supporting energy efficiency
- Advanced reporting to identify successful compliance measures
- Integration of compliance database for improved data tracking

2024 COMcheck / REScheck



2023 Development Plan – REScheck and COMcheck Stakeholder Workshops

- **Data Exchange**
 - ✓ Data import from BIM or BEM tools
 - ✓ Open-source data schema – RMD or gbXML
- **Code Officials' User Interface**
 - ✓ Code official access to project data with digital verification and compliance
- **Advanced Reporting**
 - ✓ Additional reporting requirements for advanced technologies supporting energy efficiency, decarbonization and resilience
- **Mobile Support**
 - ✓ Mobile checklist for field inspection
- **Improved Help/Usability**
 - ✓ input wizards, help bubbles, user guides, tutorials, validation prompts
- **Stakeholder Usability Suggestions**
 - ✓ project sharing, lighting schedules, sample projects, reducing number of clicks for data entry, better error reporting

2024 COMcheck / REScheck



2024 Status of REScheck and COMcheck enhancements

- Overhaul of COMcheck UI/UX - **Completed**
- Advanced Reporting – REScheck and COMcheck - **Completed**
- Data Exchange – lighting data import templates added to COMcheck – **Completed**
- Lighting Fixture Schedule – **Completed**
- Mobile Support – digital inspection checklist for REScheck and COMcheck (iOS and Android) – **Complete in May 2024**
- Wizard based workflow in COMcheck – **Completed**
- Stakeholder updates for usability for REScheck and COMcheck – **Completed**
- Improved Help/Usability – input wizards, help bubbles, user guides, tutorials, validation prompts, error reporting and project sharing – **Completed**
- Code Officials' User Interface – **future workshops with code officials to determine need/strategy**

2024 REScheck Updates



Energy Code/Standard implementation

- New Energy Codes Added
 - ✓ 2022 Denver Energy Code
 - ✓ 2023 Massachusetts Stretch Energy Code
- Compliance paths - UA and Performance
- Help bubbles
- Advanced reporting questions
- Mobile App for inspections

REScheck Project Tab



Rob Salcido | Sign off | ⚙️

Home » New Project

Project Envelope Compliance

Check Compliance

Save

Report

Help

Project Info:

Project Title*

Energy Code ⓘ

What's my code?

2021 IECC



Location ⓘ

Boulder, Colorado

Project Type ⓘ

☒ New Construction

☐ Addition

☐ Alteration

Compliance Method

☒ UA Trade-Off ⓘ

☐ Performance Alternative ⓘ

Additional Efficiency Package
Options

1 Required | 0 Proposed

Selected Package(s):

None

Edit Efficiency Package(s)

Building Characteristics

Construction Type

☒ 1- and 2-Family, Detached ⓘ

☐ Multifamily ⓘ

Conditioned Floor Area ⓘ

 ft²

Orientation - Front Faces ⓘ

Enable: ☒

Features

All ducts and air handlers are located within conditioned spaces:

☐ Yes ☒ No

Duct(s) are buried in ceiling insulation:

☐ Yes ☒ No

Thermally isolated sunroom:

☐ Yes ☒ No

Pool or inground spa:

☐ Yes ☒ No

Interior wood-burning fireplace:

☐ Yes ☒ No

All-Electric Property:

☐ Yes ☒ No

Renewable Energy Installed:

☐ Yes ☒ No

Battery Storage Installed:

☐ Yes ☒ No

EV Charger Installed:

☐ Yes ☒ No

Heat Pump Installed:

☐ Yes ☒ No

2024 COMcheck Updates



Energy Code/Standard implementation

- Energy codes implemented
 - ✓ ASHRAE 90.1-2022
 - ✓ 2024 Minnesota Energy Code
 - ✓ 2022 Denver Energy Code – May 2024
 - ✓ 2023 Massachusetts Stretch Energy Code – May 2024
- New platform
- Project sharing
- Advanced reporting
- Data entry wizards
- Data imports for fixture schedule
- Improved user help and guidance
- Mobile app for inspections

COMcheck Project Dashboard

Start a sample project

Sorting


Start a new project


COMcheck-Web™


[HELP CENTER](#)


VICTOR.SALCIDO@PNNL.GOV















[COLLAPSE](#)


MY PROJECTS


NEW PROJECT


IMPORT PROJECT

SAMPLE PROJECTS


<input type="checkbox"/> Project		Last Updated	Energy Code	Status	Sharing	Shared	Export
<input type="checkbox"/> BUTTONS		Wed Apr 10 2024	90.1 (2022) Standard	Submitted			
<input type="checkbox"/> MINNESOTA TESTING		Fri Mar 15 2024	2023 Minnesota Energy Code	Draft			
<input type="checkbox"/> SAMPLE PROJECT C : MIXED USE		Fri Feb 23 2024	2015 IECC	Draft			
<input type="checkbox"/> SAMPLE PROJECT B : 90.1 2022 OFFICE		Fri Feb 23 2024	90.1 (2022) Standard	Draft			
<input type="checkbox"/> SAMPLE PROJECT A : BASIC TEMPLATE		Fri Feb 23 2024	2015 IECC	Draft			

No Projects Selected.


Duplicate Projects


SHARED PROJECT REQUESTS

0 Items


Dense layout

Rows per page 5 1-5 of 10

Project Sharing

COMcheck Wizard Approach for Mechanical



ADD HVAC

1 — 2 — 3 — 4 — 5

Heating Equipment Cooling Equipment System Details Zoning Configure Economizer

☐ Heat Pump / VRF Condensing Unit

Configure Heating Equipment

☐ None ☒ Central Furnace
☐ Duct Furnace ☐ Hydronic or Steam Coil
☐ Radiant Heater ☐ Unit Heater
☐ Other Heating Equipment

—CANCEL— **BACK** **NEXT**

ADD HVAC

1 — 2 — 3 — 4 — 5

Heating Equipment Cooling Equipment System Details Zoning Configure Economizer

Configure Zoning Equipment

☒ Single Zone ☐ Perimeter System
☐ Multiple Zone

Multiple Zone Details ?

Distribution Type: Single Duct

Terminal Unit Type: Reheat Type:

☐ VAX Box ☐ CV Mixing Box ☐ Electricity
☐ Fan Powered VAX Box ☐ Reheat/Recoil Coil ☐ Hydronic
☐ VAV Mixing Box ☐ Steam

—CANCEL— **BACK** **NEXT**

ADD HVAC

1 — 2 — 3 — 4 — 5

Heating Equipment Cooling Equipment System Details Zoning Configure Economizer

Configure Cooling Equipment

☐ None ☐ Field-Assembled DX System
☐ Packaged Terminal DX Unit ☒ Single Package DX Unit
☐ Room Air Conditioner ☐ Single Package Vertical AC Unit
☐ Single Package Vertical AC Unit ☐ Split DX Unit
☐ VRF Air Conditioner ☐ VRF Zone Fan Unit
☐ Computer Room Air Conditioner ☐ DX-DOAS Unit
☐ DX-DOAS With Heat Recovery ☐ Hydronic Coil
☐ Passive Chilled Water Unit

—CANCEL— **BACK** **NEXT**

ADD HVAC

1 — 2 — 3 — 4 — 5

Heating Equipment Cooling Equipment System Details Zoning Configure Economizer

Configure Economizer

Economizer Type:

Air

—CANCEL— **BACK** **ADD HVAC SYSTEM**

ADD HVAC

1 — 2 — 3 — 4 — 5

Heating Equipment Cooling Equipment System Details Zoning Configure Economizer

Central Furnace

Name/Description: Furnace

Fuel Type / Heat Source: Natural Gas

Quantity: 1

Capacity: (kBtu/h) 100

Proposed Efficiency (% Et) 90

Single Package DX Unit

Name/Description: AC

Condenser Type: Air Cooled

Quantity: 1

Capacity: (kBtu/h) 100

Full Load Efficiency (EER) 15

Part Load Efficiency (EER) 13


Select Fan System

ADD FAN

—CANCEL— **BACK** **NEXT**

COMcheck Interior Lighting: Add Fixture Schedule

- COMcheck lighting dashboard highlights building areas, spaces, fixtures, wattages and controls



- HELP CENTER
- RETURN TO PROJECTS
- VICTOR.SALCIDO@PNNL.GOV
- ENVELOPE
- INTERIOR LIGHTING**
- EXTERIOR LIGHTING
- MECHANICAL
- RENEWABLE ENERGY
- REQUIREMENTS
- CREDITS
- COMPLIANCE
- COLLAPSE

Buttons

90.1 (2022) Standard • Boulder, Colorado • Climate Zone 5 • New Construction

INTERIOR LIGHTING

Totals - Building Area Method: Allowed Wattage: 14600 Proposed Wattage: 900
Totals - Space by Space Method: Allowed Wattage: NaN Proposed Wattage: 900

Cars n Stuff
Building Area Type: Automotive facility
Space by Space Method: Allowed Wattage: 0 Proposed Wattage: 900
Area: 20000 W/ft²: 0.73

SPACES/FIXTURES ? CONTROLS ?

Lighting Spaces

	Space Name	Area	Lighting Power Density (LPD)	Space Proposed Wattage
1	Bank Banking Activity Area	20000	0.61	900
1	F1 LED			

PLAN REVIEW CONTROLS WATTAGE POST CONSTRUCTION

[4.2.2, 9.4.3, 9.7] Plans, specifications, and/or calculations provide all information with which compliance can be determined. Information provided should include interior lighting power calculations, wattage of bulbs and ballasts, transformers and controls.

