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

AIA Approved Continuing Education

ICC PREFERRED EDUCATION PROVIDER

RESNET® RESIDENTIAL ENERGY SERVICES NETWORK

AIA and ICC Continuing Education Provider

Continuing Education Credits Earned on Completion of this Live Session:

- 1.5 LUs will be reported to AIA CES for AIA members.
- 0.15 ICC CEUs for ICC members must self-report to ICC with the Certificate of Completion.
- Certificates of Completion for self-reporting to your professional organization for non-AIA and non-ICC members are available upon request.

- This course is registered with AIA CES and ICC PP for continuing professional education. As such, it does not include content that may be deemed or construed to be an approval or endorsement by the AIA or ICC of any material of construction or any method or manner of handling, using, distributing, or dealing in any material or product.

AIA Approved Continuing Education

ICC PREFERRED EDUCATION PROVIDER

RESNET RESIDENTIAL ENERGY SERVICES NETWORK

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.

AIA Approved Continuing Education

ICC PREFERRED EDUCATION PROVIDER

RESNET RESIDENTIAL ENERGY SERVICES NETWORK

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.

AIA Approved Continuing Education

ICC PREFERRED EDUCATION PROVIDER

RESNET RESIDENTIAL ENERGY SERVICES NETWORK

Speakers

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

Eric Engelman – Policy Studio

Rob Salcido – Pacific Northwest National Laboratory (PNNL)

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

POLICY STUDIO

Digital Tools to Accelerate Decarbonization

California and Beyond: Tool for Accelerating Code Adoption

Eric Engelman | Founder & Managing Director | Policy Studio

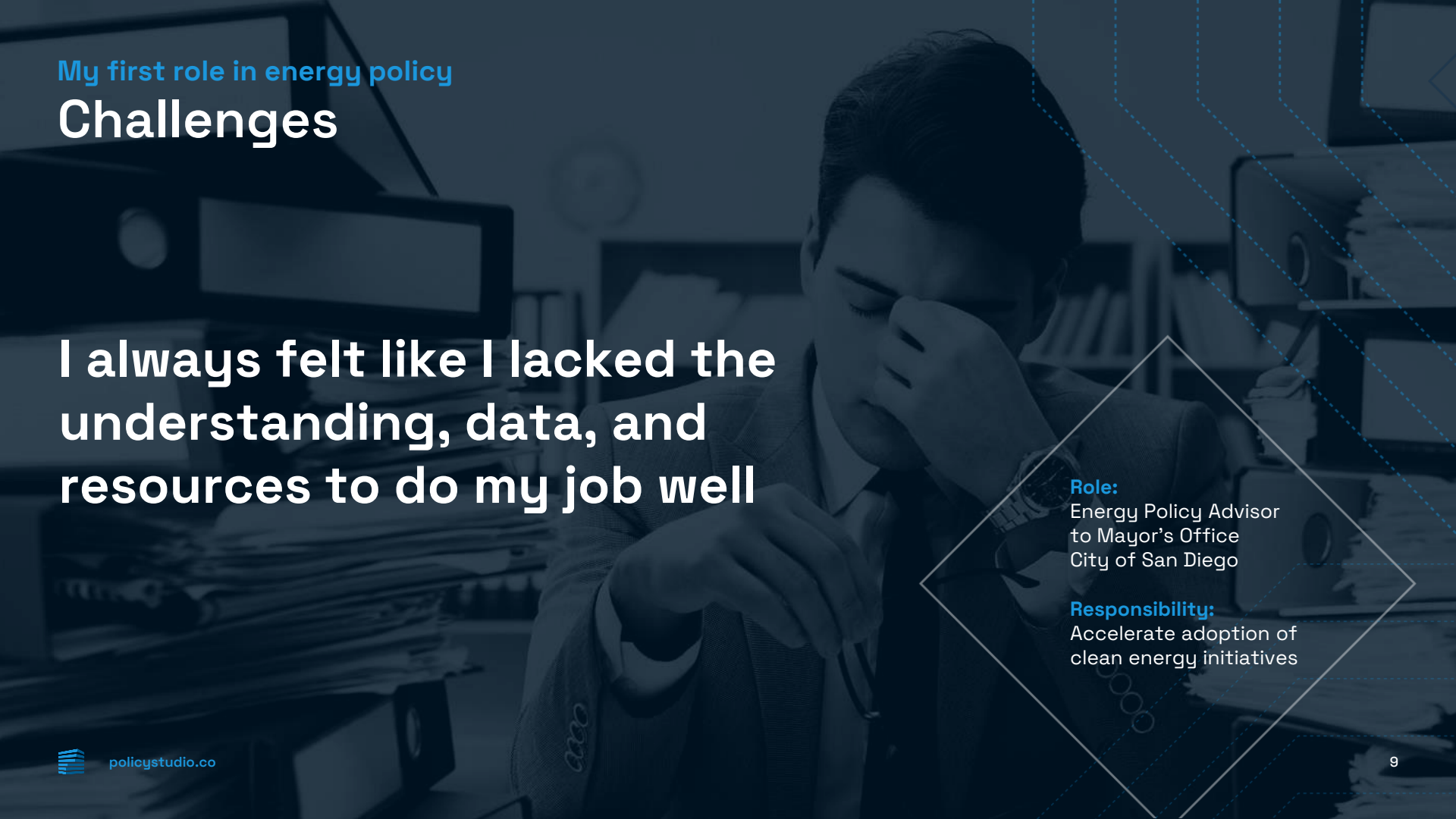
Overview

- 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

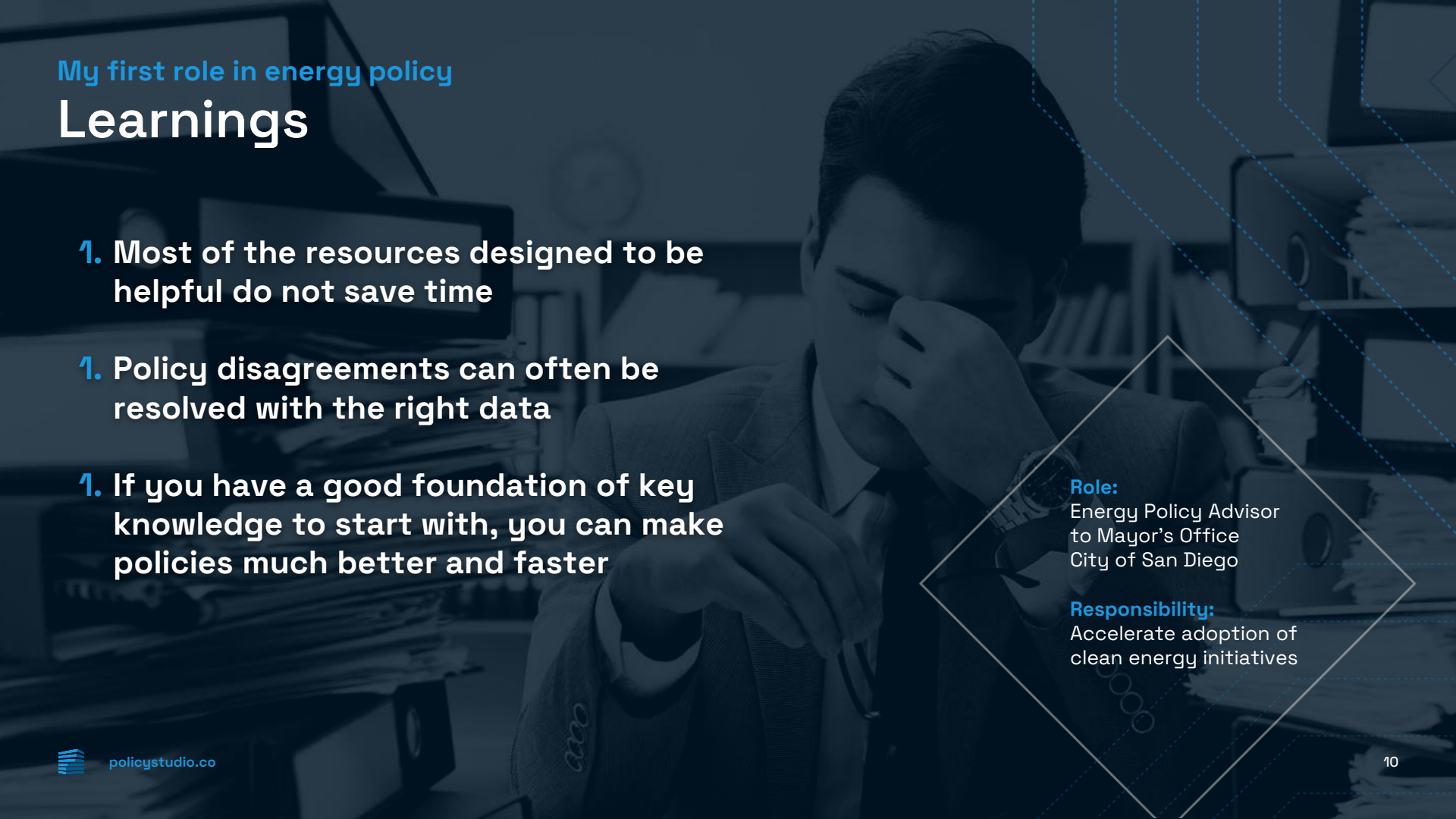
My first role in energy policy

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



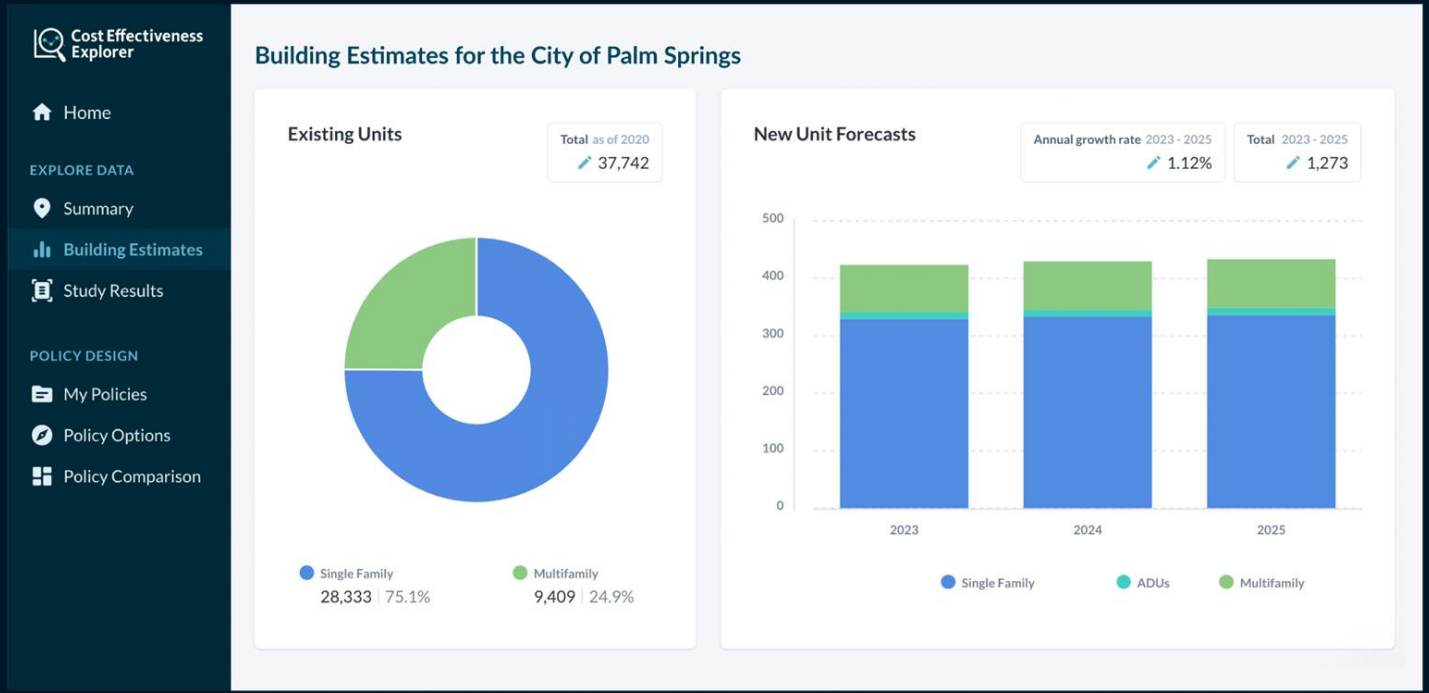
Role:
Energy Policy Advisor
to Mayor's Office
City of San Diego