FIXTURE SCHEDULE

CHECK COMPLIANCE

SAVE

Fixture Schedule

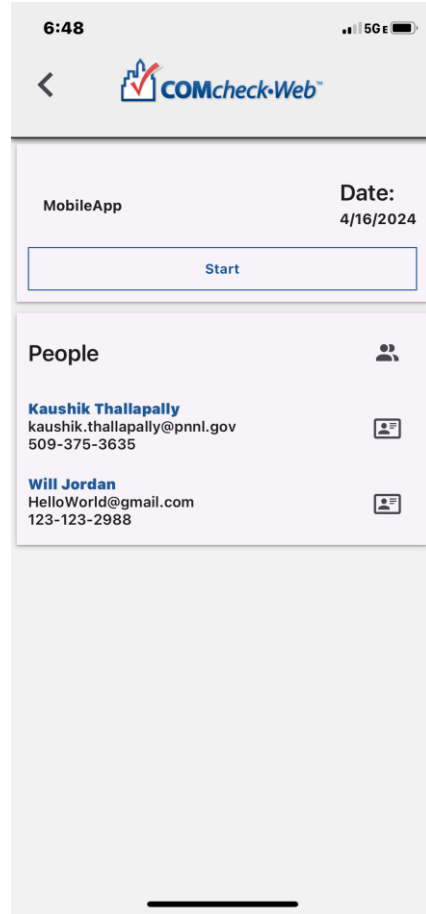
	FIXTURE NAME	FIXTURE DESCRIPTION	LIGHTING TYPE	FIXTURE WATTAGE
	F1	F1 CXD 9W	LED	9
	F2	F2 CXL 11W	LED	11
	F3	F3 CXR 12W	LED	12
	F4	F4 FXD 15W	LED	15
	F5	F5 CXD 8W	LED	8

Rows per page: 5 1-5 of 6

ADD A FIXTURE ADD FIXTURE FROM LIBRARY DOWNLOAD DATA TEMPLATE UPLOAD FIXTURE DATA


CANCEL UPDATE FIXTURE SCHEDULE

Mobile App



Mobile App

6:47
5G

<



Inspection: Controls

In Compliance:	0
Not In Compliance:	0
Not Started:	1

8.4.2-Controls
At least 50% of all 125 volt 15- and 20-Amp receptacles are controlled by an automatic control device.
[Exceptions](#)

8.4.3-Controls
New buildings have electrical energy use measurement devices installed. Where tenant spaces exist, each tenant is monitor...
[Exceptions](#)

6:47
5G


<


Section: Project
Requirement ID: 8.4.2
Requirement: EL10_90.1_2022_C_8.4.2

Status:
Not Observed

In Compliance
Not In Compliance

Notes:
Not observed

Photos:


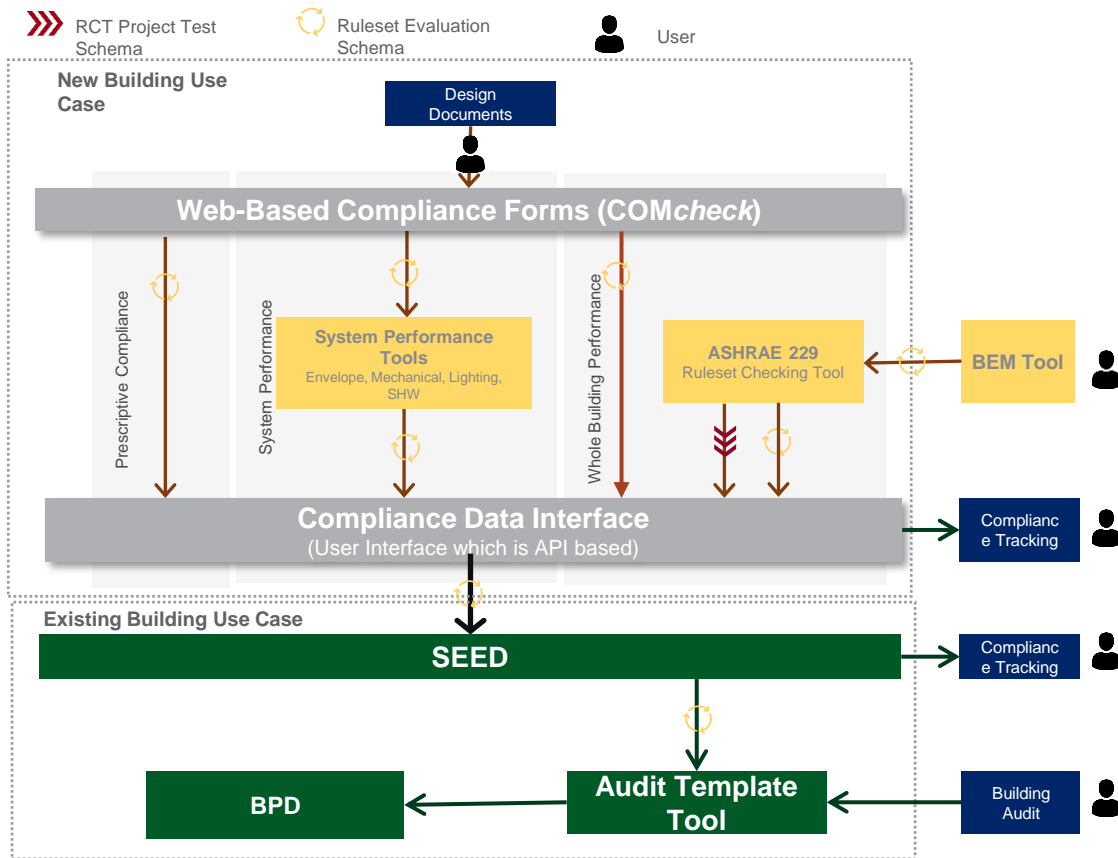
2024/2025 COMcheck/REScheck



Future Work

- 2024 IECC Implementation in REScheck and COMcheck
- 2023 Vermont Energy Code in REScheck and COMcheck
- 2023 Illinois Stretch Energy Code in REScheck and COMcheck
- Cloud based operation with scalability
- Refactoring of source code
- Further adaptation of mobile app
- Additional data exchange
- Compliance portals (proposed)
 - ✓ REScheck code official tool/portal
 - ✓ COMcheck code compliance portal

COMcheck Compliance Portal



Compliance Data Interface

Live interface with meta-data from various databases. Ability to run API calls to generate desired data set

Ruleset Evaluation Schema

Data exchange between COMcheck and SEED, using RES for sharing building performance and building asset data
AT would add ability to import data using RES, allowing asset data from BEM tools to be imported.

Unknowns

Unique building ID to track a building across its life cycle.

Evaluation of the RES to identify additional data elements/data groups required

THANK YOU!!!

V. Robert Salcido
victor.salcido@pnnl.gov

Building Energy Codes Program
www.energycodes.gov

BECP help desk
<http://www.energycodes.gov/resource-center/help-desk>

Thank you



2024 National Energy Codes Conference

Using Tools and Data Analysis to Inform Building Policy Adoption and Implementation

Data-Driven Commercial Building Energy Code Compliance Analysis for New York City

MAY 7, 2024

DUNCAN PRAHL, RA, AIA
DIRECTOR, TECHNICAL SERVICES
CUNY BUILDING PERFORMANCE LAB

Research Project Overview

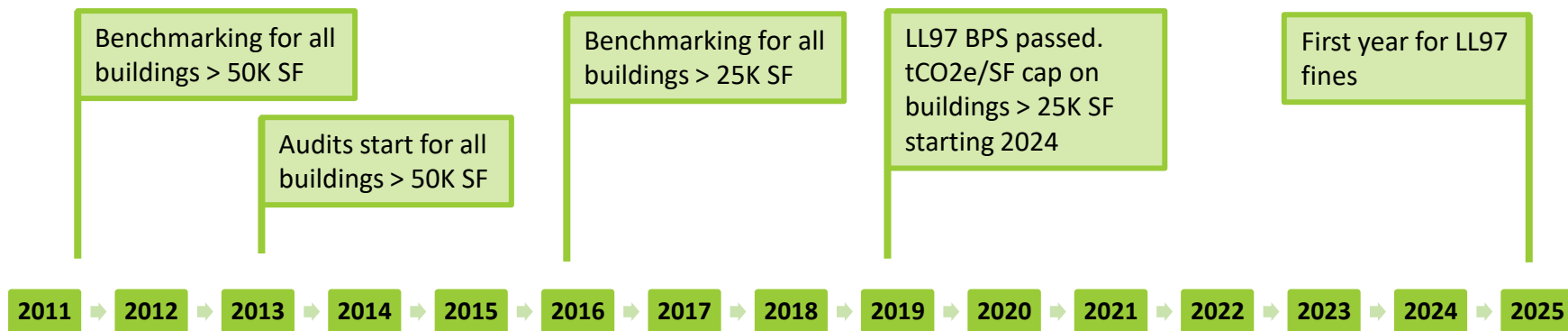
- NYC has been at the forefront of rigorous energy codes and has passed annual carbon limits on buildings that get progressively more stringent over time (2024-2029, 2030-2034, etc.)
- NYC has a very rich open data ecosystem
 - Data, data, everywhere...
 - Benchmarking, permits, energy audits, boilers, cooling tower inventories...
- *Research Questions:*
 1. Can these data be used to evaluate how various policies (e.g., energy audits, benchmarking, carbon caps, energy codes) are impacting actual building energy use in the market?
 2. Are there tools that can help building owners predict and better understand how energy is being used in the building?
 3. What is the contribution of various plants, systems, and components to overall building energy consumption and GHG emissions?

Acknowledgments and Caveats

- This material is based upon work supported by the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) under the Advanced Building Construction program, award number(s) DE-EE0009081
- Additional support was provided by the NYC Department of Citywide Administrative Services, Division of Energy Management
- Project partners include the NYC Mayor's Office of Climate and Environmental Justice, the NYC Department of Buildings, and the New York State Energy Research and Development Authority
- Dedicated CUNY BPL staff and interns:
 - Honey Berk, Executive Director, Tyna Horn, Director of Data Solutions, Stephania Castro, Jr. Analyst
 - Interns: Po Ki Chui, Edgar Santamaria, Rami Khan, Sam Wolnerman, Tiffany Beckles, Lourdes Rivera, Golvis Tavaréz, Samiul Ahmed
- Best efforts have been used to check and use correct data. There is conflicting and duplicative data and significant cross-referencing was necessary to reach conclusions presented here today.
- The views expressed herein do not necessarily represent the views of the U.S. Department of Energy, the United States Government, the NYC Mayor's Office of Climate and Environmental Justice, the NYC Department of Buildings, or the New York State Research and Development Authority.

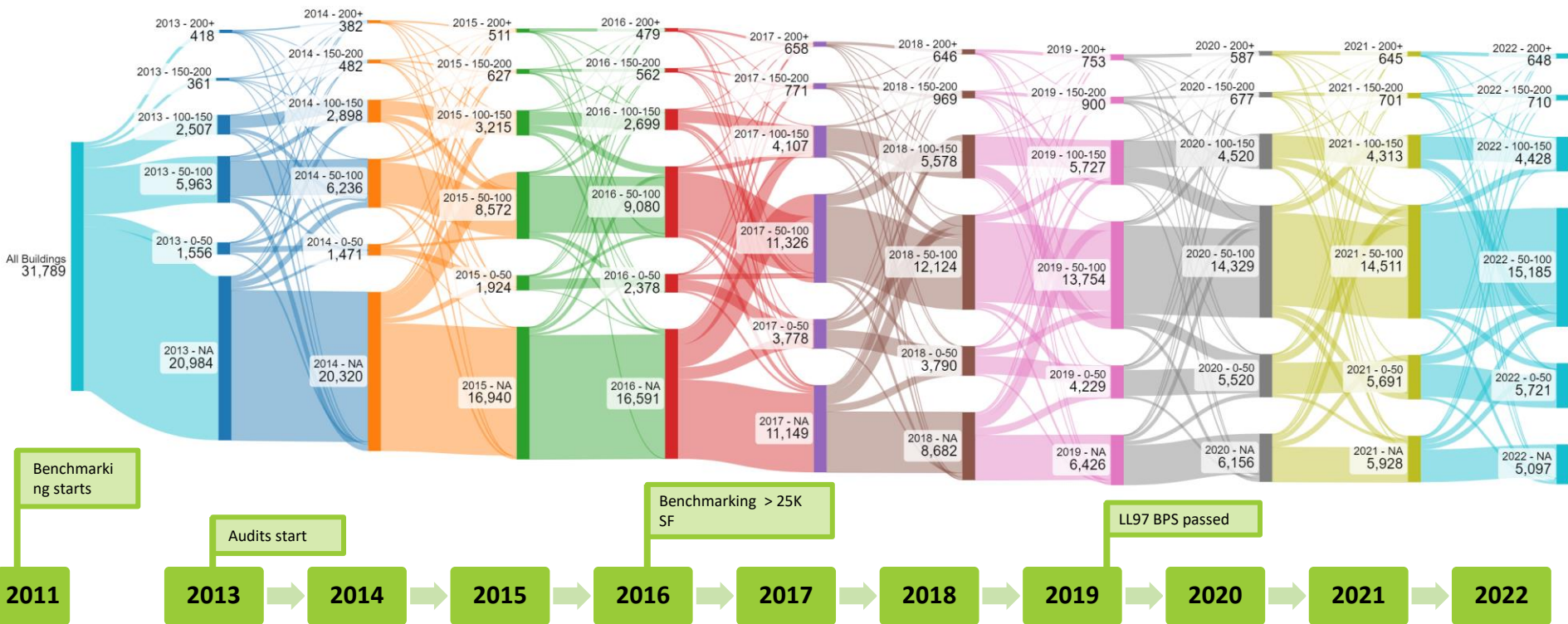
High-Level Data Analysis

- Looked at NYC Open Data from 2013 to 2022, as well some limited proprietary data
- Benchmarking, audits, permits, energy, drawing sets, and real-time energy management data

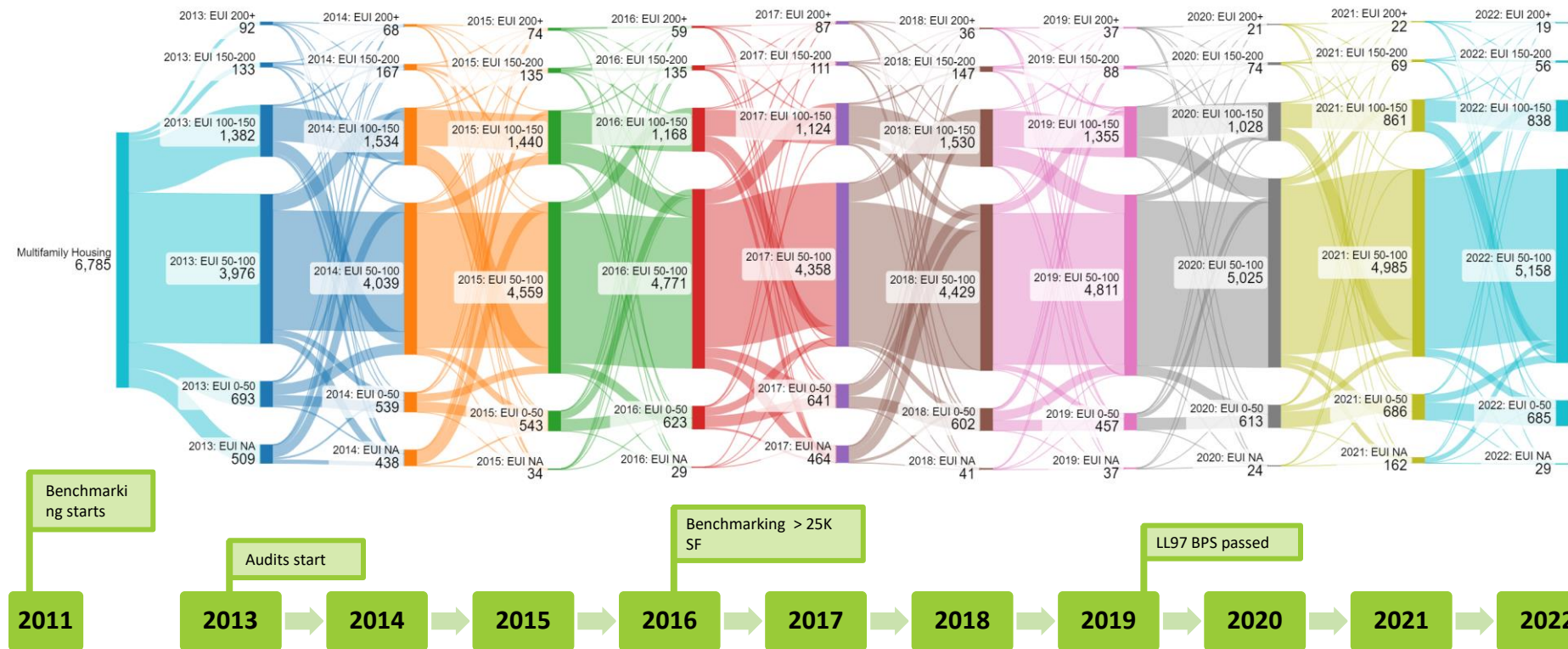


So, what did we find?