Responsibility:
Accelerate adoption of
clean energy initiatives

Since my first role in energy policy

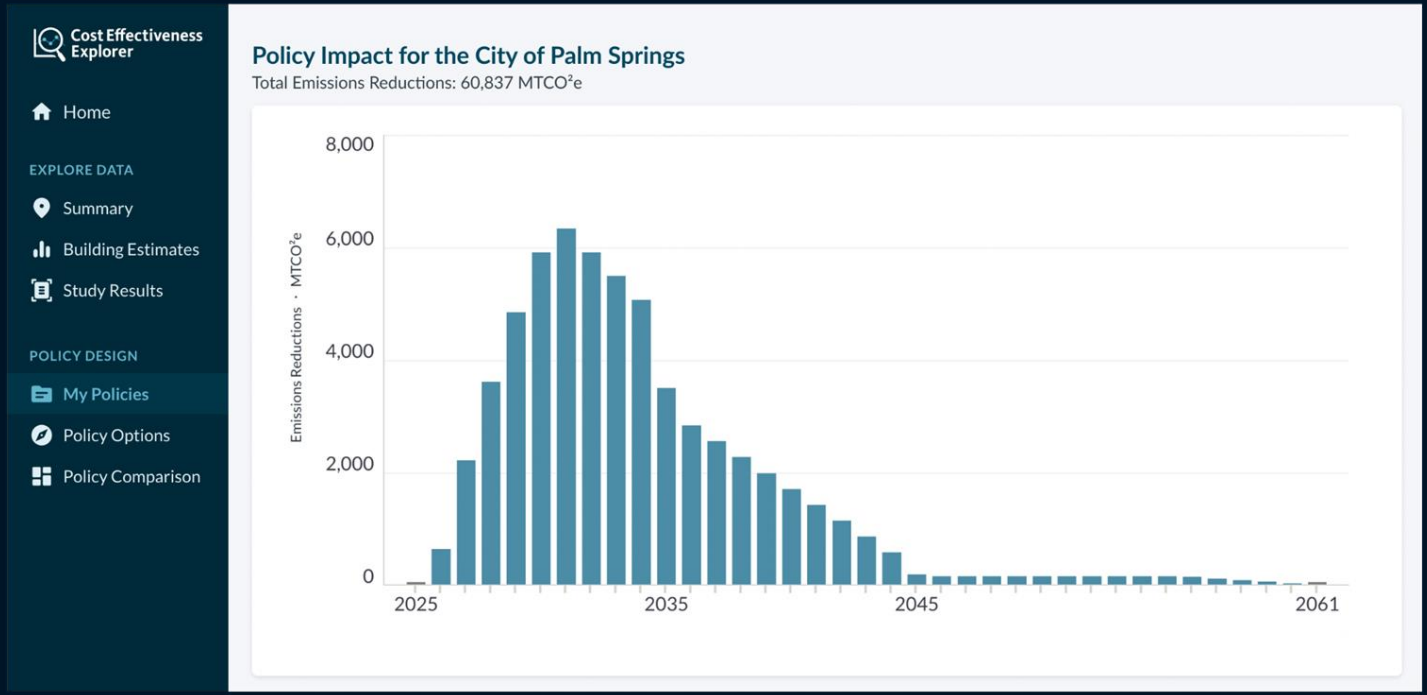
What we built

Building Estimates



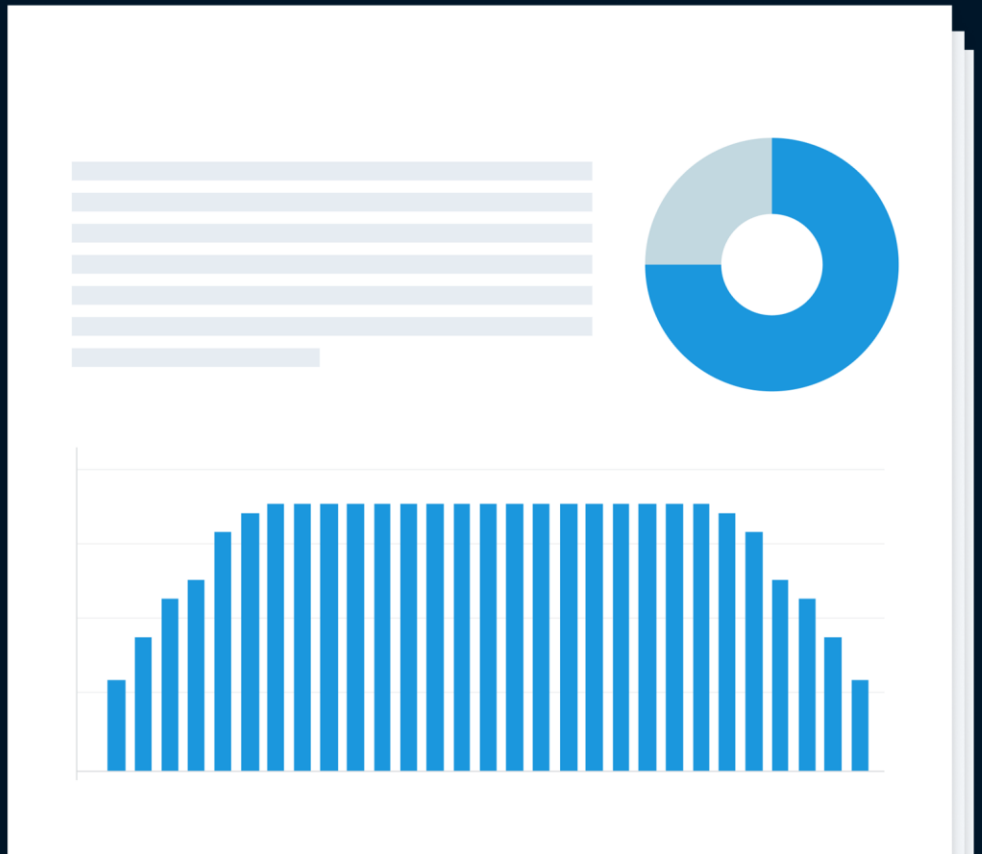
What we built

Policy Impacts



What we built

Policy Documents



Cost-Effectiveness Explorer

Launched in 2021

Free for all cities and counties

Provides customized data for each jurisdiction

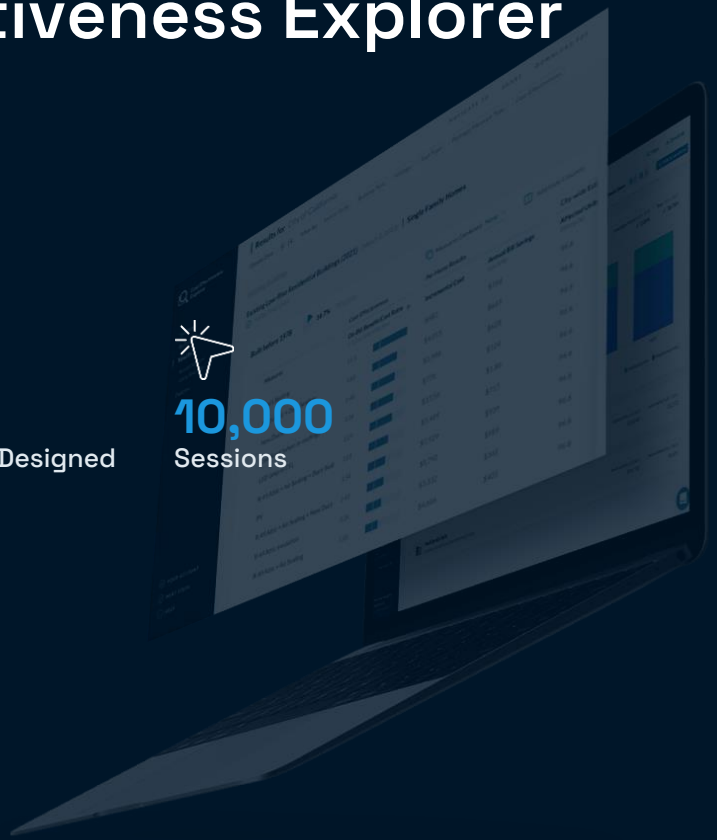
Supports learning

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

Beyond CA

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

Beyond CA

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

Beyond CA

What will it take to make it happen?

Collaboration and Partnerships

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

Funding

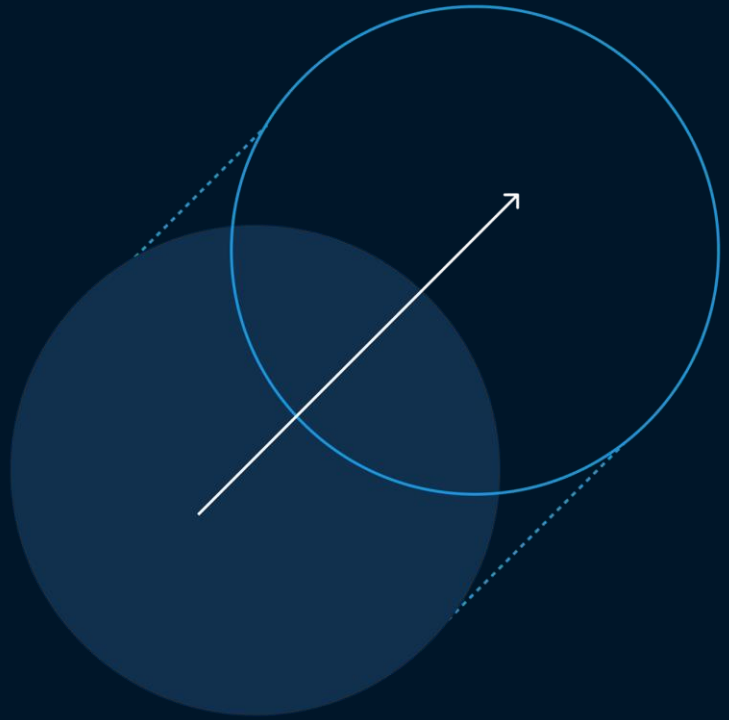
-Development costs
-Ongoing maintenance costs