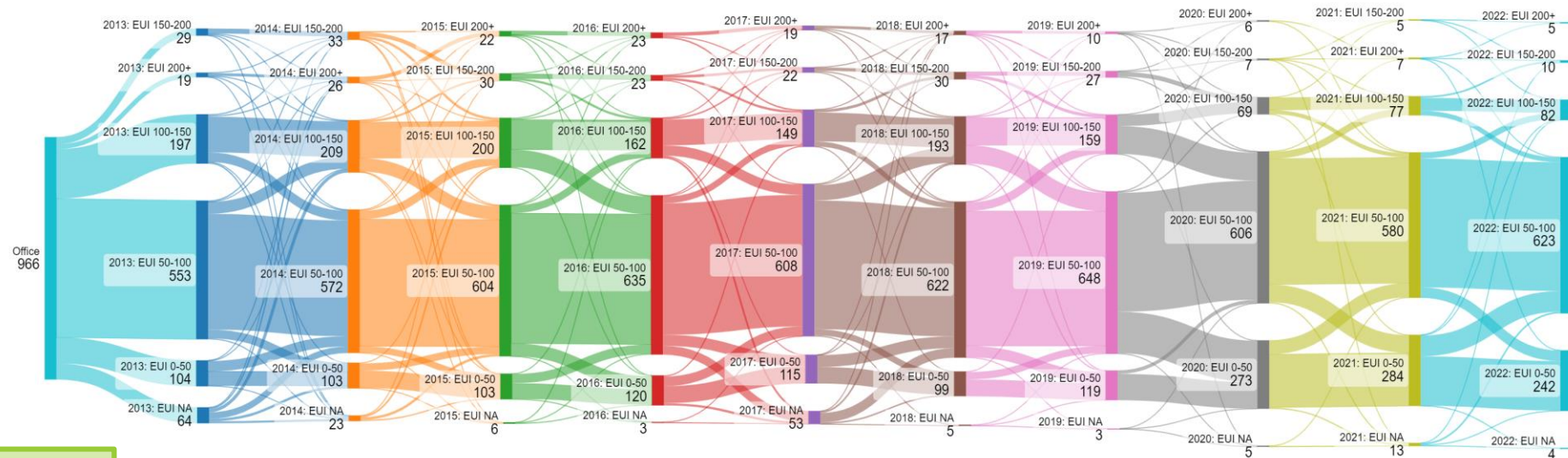
EUI is Not Stable Over Time



EUI – Multifamily with 5+ Years of Data



EUI – Offices with 5+ Years of Data



Benchmarking starts

Audits start

Benchmarking > 25K SF

LL97 BPS passed

2011

2013

2014

2015

2016

2017

2018

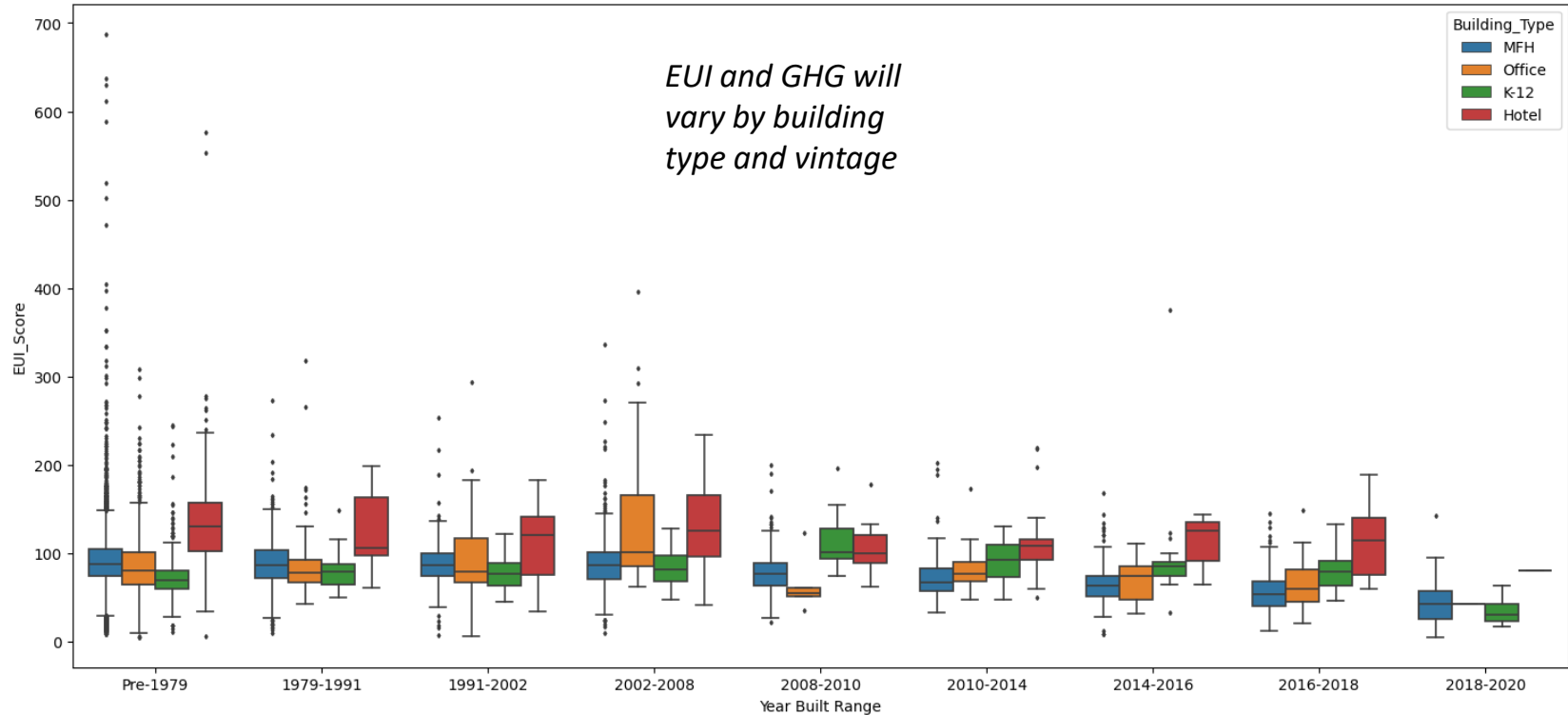
2019

2020

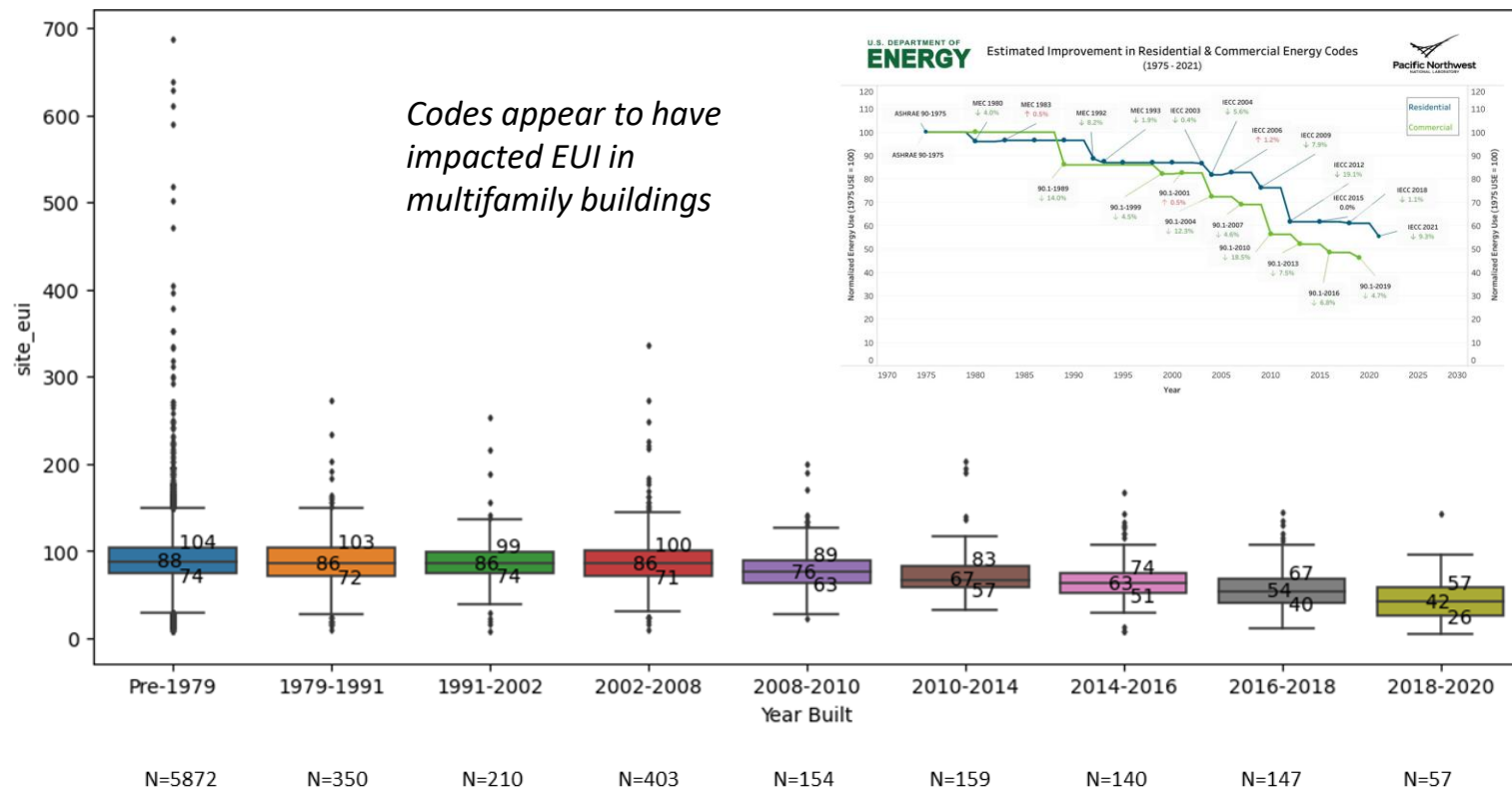
2021

2022

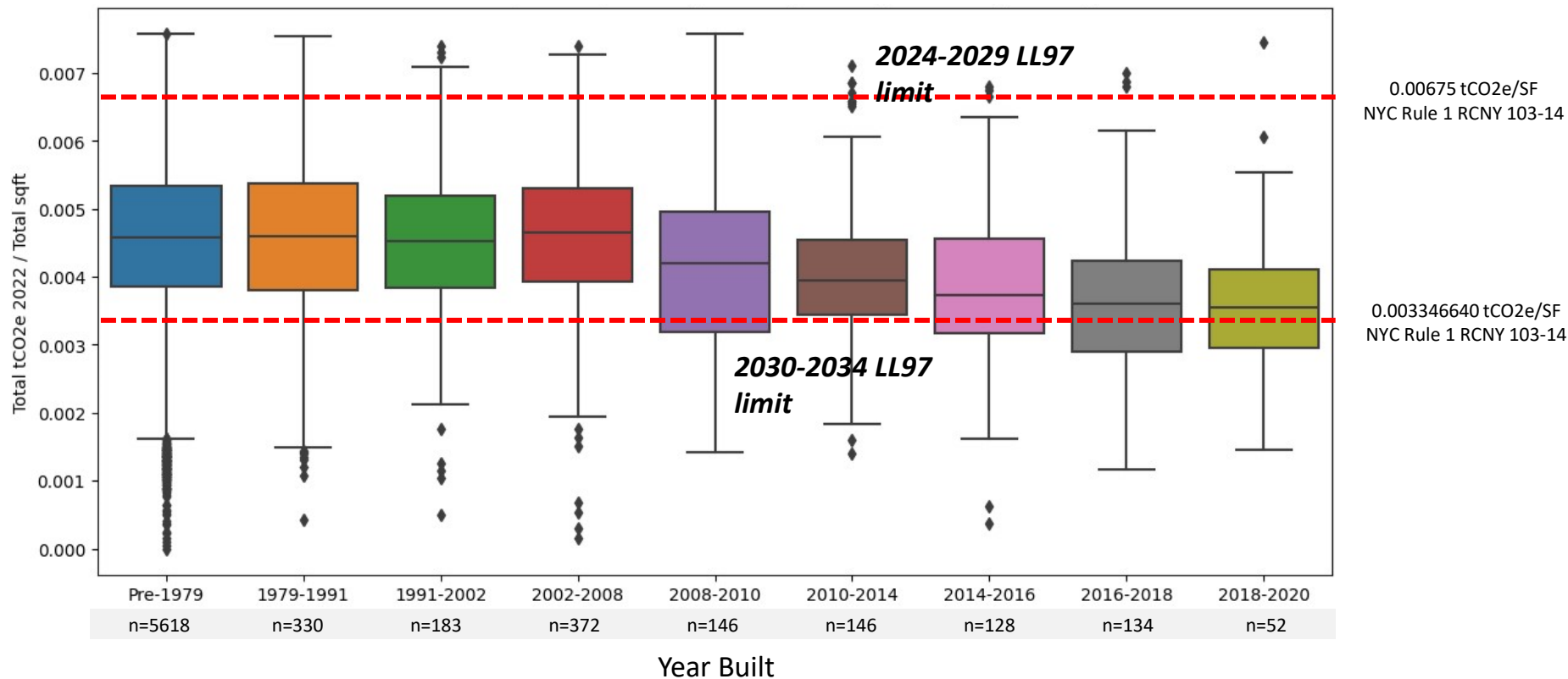
2019 EUI Distribution by Vintage



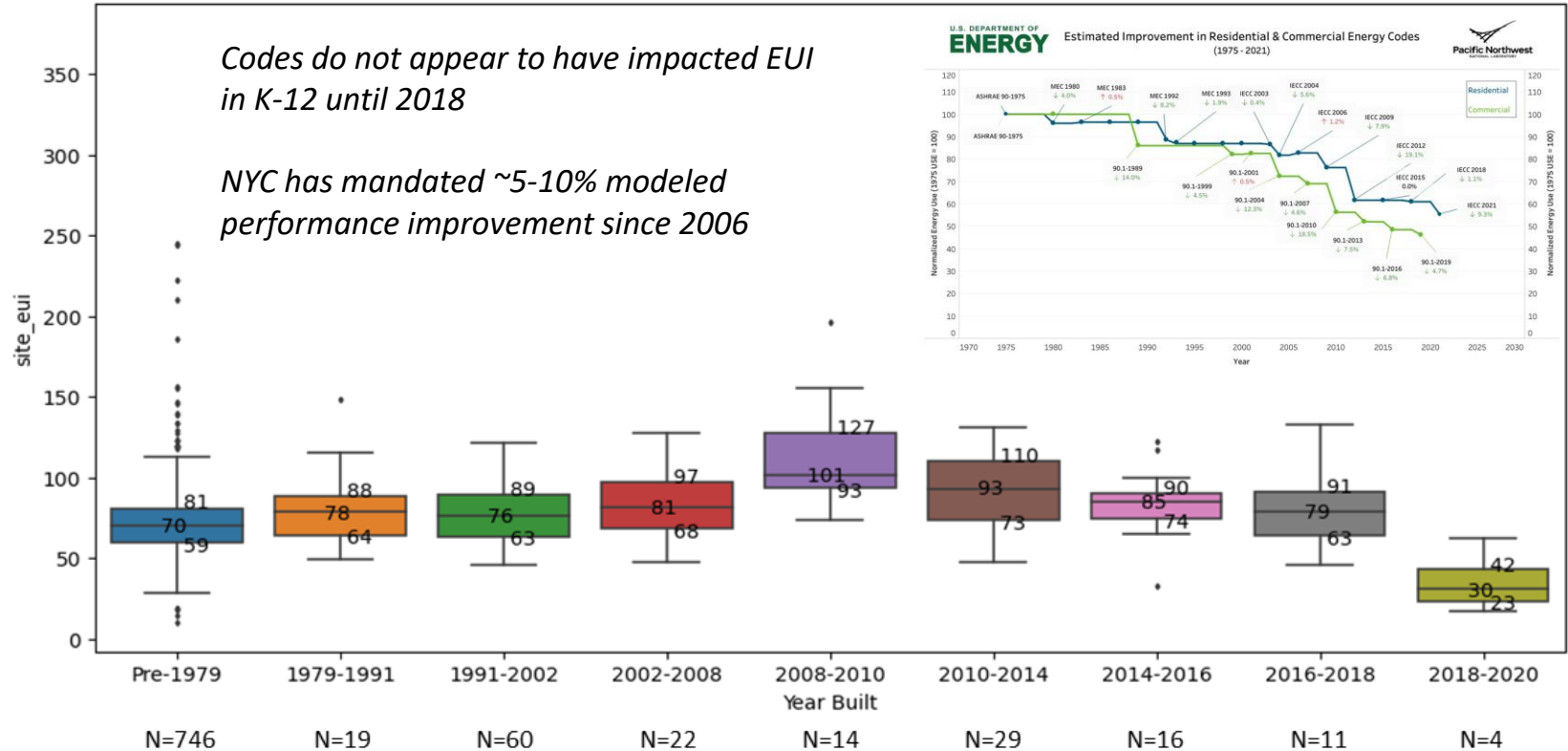
2019 EUI Distribution by Vintage – Multifamily