POLICY STUDIO

Digital Tools
to Accelerate
Decarbonization

Thank you

eric@policystudio.co
818.917.3425



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

Pacific Northwest NATIONAL LABORATORY

RES*check* and COM*check* Updates

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

May 7, 2024

V. Robert Salcido
Senior Engineer

U.S. DEPARTMENT OF ENERGY BATTELLE

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 & COM*check* Energy Codes

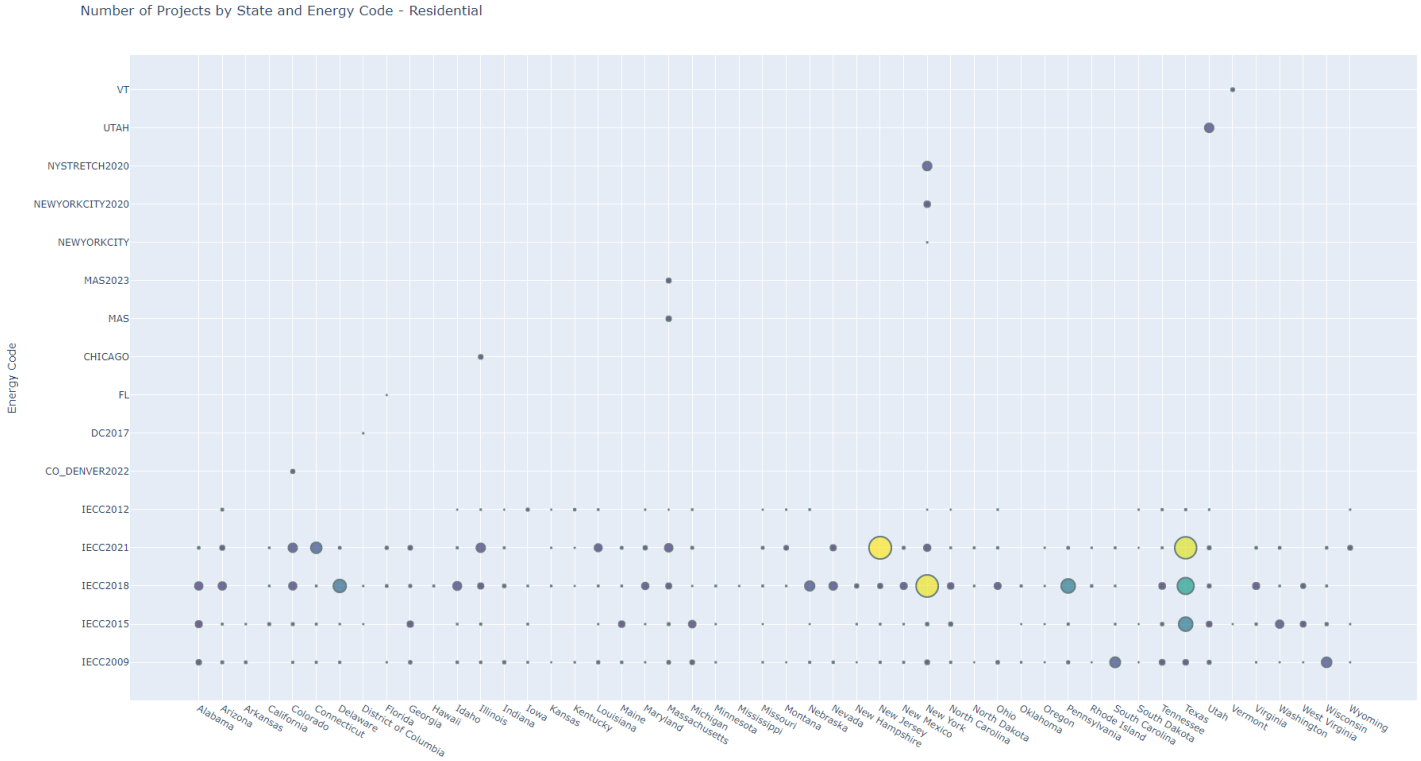
- **National, state and local energy codes (approved by DOE)**
  - ✓ **ASHRAE 90.1 Standard editions** 2007/2010/2013/2016/2019/2022
  - ✓ **IECC editions** 2006/2009/2012/2015/2021/ 2024 in 2024
  - ✓ **Local Jurisdictions** - Boulder, Washington DC, Denver, Chicago, New York, Ontario
  - ✓ **State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



REScheck March 2024

11,360 New Residential Projects

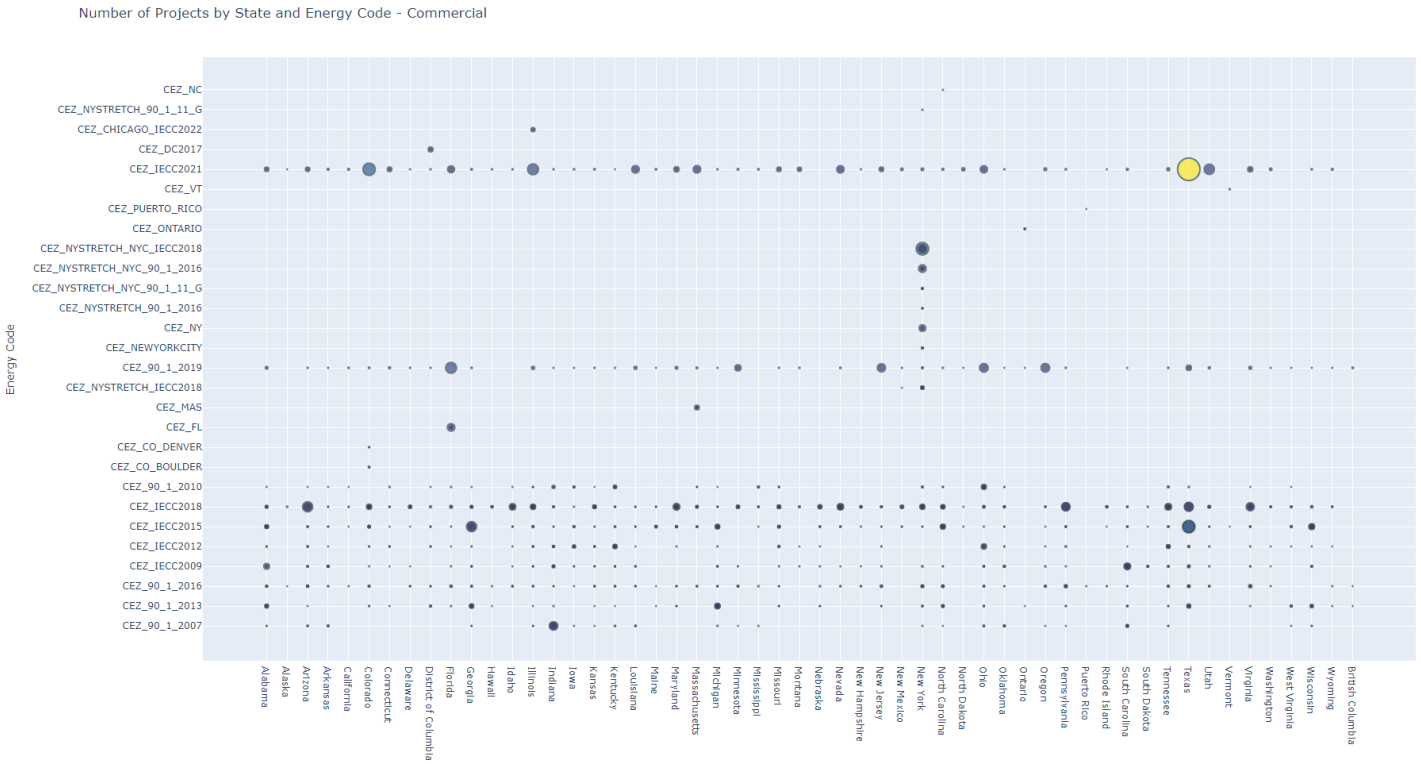
16 Energy Codes

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

Annual New Projects

124,316 New

COMcheck Activity



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

2024 COM*check* / RES*check*

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 COM*check* / RES*check*

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 COM*check* / RES*check*

2024 Status of REScheck and COMcheck enhancements

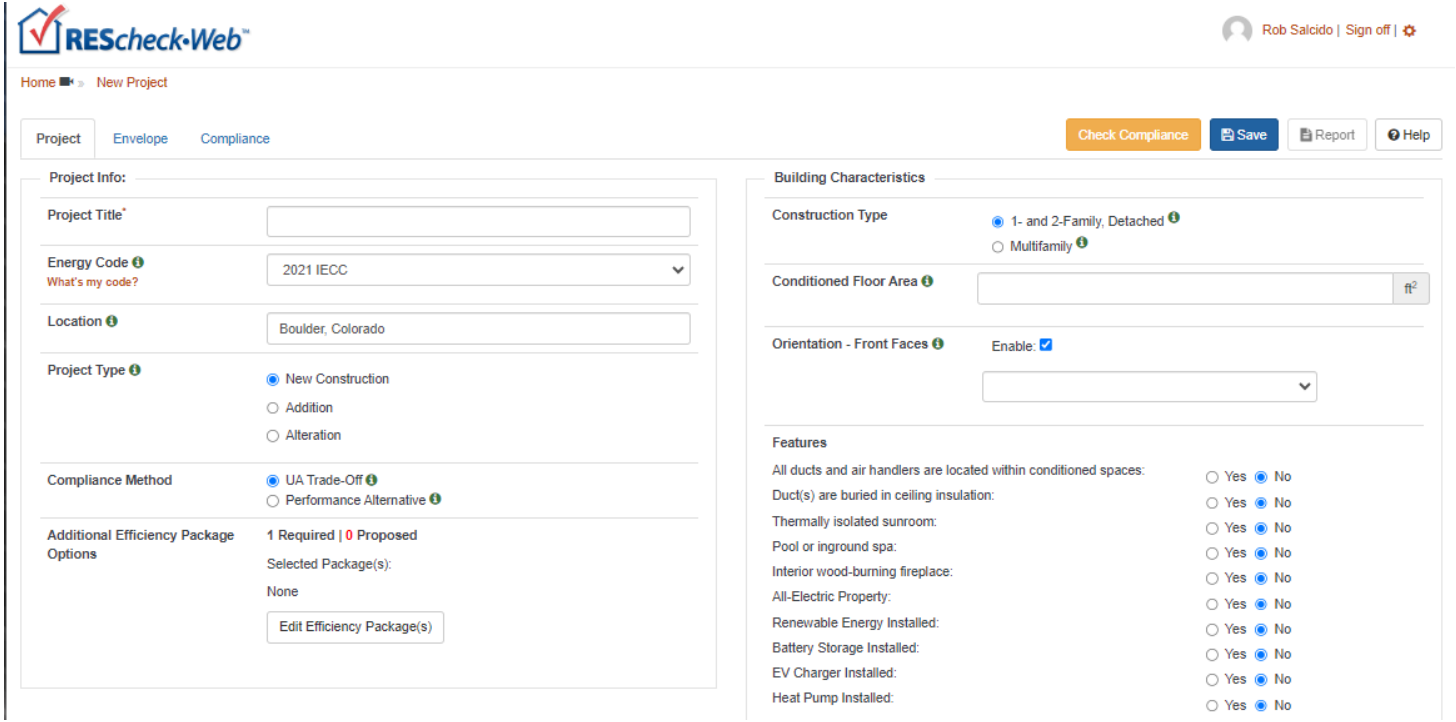
- Overhaul of COMcheck UI/UX - Completed
- Advanced Reporting – REScheck and COMcheck - Completed
- Data Exchange – lighting data import templates added to COMcheck – Completed
- Lighting Fixture Schedule – Completed
- Mobile Support – digital inspection checklist for REScheck and COMcheck (iOS and Android) – 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 RES*check* 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



2024 COM*check* Updates

Energy Code/Standard implementation

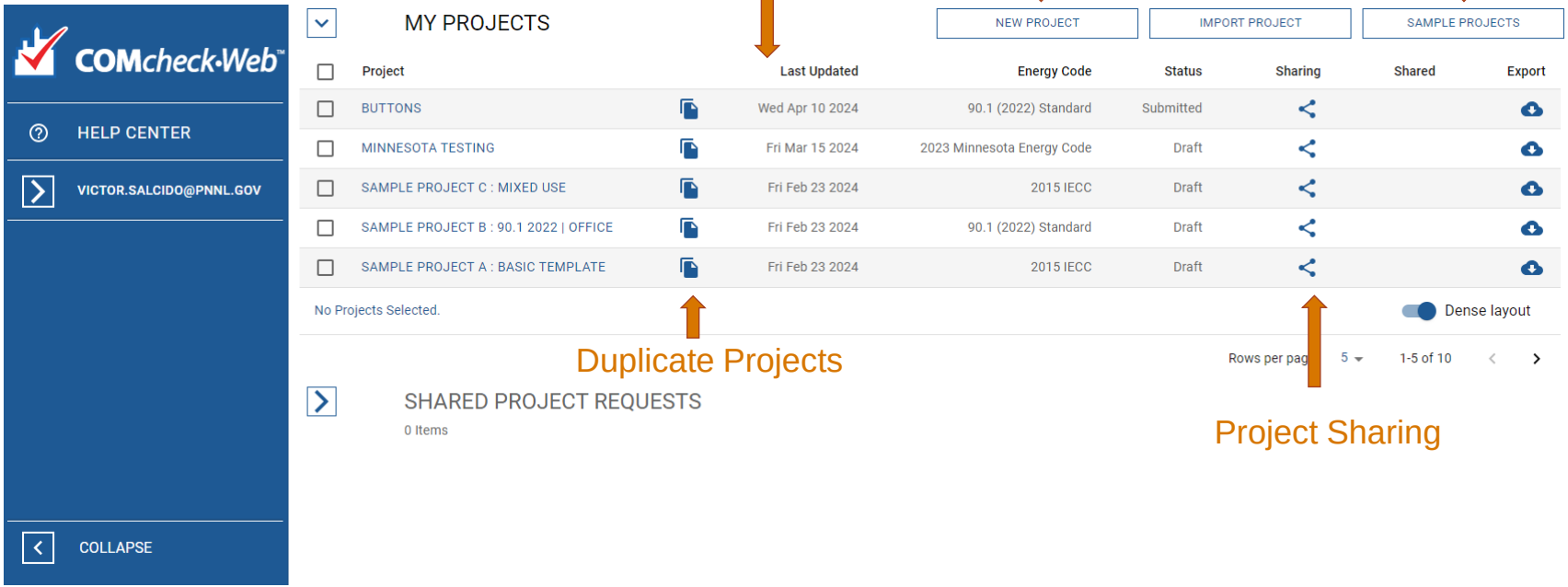
- Energy codes implemented
  - ✓ ASHRAE 90.1-2022
  - ✓ 2024 Minnesota Energy Code
  - ✓ 2022 Denver Energy Code – May 2024
  - ✓ 2023 Massachusetts Stretch Energy Code – May 2024
- New platform
- Project sharing
- Advanced reporting
- Data entry wizards
- Data imports for fixture schedule
- Improved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