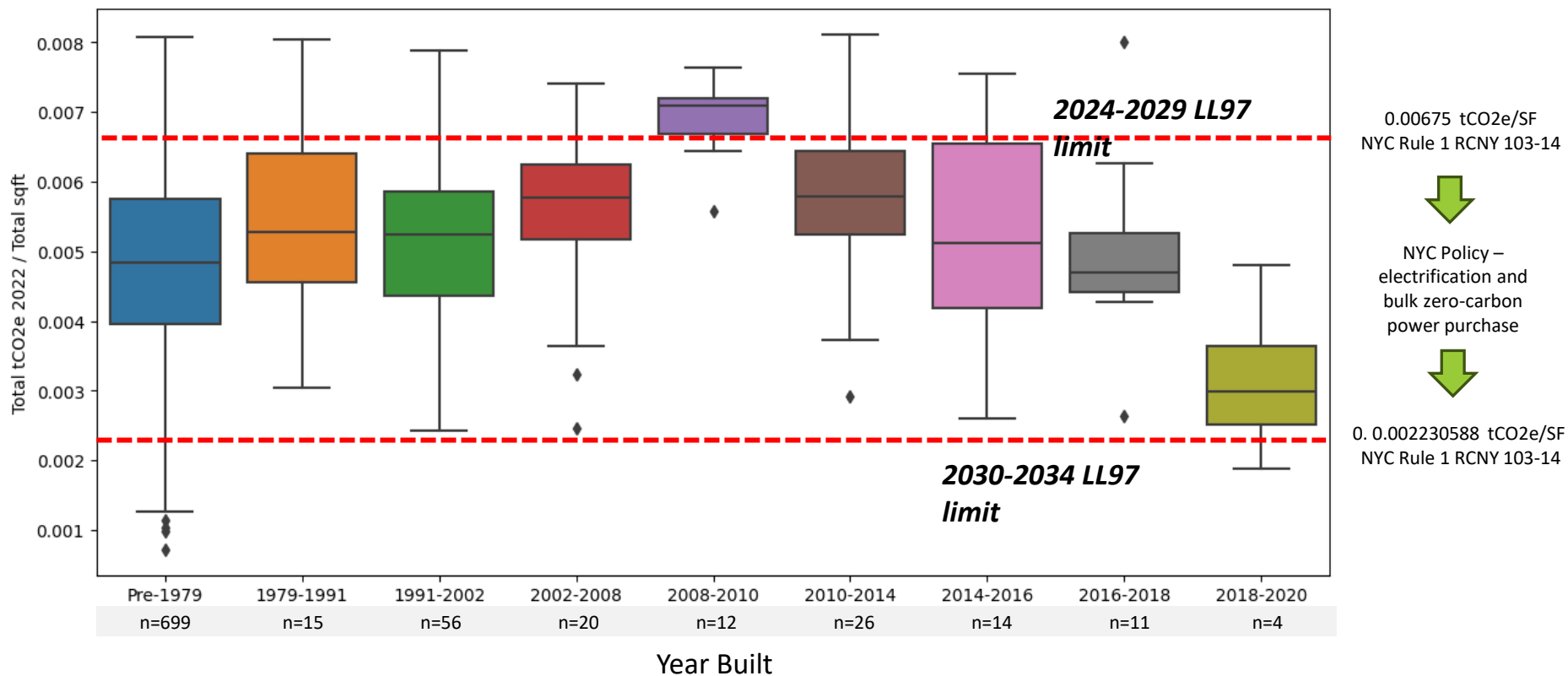
2022 GHG per Sq. Ft. – Multifamily



2019 EUI Distribution by Vintage – K-12



2022 GHG per Sq. Ft. – K-12 Schools



BPS and New Construction Energy Codes

QUESTION: Are new buildings in NYC going to incur fines under the building performance standards enacted in 2019 as part of Local Law 97 (LL97)?

ANALYSIS: Find data on buildings > 25K square feet, permitted between 2015-2020

- Sorted by NYC code compliance and analysis pathways
 - NYC Energy Conservation Code (NYCECC), ASHRAE 90.1
 - Energy Modeling, COMcheck or Tabular Analysis
- Calculated GHG emissions from EPA Portfolio Manager (EPAPM) data for 2022 using same gross square footage based on the top three uses
- Calculated LL97 GHG limits (tCO₂e per square foot) for 2024-2029 and 2030-2034

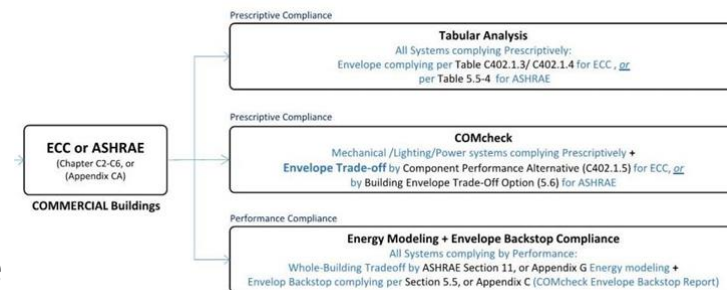
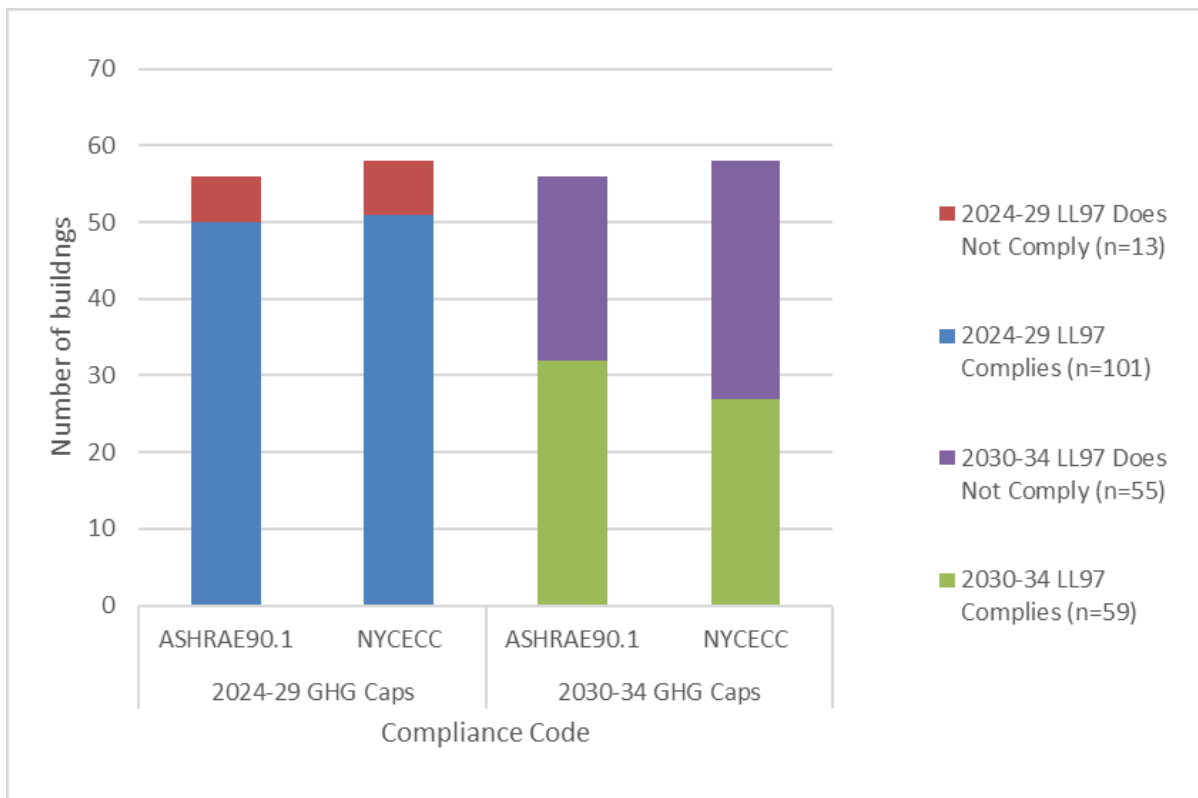


Image from https://www.nyc.gov/assets/buildings/pdf/h2g_all_2020_nycecc.pdf

GHG Compliance by Code Compliance Path

- 1,000+ permits
- Filtered for buildings with 2022 benchmarking data and reliable square footage
- Ended up with 114 buildings
- 5+ years between permitting and first benchmarking
- 90% will comply with 2024-29 caps
- 52% will comply with 2030-34 caps