COMcheck Project Dashboard

Start a sample project

Sorting

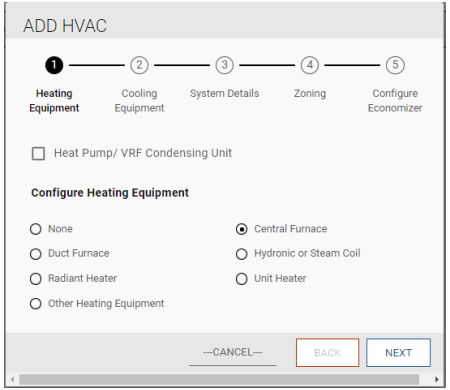
Start a new project

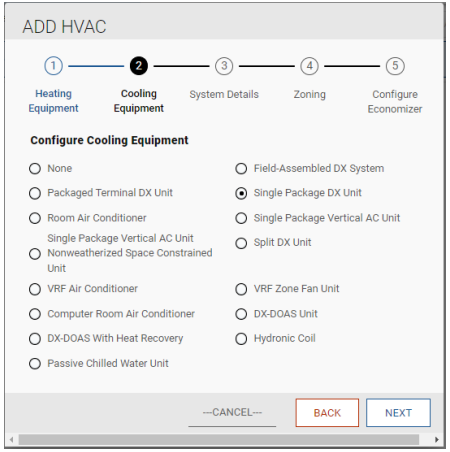


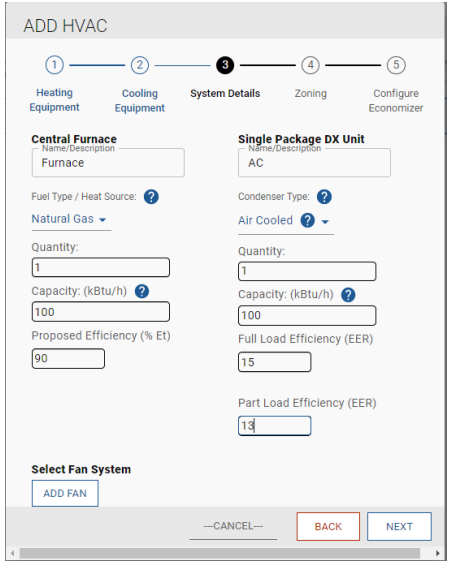
Duplicate Projects

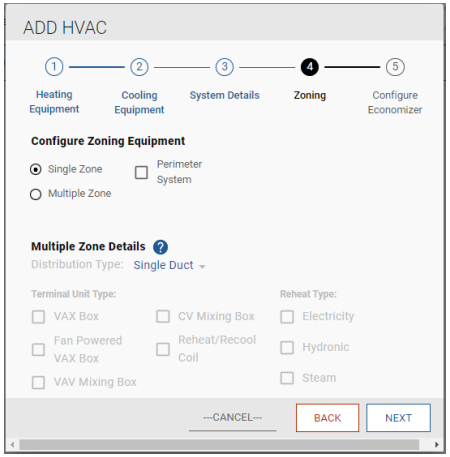
Project Sharing

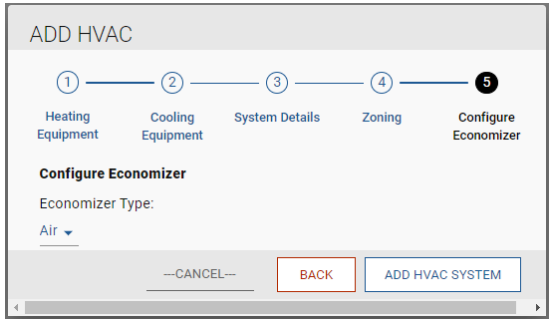
COMcheck Wizard Approach for Mechanica





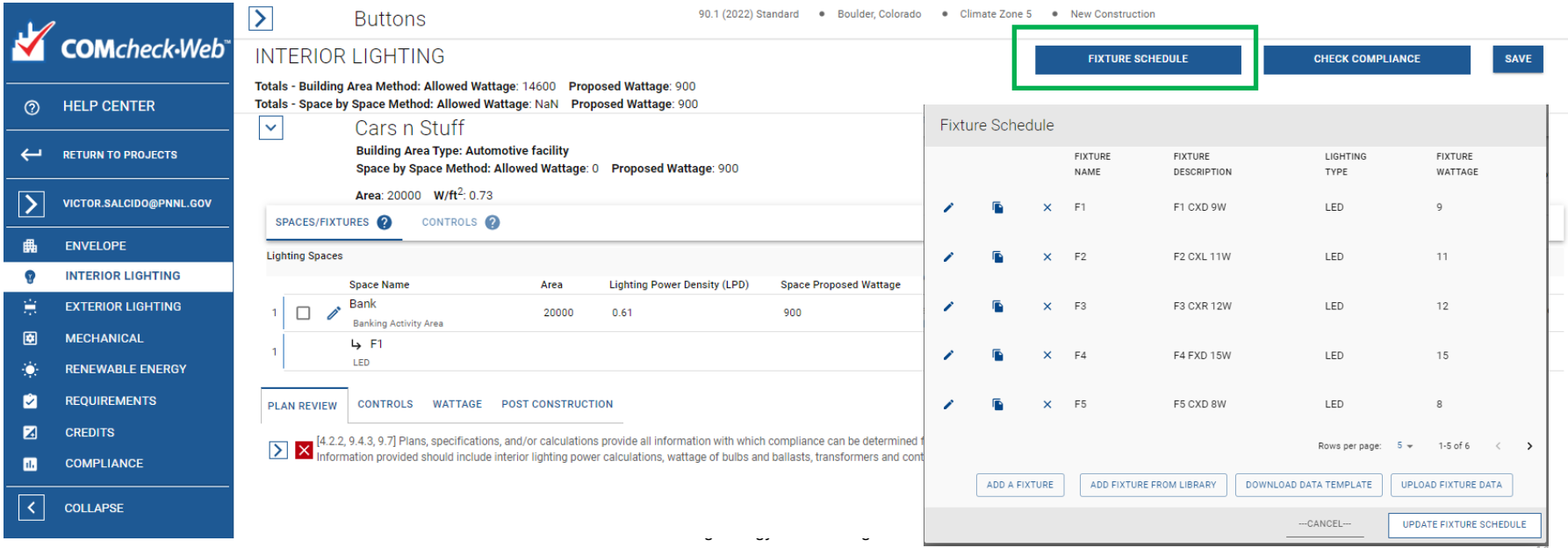






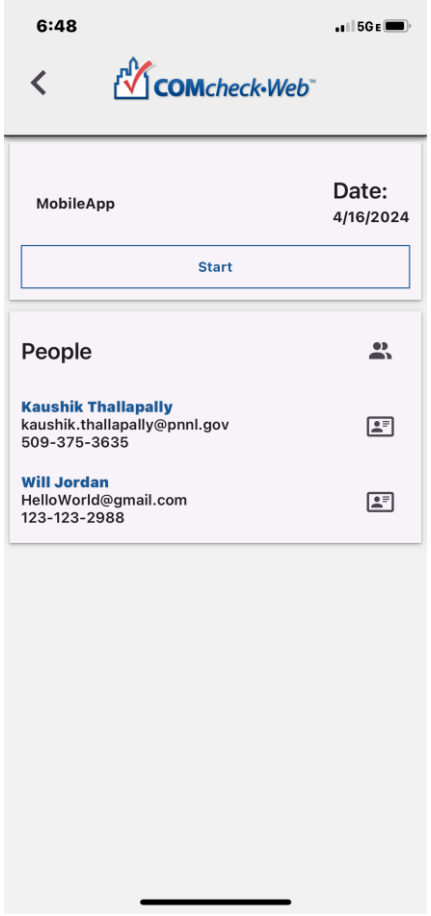
COMcheck Interior Lighting: Add Fixture Schedule

- COM*check* lighting dashboard highlights building areas, spaces, fixtures, wattages and controls

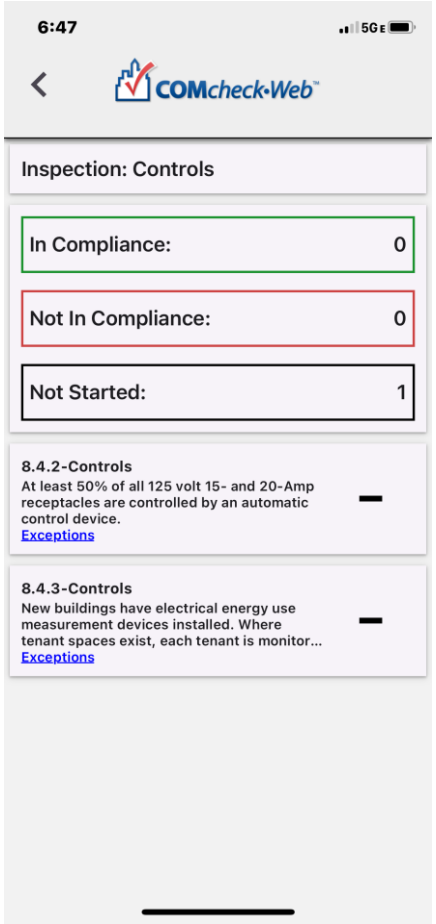


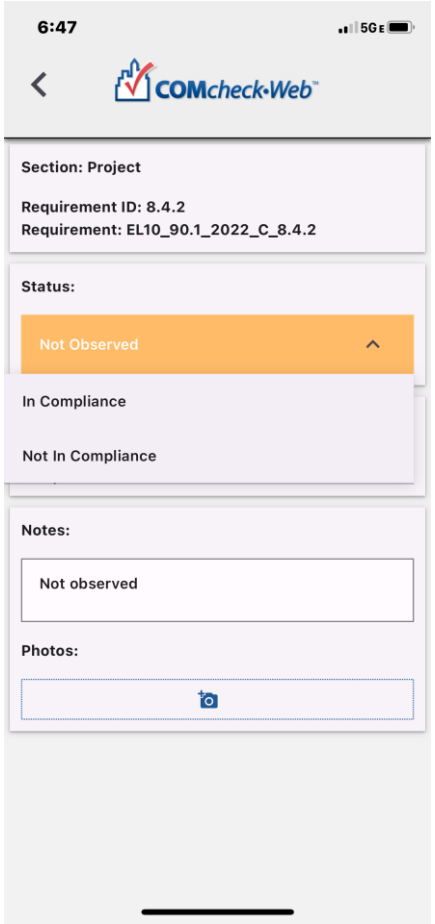
Mobile App


6:44
5G E
COMcheck•Web™
REScheck•Web™
COMcheckWeb
REScheckWeb


6:48
5G E
COMcheck•Web™
MobileApp
Date:
4/16/2024
Start
People
Kaushik Thallapally
kaushik.thallapally@pnnl.gov
509-375-3635
Will Jordan
HelloWorld@gmail.com
123-123-2988

Mobile App


6:47
5GE
COMcheck-Web
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

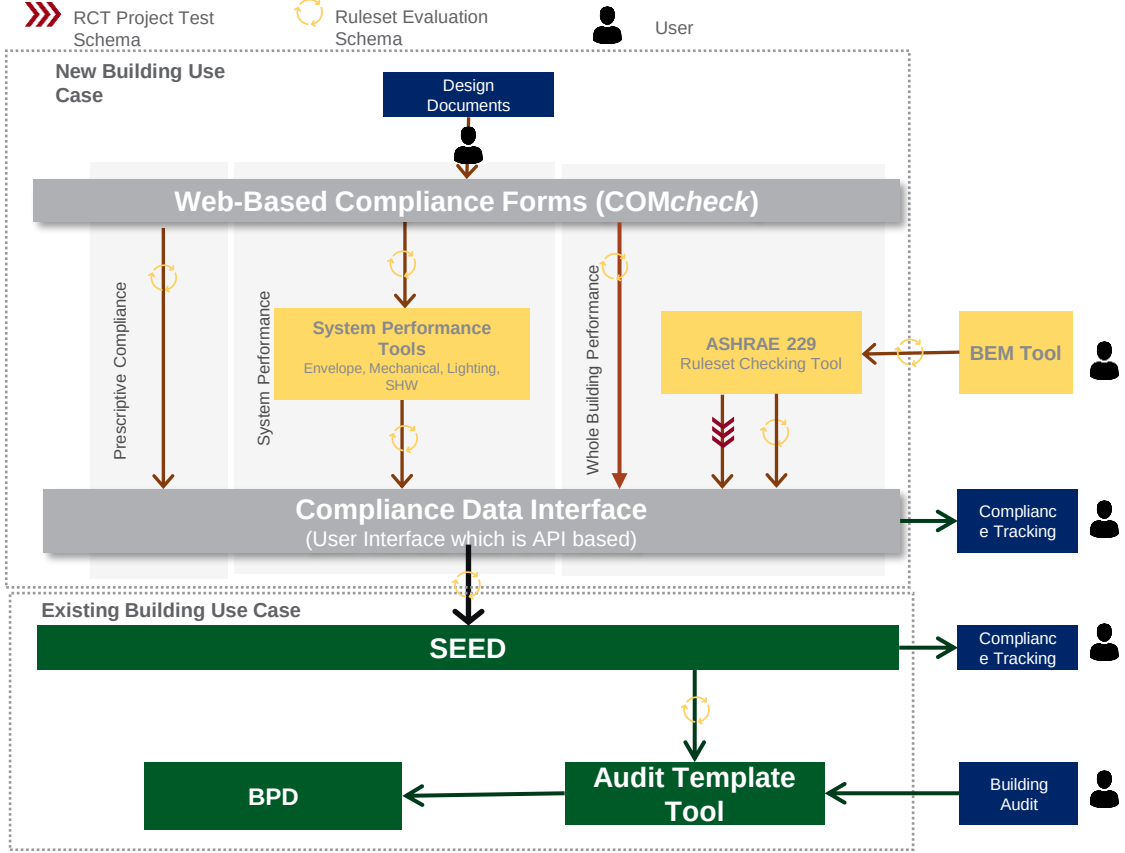

6:47
5GE
COMcheck-Web
Section: Project
Requirement ID: 8.4.2
Requirement: EL10_90.1_2022_C_8.4.2
Status:
Not Observed
In Compliance
Not In Compliance
Notes:
Not observed
Photos:

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

Pacific Northwest
NATIONAL LABORATORY

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?

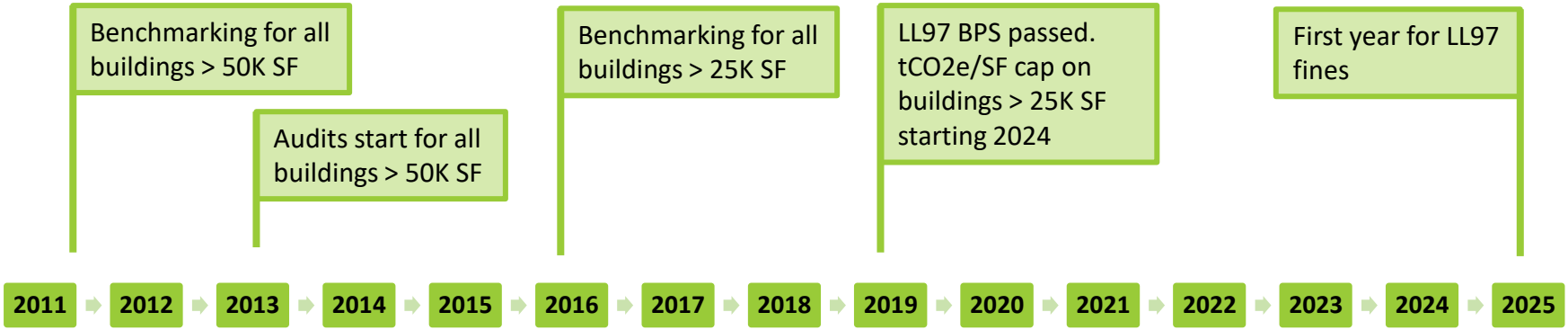
Acknowledgments and Caveats

- 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 Tavarez, 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.