GHG Compliance by Occupancy Group

**Percentage Compliance
By Occupancy Group**

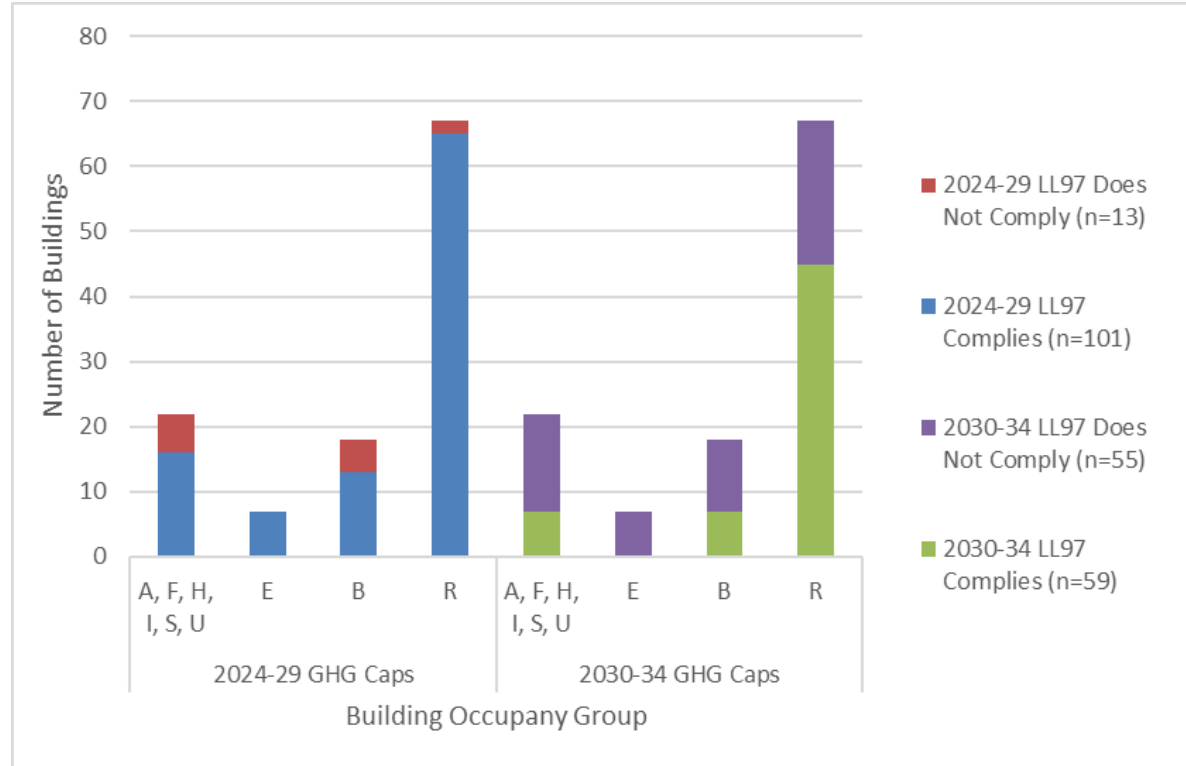
	A, F, H, I, S, U	E	B	R
2030-34 LL97 Compliance	73%	100%	72%	97%
2024-29 LL97 Compliance	32%	0%	39%	67%

A = Assembly
F = Factory and Industrial
H = High Hazard
I = Institutional
S = Storage
U = Utility and Misc

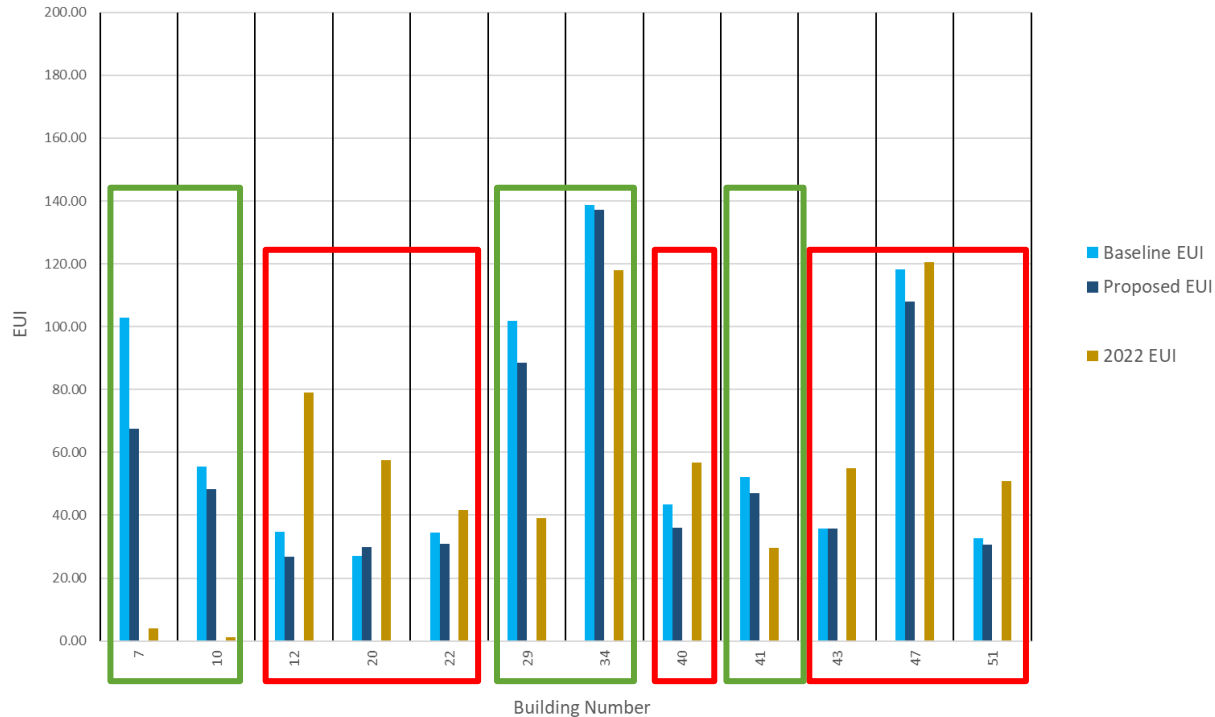
E = Educational

B = Business

R = Residential (multifamily)



Modeled Compliance vs. 2022 EUI



- Not a statistical sample
- Group of buildings that used ASHRAE Appendix G (8760-hour modeling) as compliance path
- Modeled performance does not appear to predict actual EUI
 - In line with industry opinion

Building Performance Standards as a “Code”

- No “inspections”, just energy performance, some translated to emissions
- Simple in concept, may be hard for building owners
- Emissions may change year-over-year
- No indication of plant, system or component that uses the energy

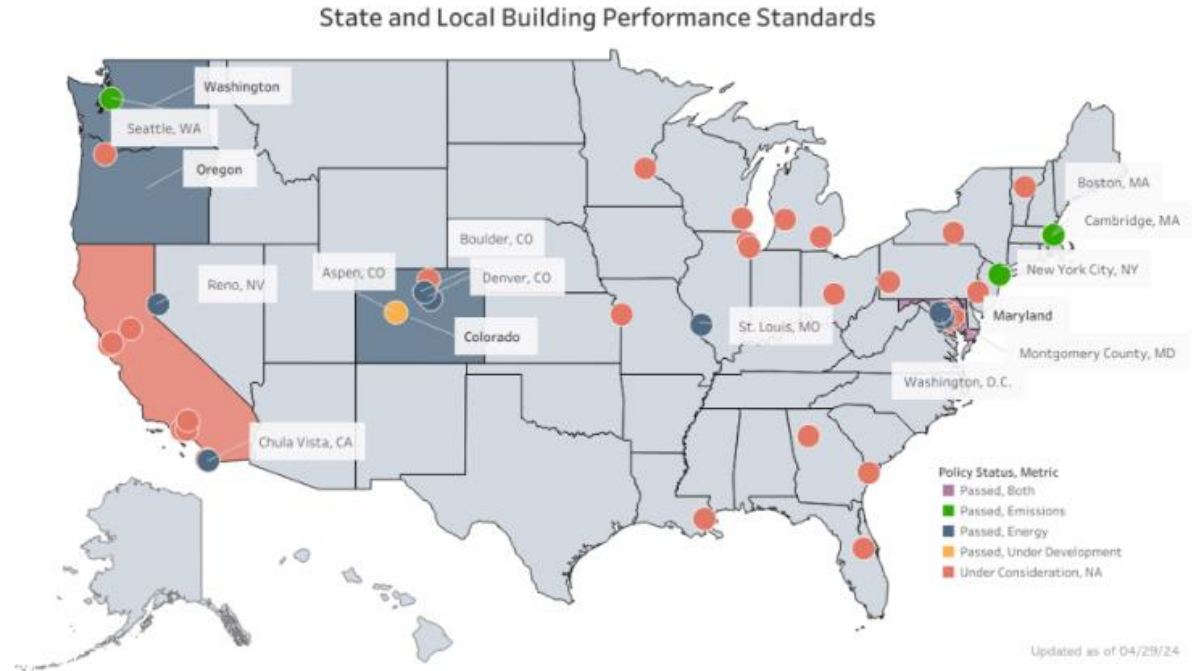
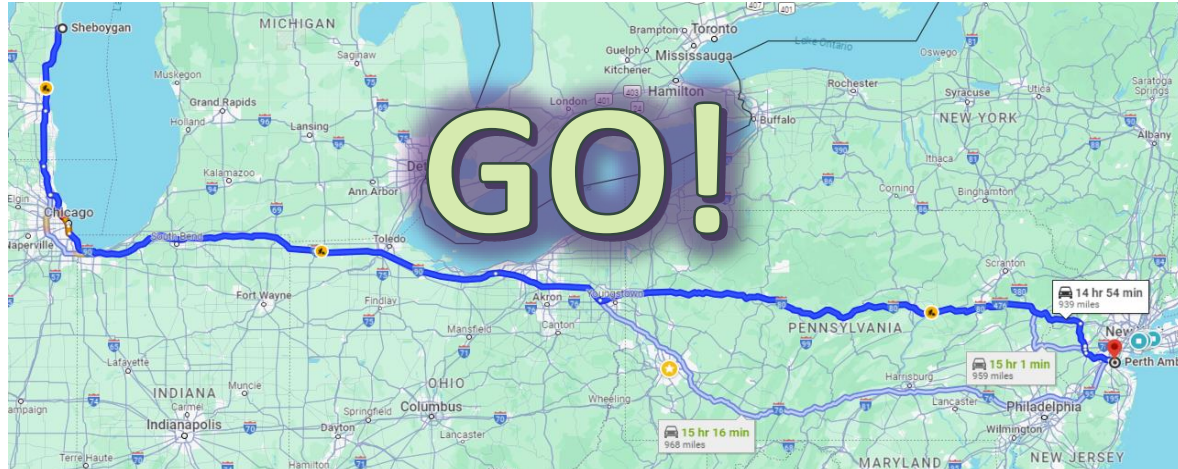


Image from
<https://www.energycodes.gov/BPS>

A Driving Performance Standard

Drive from point A to point B using a fixed amount of fuel

- Sheboygan, MI to Perth Amboy, NJ (~950 miles)
- 2005 Hybrid (~47 MPG)
- Four 5-gallon cans of gas
- Dashboard helpers don't work – no check engine, no energy monitor, no gas gauge, just speedometer and odometer
- Will you make it?



A Building Performance Standard

Run your 237,862 sq. ft. building from Jan 1-Dec 31, keep occupants happy, and use no more than 1,803 tCO₂e/year, or incur a fine

- Your BAS is old and can't trend more than a week
- Your utility sends you a monthly energy bill
- Will you make it?



Use Building Data to Predict Performance

What data exists?

- Monthly utility bills?
- 15-minute interval data from the utility?
- Submetered data?
- Simple trend data from the BAS?
- Detailed trend data from a real-time energy management system?