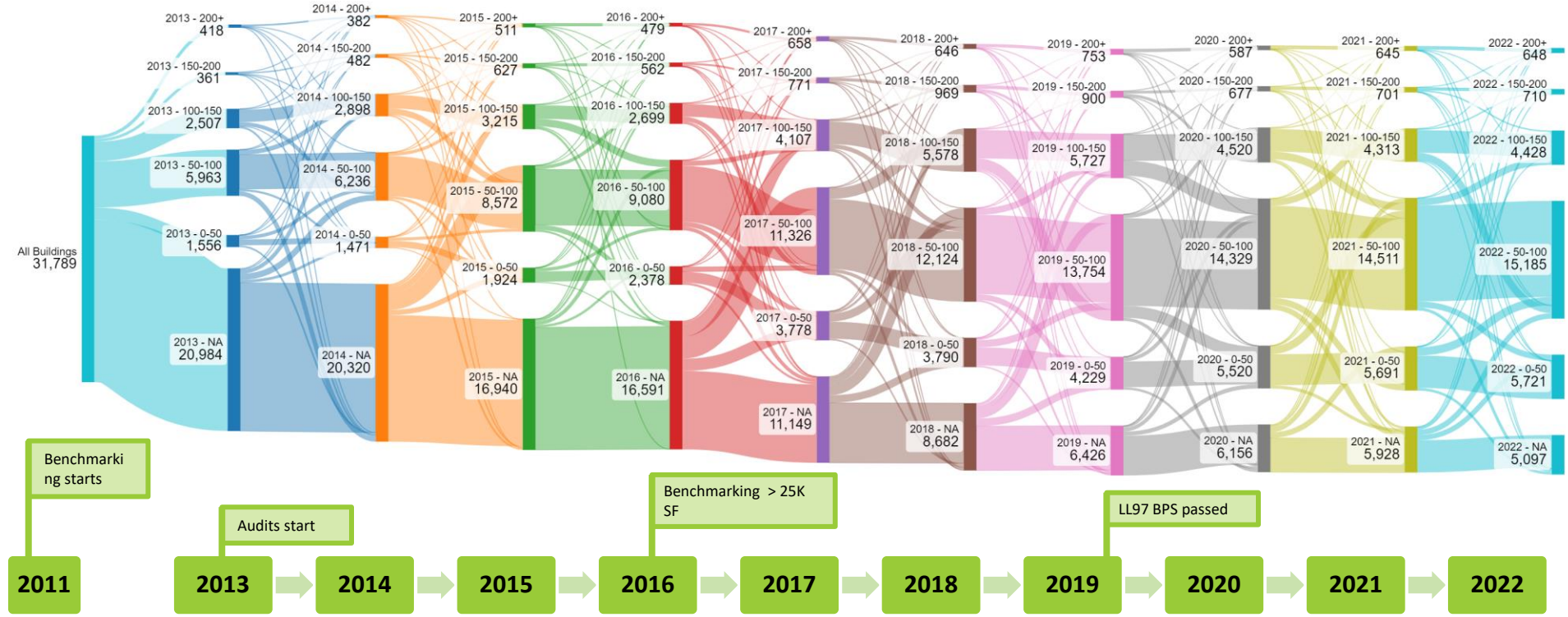
High-Level Data Analysis

- 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



Benchmarking starts

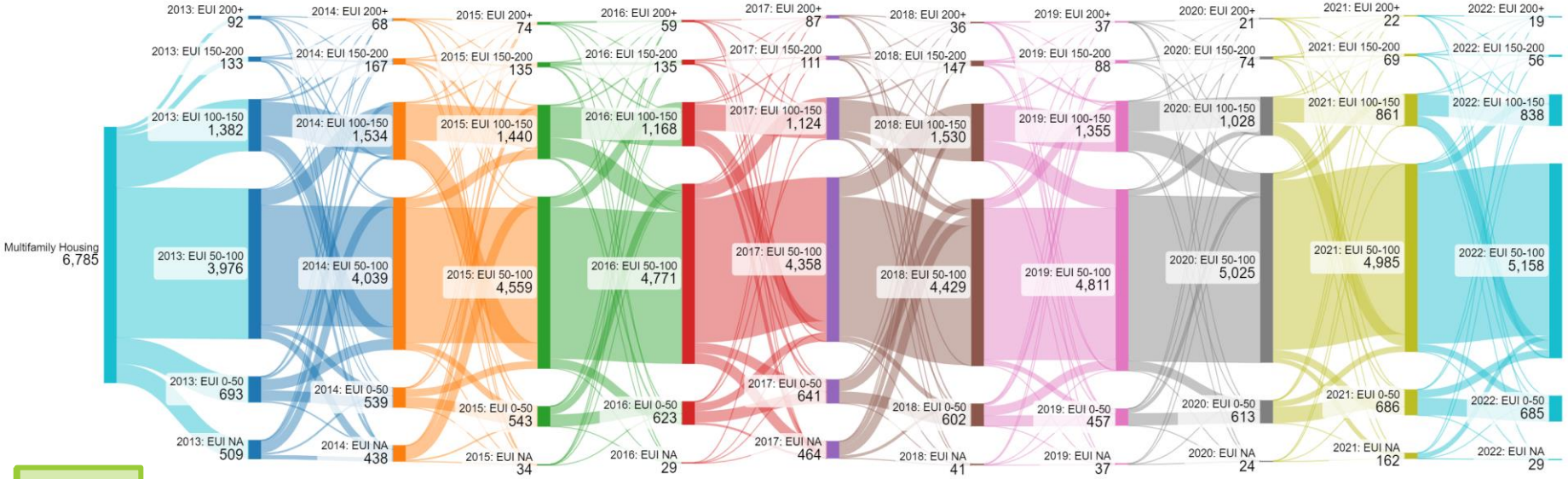
Audits start

Benchmarking > 25K SF

LL97 BPS passed

2011 → 2013 → 2014 → 2015 → 2016 → 2017 → 2018 → 2019 → 2020 → 2021 → 2022

EUI – Multifamily with 5+ Years of Data



Benchmarking starts

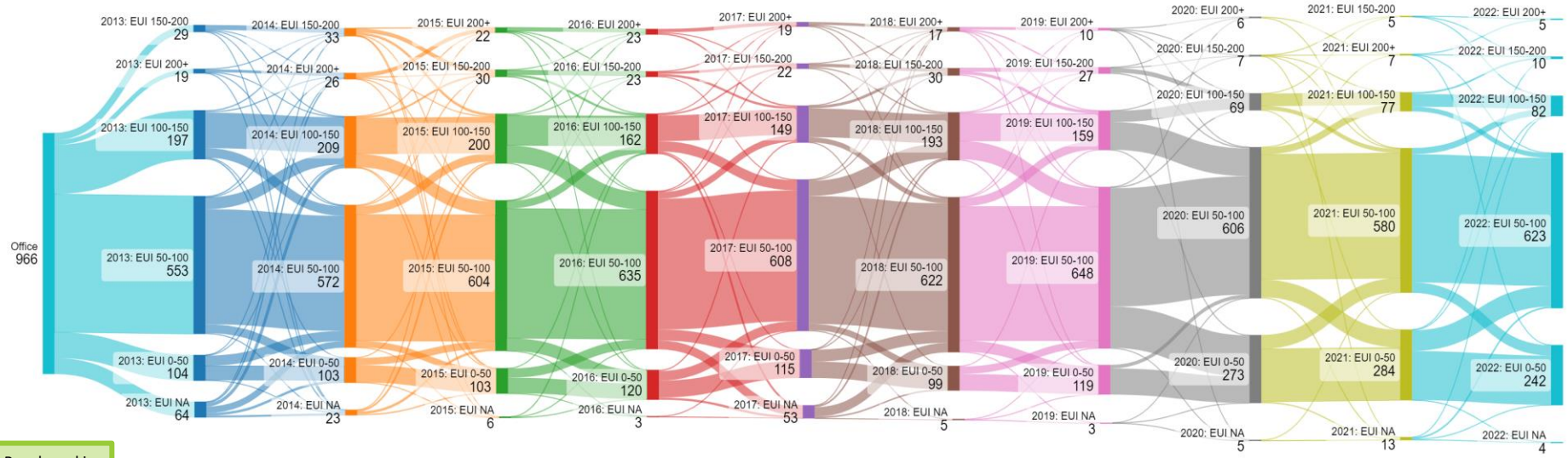
Audits start

Benchmarking > 25K SF

LL97 BPS passed

2011 → 2013 → 2014 → 2015 → 2016 → 2017 → 2018 → 2019 → 2020 → 2021 → 2022

EUI – Offices with 5+ Years of Data



Benchmarking starts

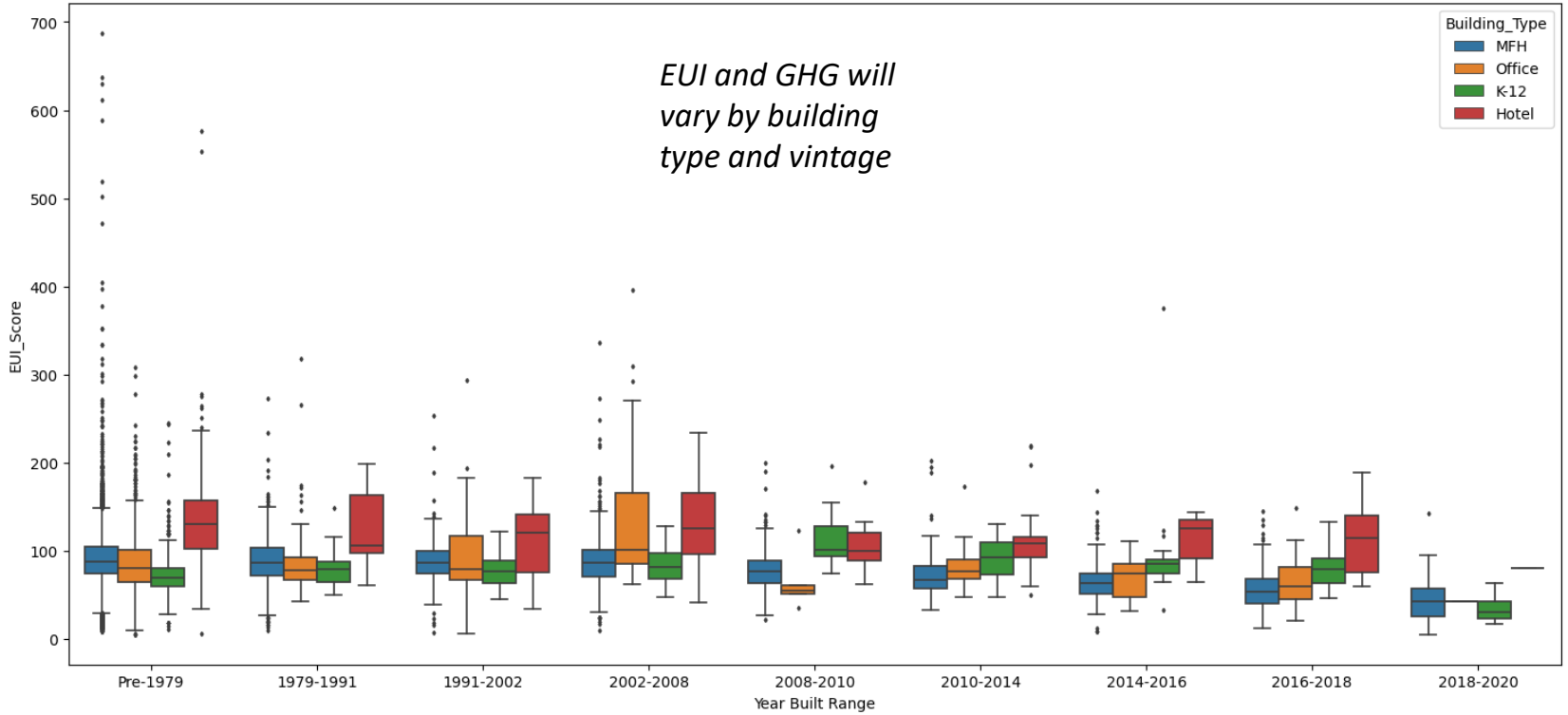
Audits start

Benchmarking > 25K SF

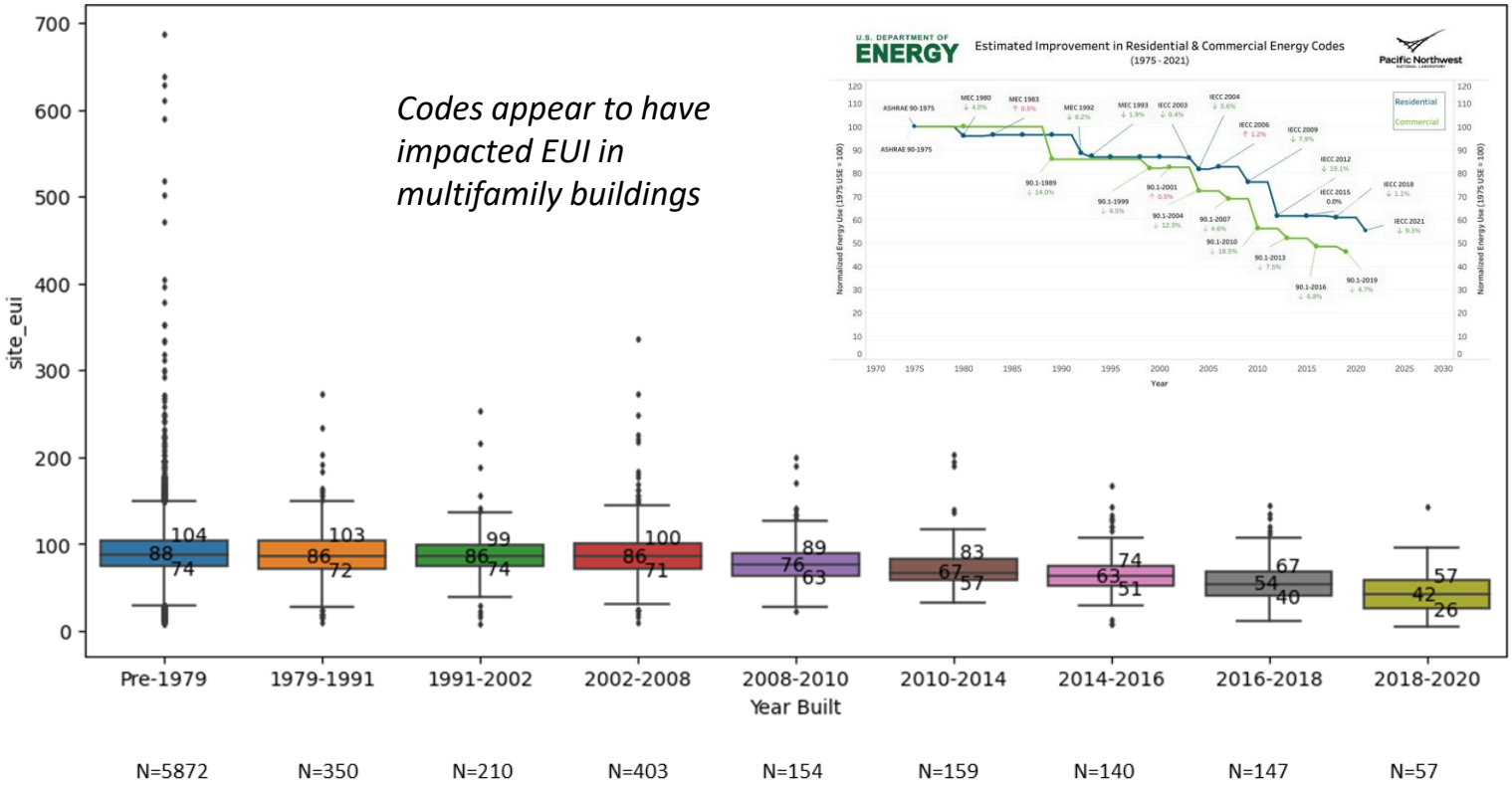
LL97 BPS passed

2011 → 2013 → 2014 → 2015 → 2016 → 2017 → 2018 → 2019 → 2020 → 2021 → 2022

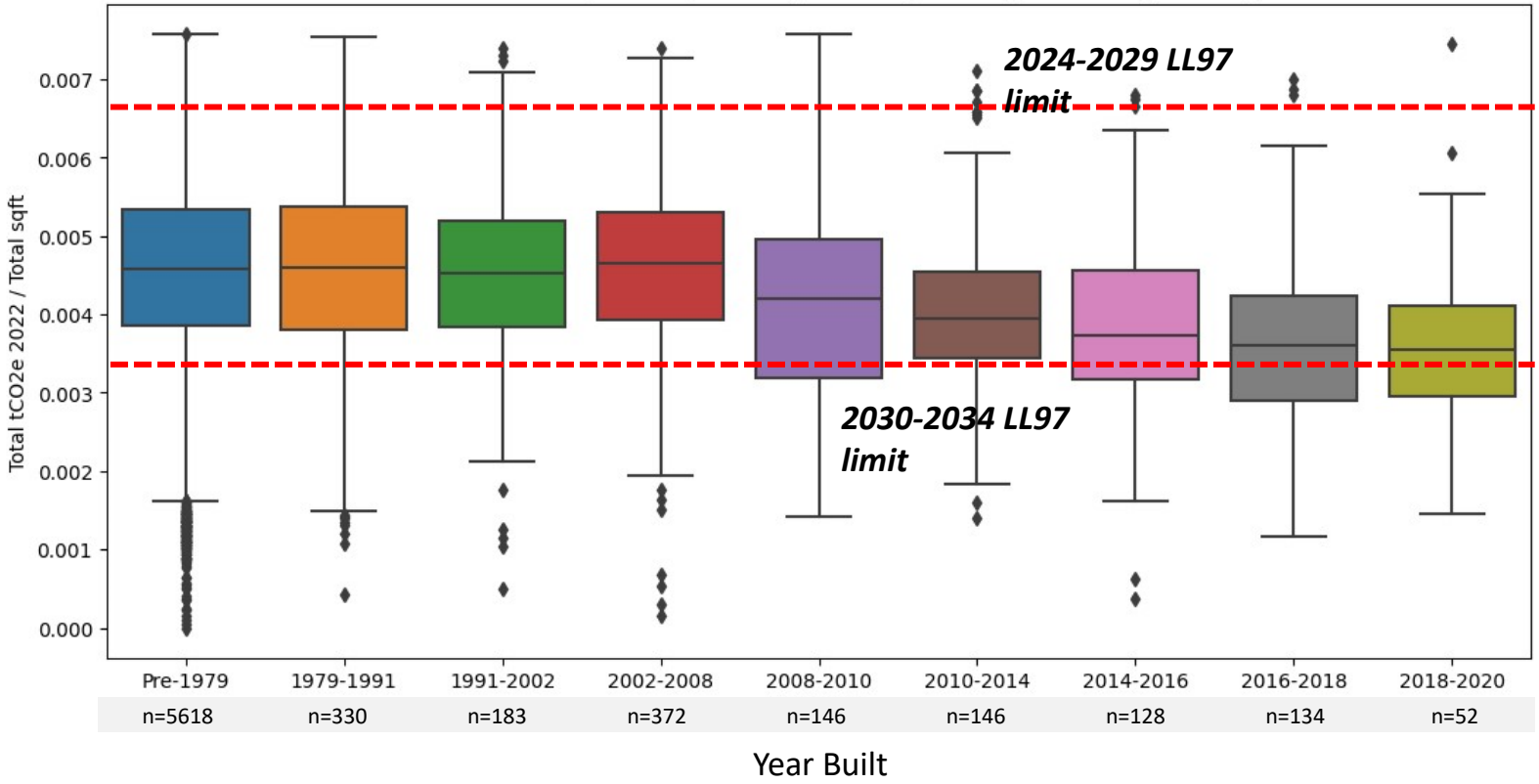
2019 EUI Distribution by Vintage



2019 EUI Distribution by Vintage – Multifamily



2022 GHG per Sq. Ft. – Multifamily