“Simple” techniques to analyze data

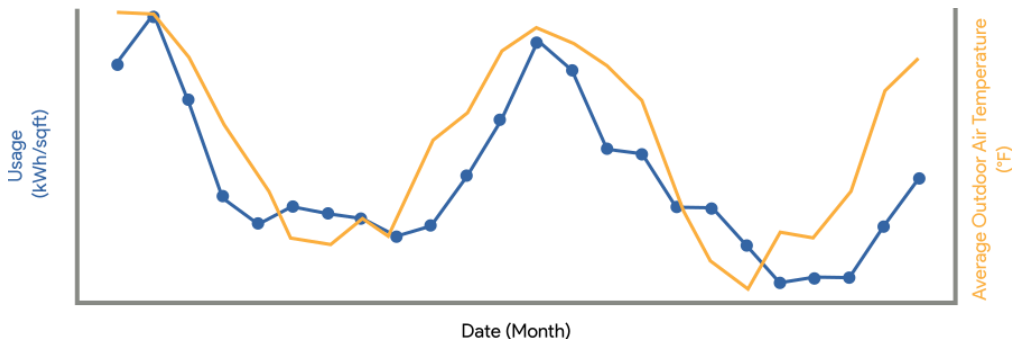
- Linear change-point regression models
- Time-of-day or day-of-week models
- Time-of-week and temperature

Change-point Modeling

Regression model uses monthly energy consumption and monthly average outdoor air temperature

CUNY BPL uses monthly utility bills to generate estimates of baseload, heating, and cooling energy consumption

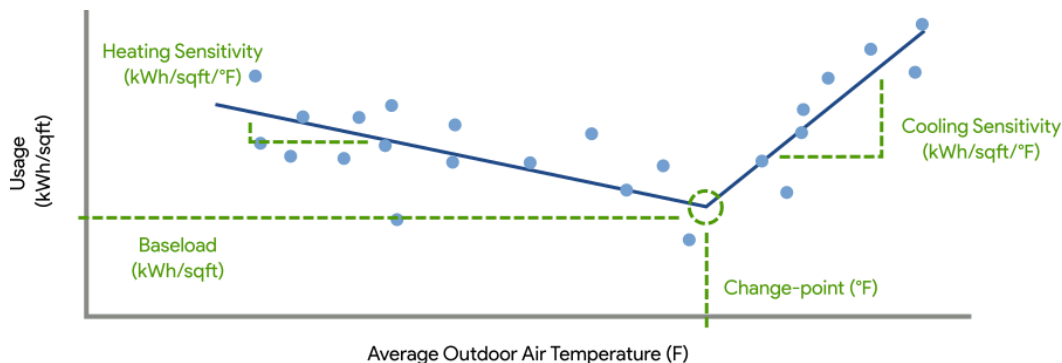
Change-point modeling provides an indicator of the rate of energy consumption for heating and cooling based on outdoor air temperature



From time series...

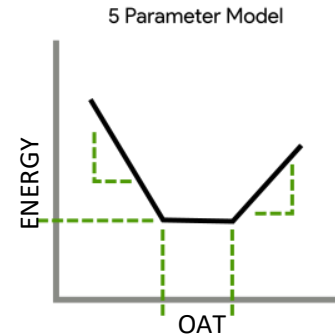
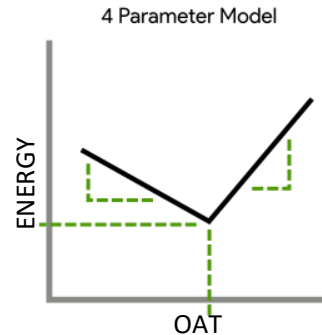
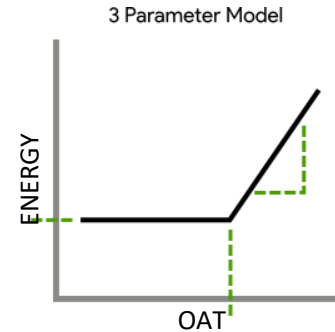
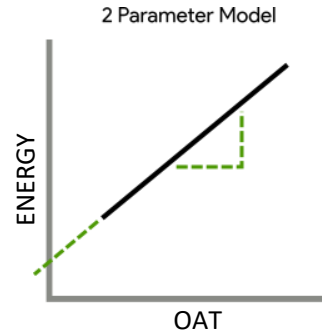


to change-point model



Change-point Model Types

- Model types show how a building uses electricity and/or thermal energy
- May have different model types for the same building per energy type
 - *Example:* building with gas-fired boiler and electric cooling tower with water-source heat pumps
 - 4P electricity model
 - Uses electricity during heating and cooling seasons
 - 3P gas model
 - Uses gas during heating season



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Change-points

- Setpoint temperatures
- Internal heat gain (loads from electric use, solar gain)
- Building envelope efficiency

Identify areas of poor performance
Prioritize audits and energy efficiency projects

- Heat loss / gain through envelope (infiltration)
- Efficiency of heating / cooling system equipment

Heating or Cooling Sensitivity

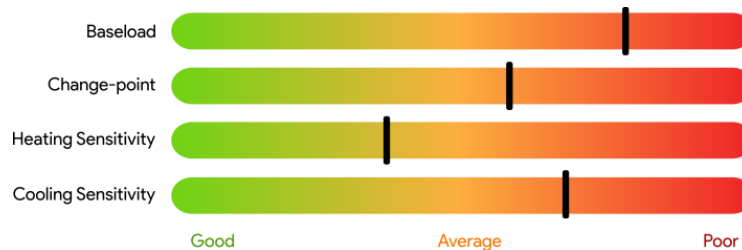
Baseload Electricity

Baseload Fuel

Lean Energy Analysis (LEAN)

- Used to compare building performance across change-point model parameters

- Baseload
- Change-points (cooling / heating)
- Cooling sensitivity
- Heating sensitivity



- Buildings are segmented into peer groups by use type (typically, EPAPM primary function)
- Regression coefficient values for each parameter are split into quartiles to rank good, average, and poor performers for each use type

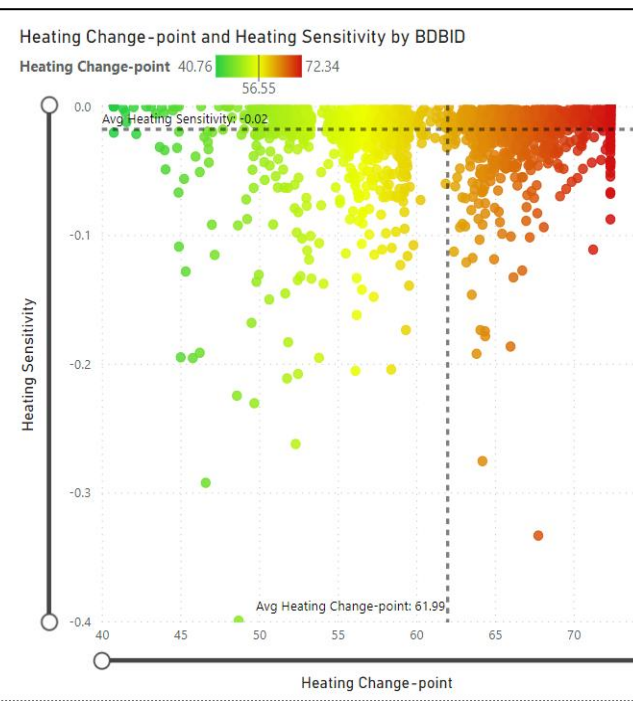
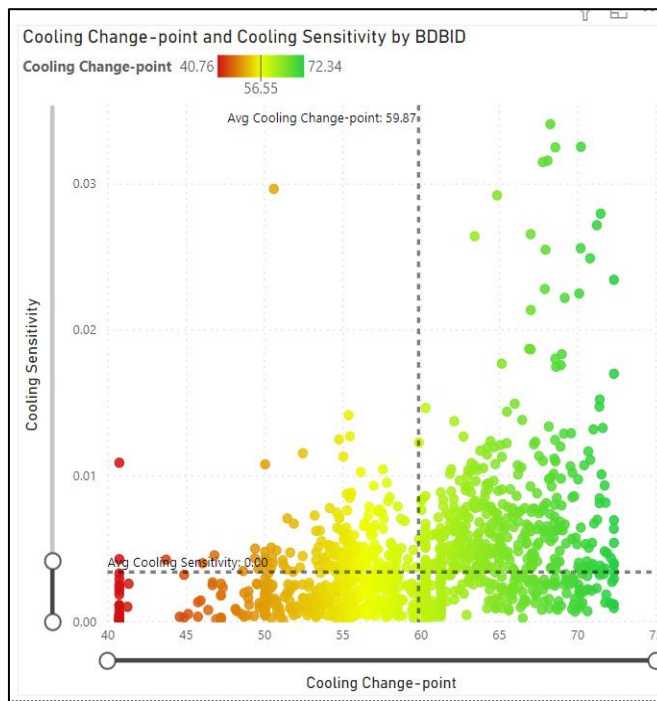
LEAN Segmentation

- Rankings can be used to segment buildings by desired attributes
- Attributes can be combined to target buildings for audits or specified types of efficiency projects (e.g., electrification, envelope, Building Re-tuning)

Use Type	Year Built	Sq Ft	EER Filed for Previous Audits	LL87 Target Sq Ft	Sq Ft > 25,000	Has Fuel Oil	EUI Percentile > 75%	GHG Percentile > 75%	2+ Electricity Coefficient Percentiles > 75%	2+ Fuel Coefficient Percentiles > 75%	Possible Simultaneous Heating/Cooling
Veterinary Office	2019	5,000		False	False		True	True			
Urgent Care-Clinic-Other Outpatient	2016	15,000		False	False		True	True			True
Race Track	2016	12,600		False	False		True	True			
Prison-Incarceration	1993	128,914		True	True	True	True	True		True	
Other - Recreation	1939	2,500		False	False		True	True			
Vocational School	2012	750,000		True	True		True	True			True
Other - Entertainment-Public Assembly	1930	13,063		False	False		True	True	True		True
College-University	1907	3,145,589		True	True	True	True	True	True		
Personal Services Health-Beauty Dry Cleaning etc	1970	19,350		False	False	True	True	True			
Food Service	1970	111,450		True	True	True	True	True			
Enclosed Mall	1950	30,000		False	True		True	True			
K-12 School	1992	21,600		False	False		True	True			
Office	1900	3,200		False	False		True	True	True		
Food Sales	1941	15,000		False	False		True	True	True	True	True
Distribution Center	1954	200,000		True	True		True	True		True	
Library	1958	15,700		False	False		True	True			
Performing Arts	1854	61,420		True	True		True	True		True	
Police Station	1925	2,350		False	False		True	True			
Outpatient Rehabilitation-Physical Therapy	2004	8,560		False	False		True	True			
Medical Office	1920	10,900		False	False		True	True	True	True	
Fire Station	1907	4,500		False	False		True	True			
Fire Station	1896	5,278		False	False		True	True			True
Fire Station	1925	2,425		False	False		False	True	True		
Museum	1730	4,500		False	False		True	True			