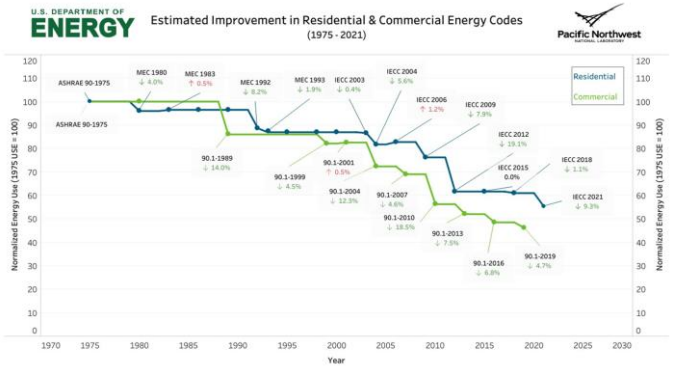
0.00675 tCO2e/SF
NYC Rule 1 RCNY 103-14

0.003346640 tCO2e/SF
NYC Rule 1 RCNY 103-14

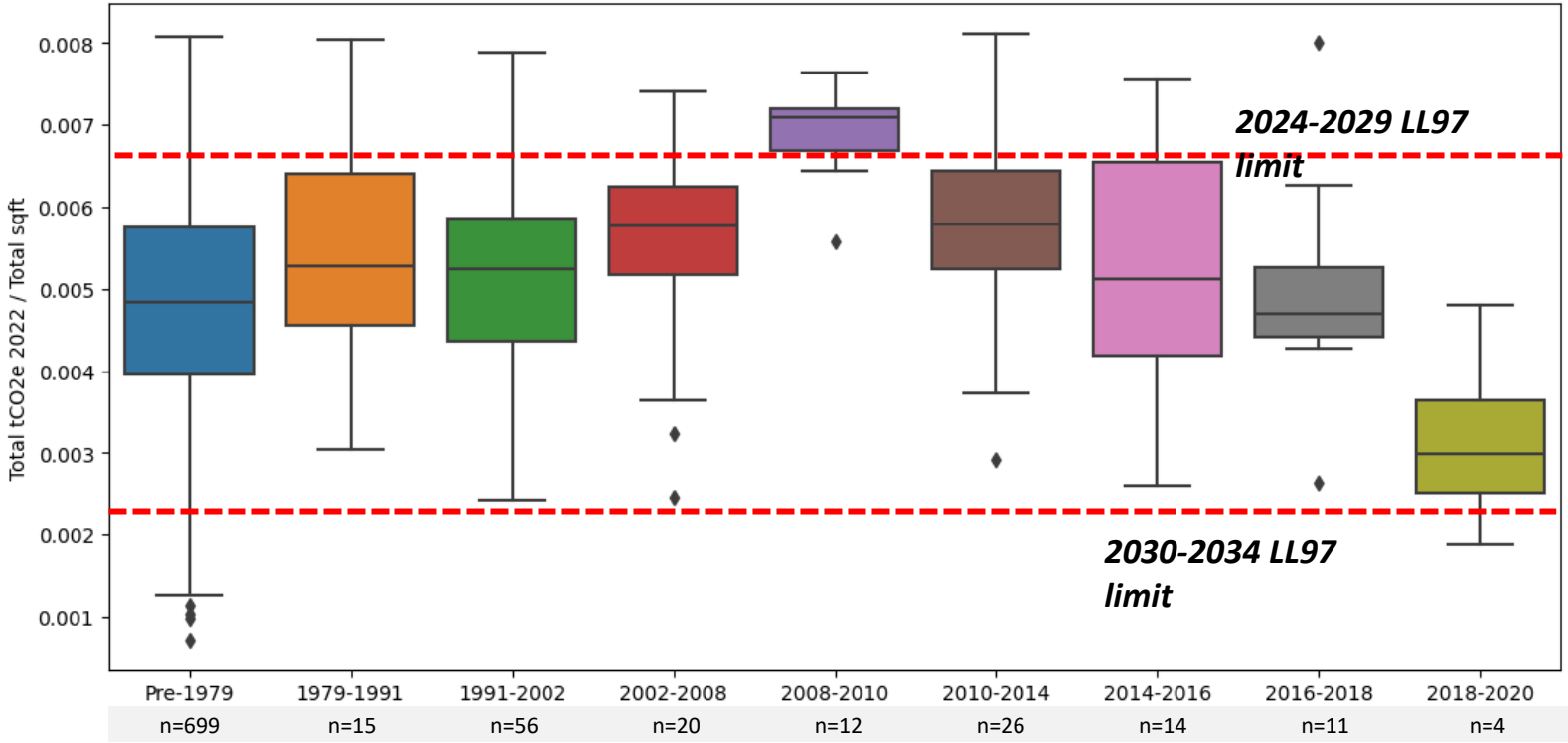
2019 EUI Distribution by Vintage – K-12

Codes do not appear to have impacted EUI in K-12 until 2018

NYC has mandated ~5-10% modeled performance improvement since 2006



2022 GHG per Sq. Ft. – K-12 Schools



0.00675 tCO2e/SF
NYC Rule 1 RCNY 103-14

NYC Policy – electrification and bulk zero-carbon power purchase

0. 0.002230588 tCO2e/SF
NYC Rule 1 RCNY 103-14

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

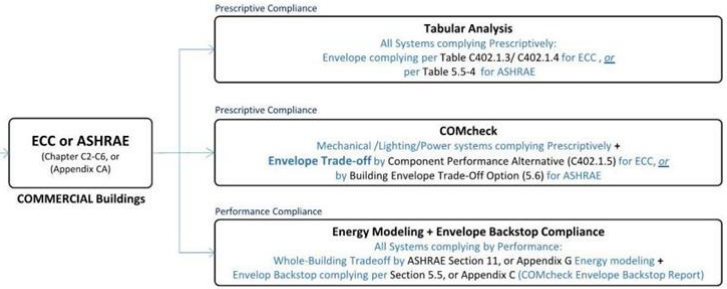
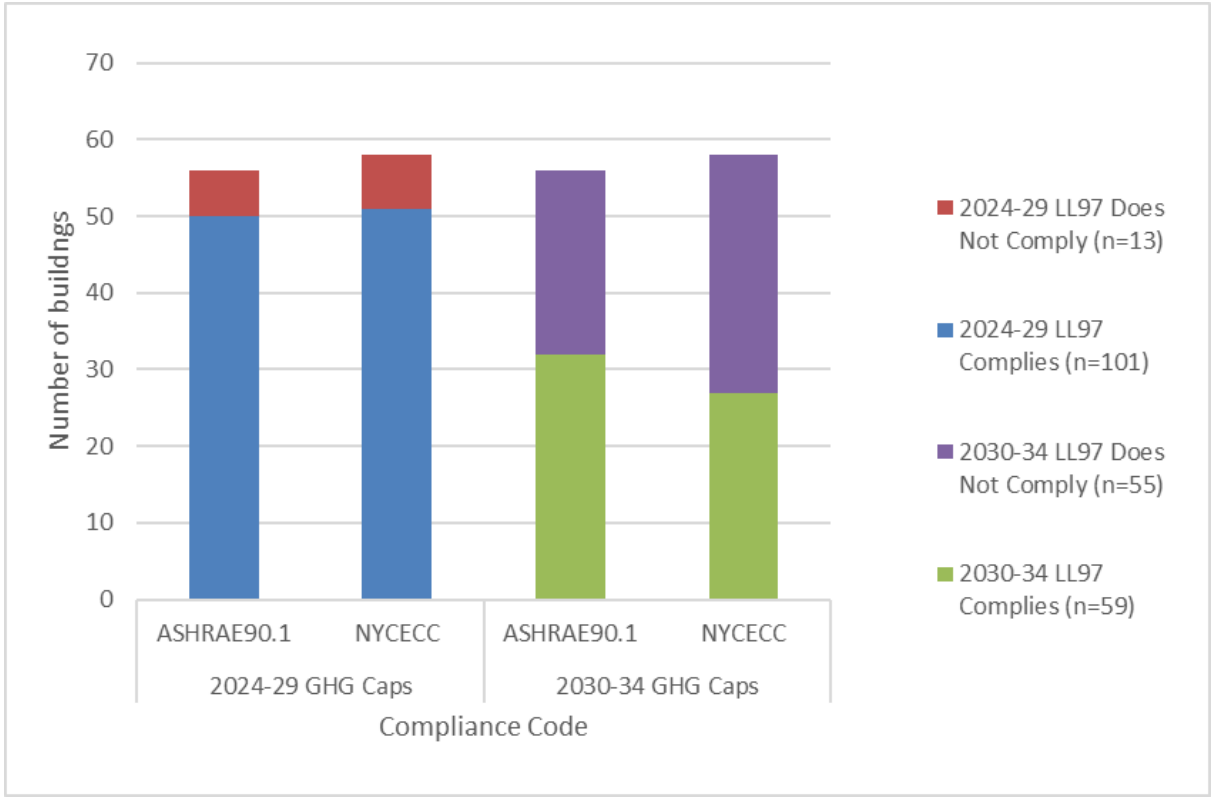


Image from https://www.nyc.gov/assets/buildings/pdf/h2g_all_2020_nycecc.pdf

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 Occupany Group

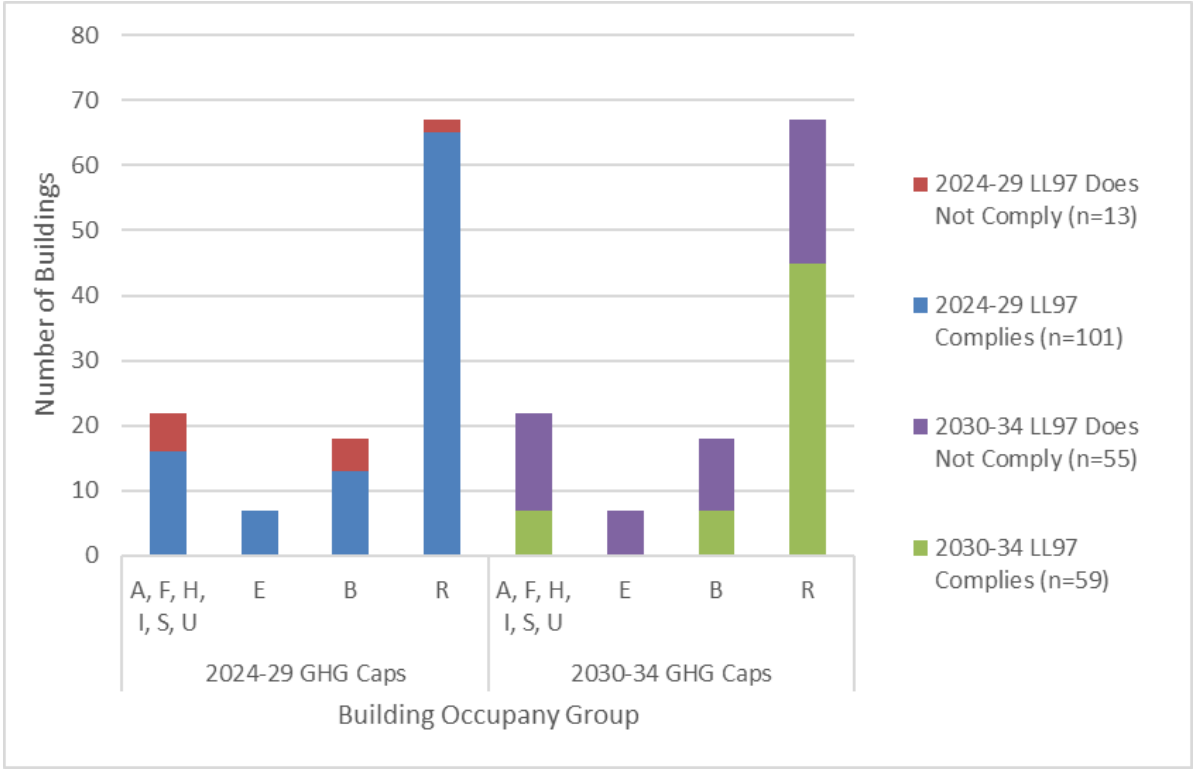
	A, F, H, I, S, U	E	B	R
2030-34 LL97 Compliance	73%	100%	72%	97%
2024-29 LL97 Compliance	32%	0%	39%	67%