LEAN Quad Charts

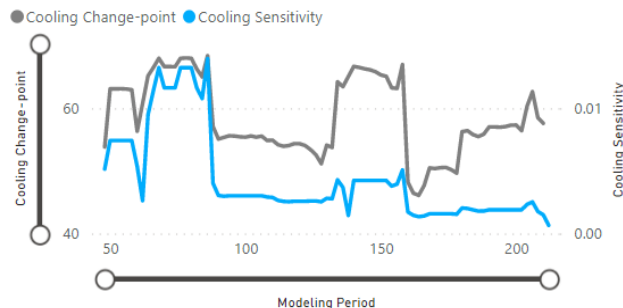
- Regression coefficients can also be segmented visually
- *Example:*
 - Cooling change-point vs. cooling sensitivity – worst performers have low change-points and high sensitivity
 - Identifies buildings where cooling energy starts at lower temperatures and rate of consumption is high



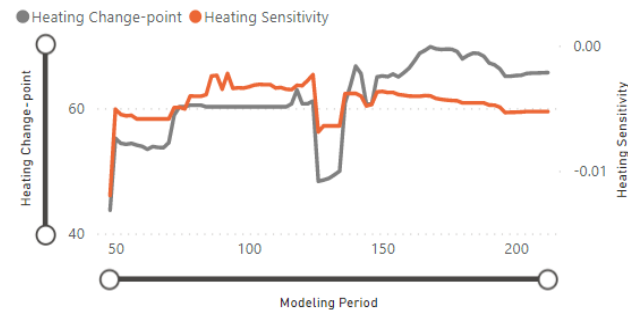
Track Performance Over Time

- Each data point represents 12 months; successive points slide period forward by one month (e.g., Jan-Dec., Feb-Jan, Mar-Feb)
- Can reveal trends that cannot be seen in a single year of data
- Easy to see when performance degradation occurs
- Monitor persistence of savings, emissions reductions

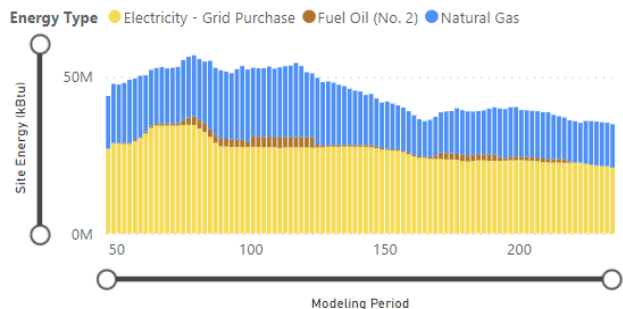
Rolling Cooling Change-point and Sensitivity



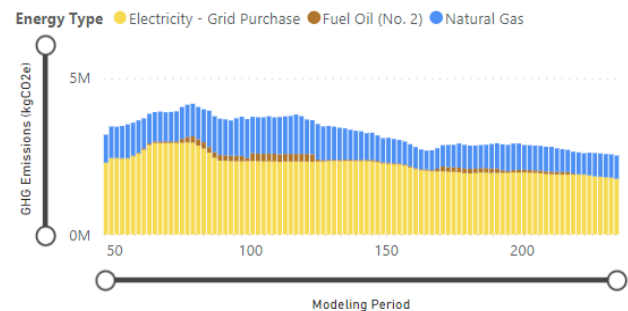
Rolling Heating Change-point and Sensitivity



Rolling Site Energy by Energy Type



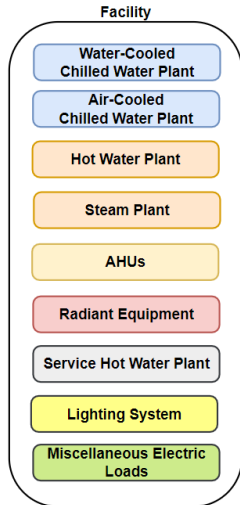
Rolling GHG Emissions (kgCO2e) by Energy Type



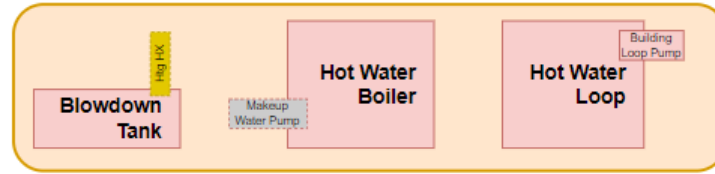
Energy Analysis by End-Use

What is the contribution of particular plants, systems or components to overall building energy consumption and GHG emissions?

- CUNY BPL developed a "Stretch Standard of Care for Building Automation Systems"
- Breaks down end-uses into plants, systems and components
- Uses tags compatible with Project Haystack



Hot Water Plant



BUILDING *performance* LAB

Plant	System	Energy-consuming Component	Data point	Direct or Proxy Measurement	Project Haystack Tags			
					Plant	System	Energy-consuming Component	Data Point
Hot water heating plant	Hot water boiler	Burner: Fuel measured by utility meter or dedicated meter connected to the BAS	Daily average fuel usage (Btuh) for utility-metered fuel (e.g., natural gas) or delivered fuel (e.g., fuel oil, propane)	Daily meter reading	id, dis, equip, hot, water, hvac, plant, siteRef	id, boiler, dis, equip, hvac, equipRef, hotWaterRef, siteRef	N/A	Natural Gas Flow: id, cur, sensor, his, point, dateTime, tz, kind, unit, dis, naturalGas, flow, equipRef, siteRef

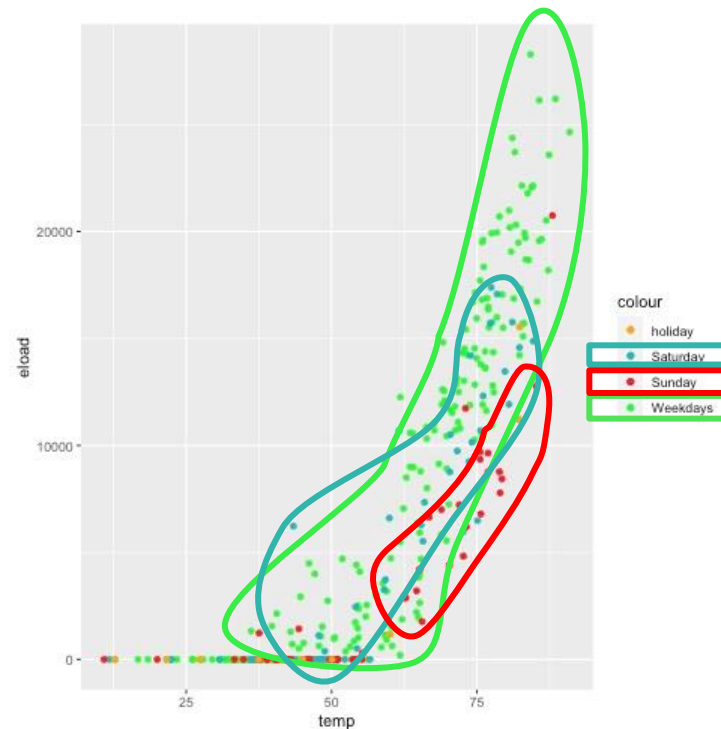
Energy Analysis by End-Use

Collected data from real-time energy management (RTEM) systems installed in NYC and NYS under the NYSEDA RTEM program

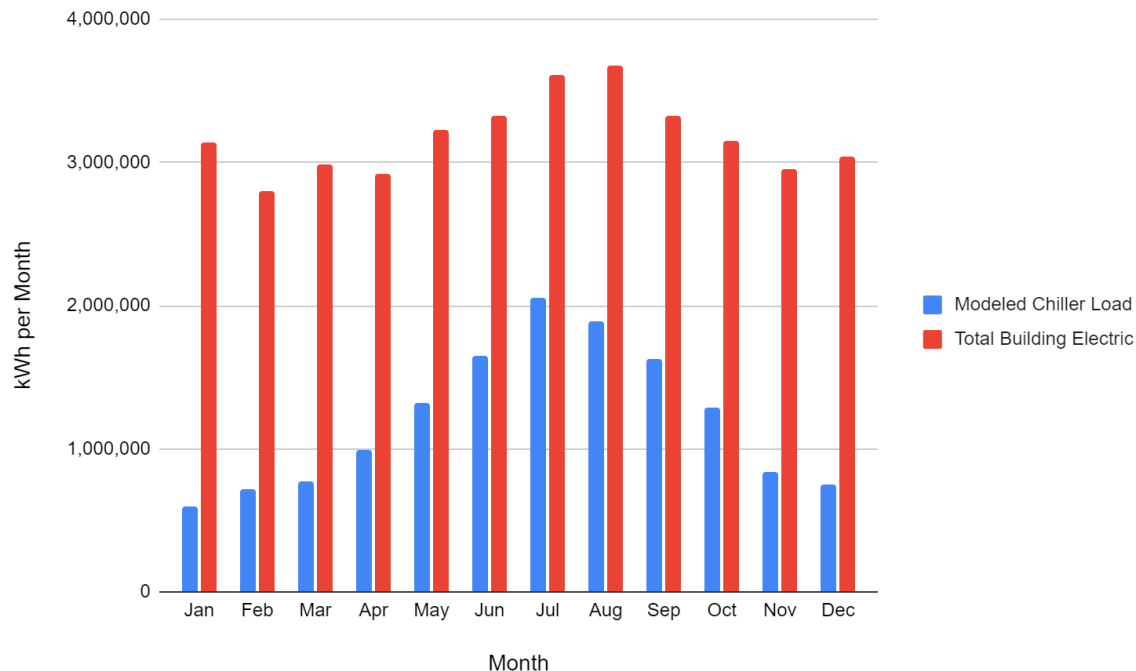
<https://www.nyserda.ny.gov/All-Programs/Real-Time-Energy-Management>

- Compared contribution of measured plant, system or component to whole building energy consumption
- Evaluated various regression approaches
 - Linear change-point regressions
 - Time-of-week and temperature

R package by kW labs (<https://github.com/kW-Labs/nmocr>)



Chiller End-Use – Office Building (2018)



Lessons Learned

- **Clear Definitions**

- Square footage, annual usage, annual emissions
- Legislative language vs. implementable rules

- **Consider a Chief Data Officer**

- Complicated analysis and calculations are critical – square footage, emissions by use type, emissions by energy type, regional coefficients, time-of-use
- Need broad coordination of data – permits, energy, square footage, other agency data

- **Consider Platforms that Serve All Stakeholders**

- A one-way data flow (owner to code enforcement) limits value of data
- Data can be very valuable to policymakers, owners, consultants, A&E firms, contractors, researchers (others?)

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Questions?