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

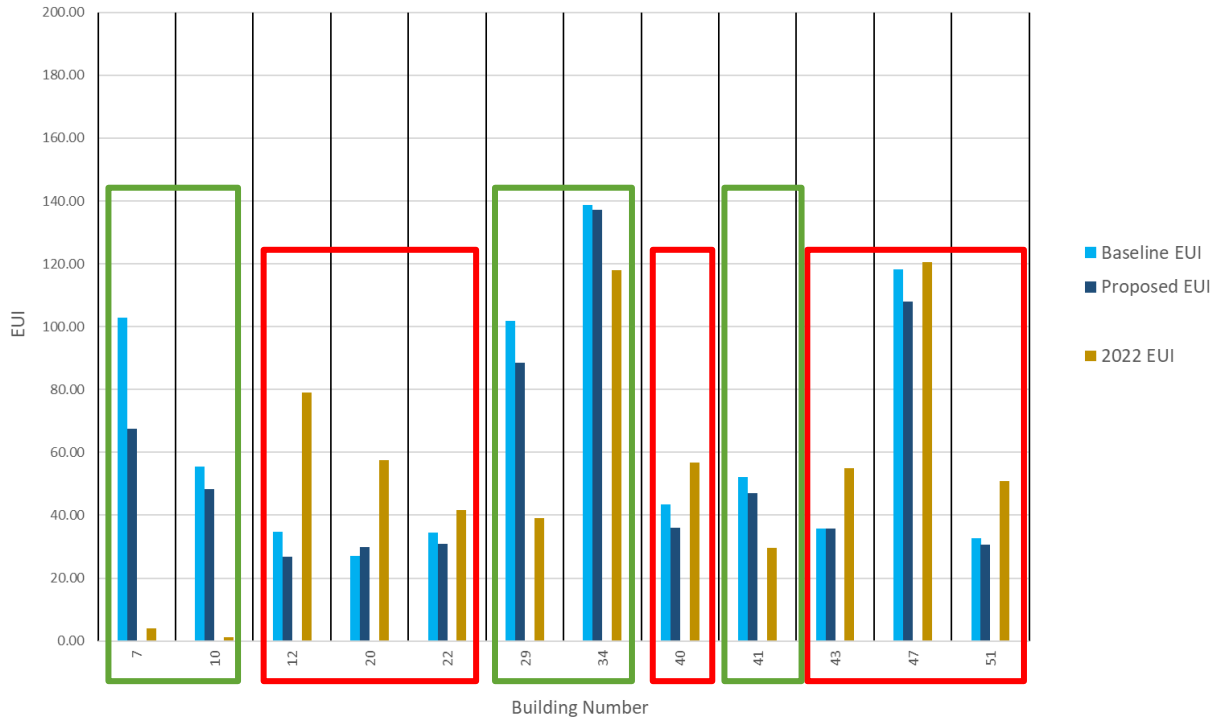
E = Educational

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

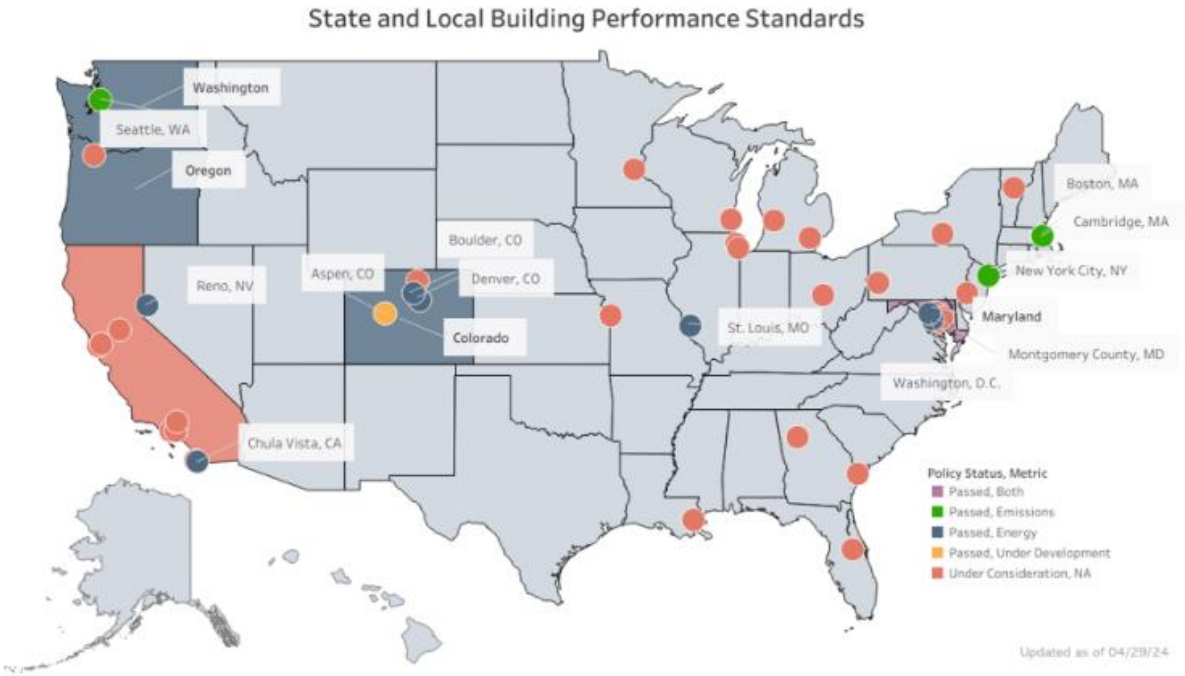
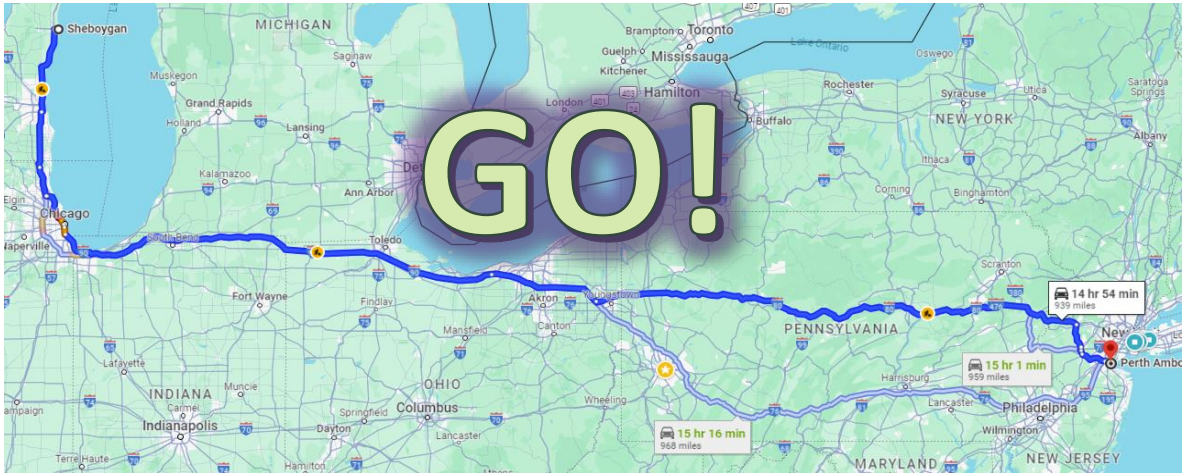


Image from https://www.energycodes.gov/BPS

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

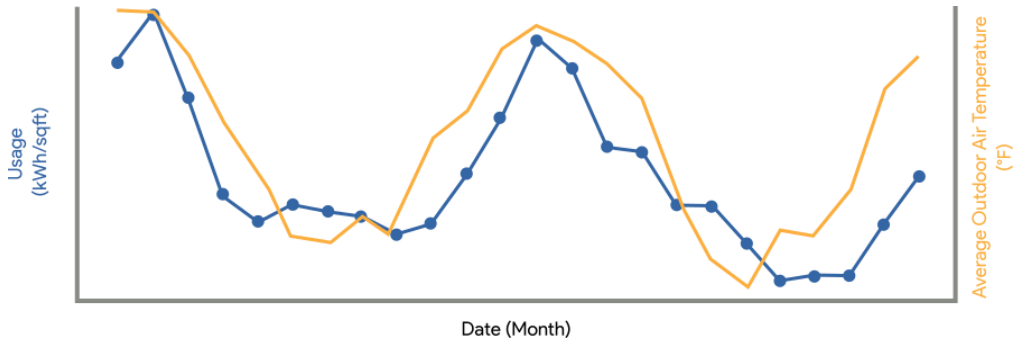
- Linear change-point regression models
- Time-of-day or day-of-week models
- Time-of-week and temperature

Change-point Modeling

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

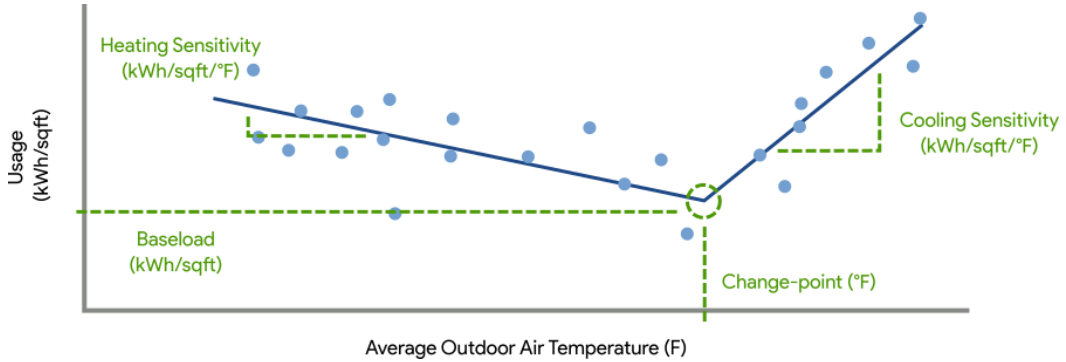
CUNY BPL uses monthly utility bills to generate estimates of baseload, heating, and cooling energy consumption

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



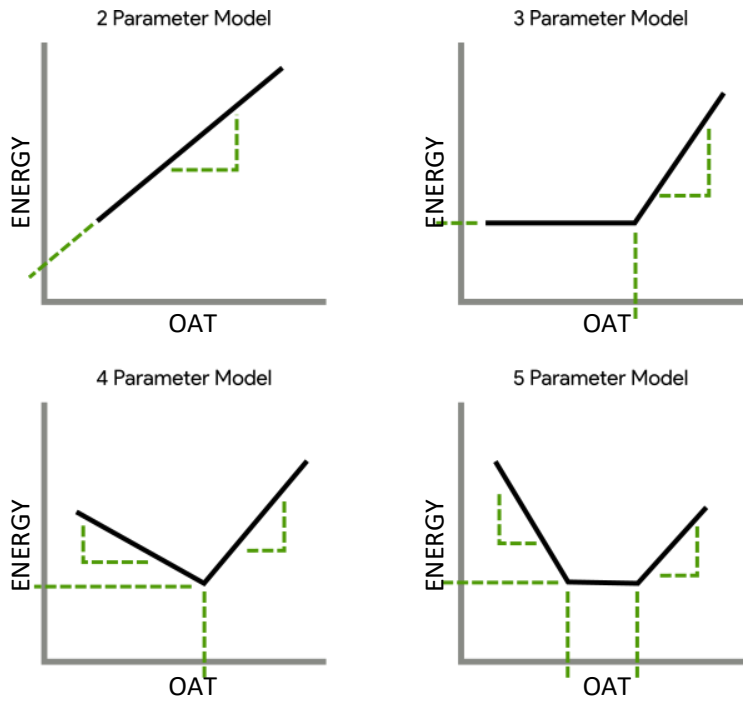
From time series…

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



Re n er n

Change-points

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

Heating or Cooling Sensitivity

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

Baseload Electricity

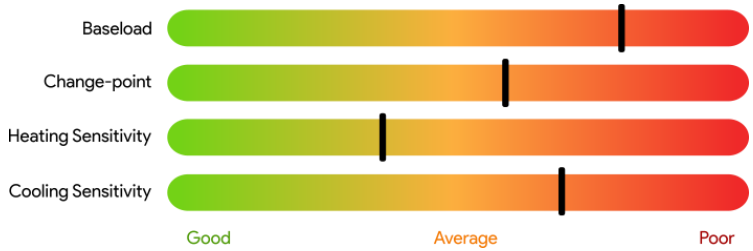
Baseload Fuel

Identify areas of poor performance

Prioritize audits and energy efficiency projects

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

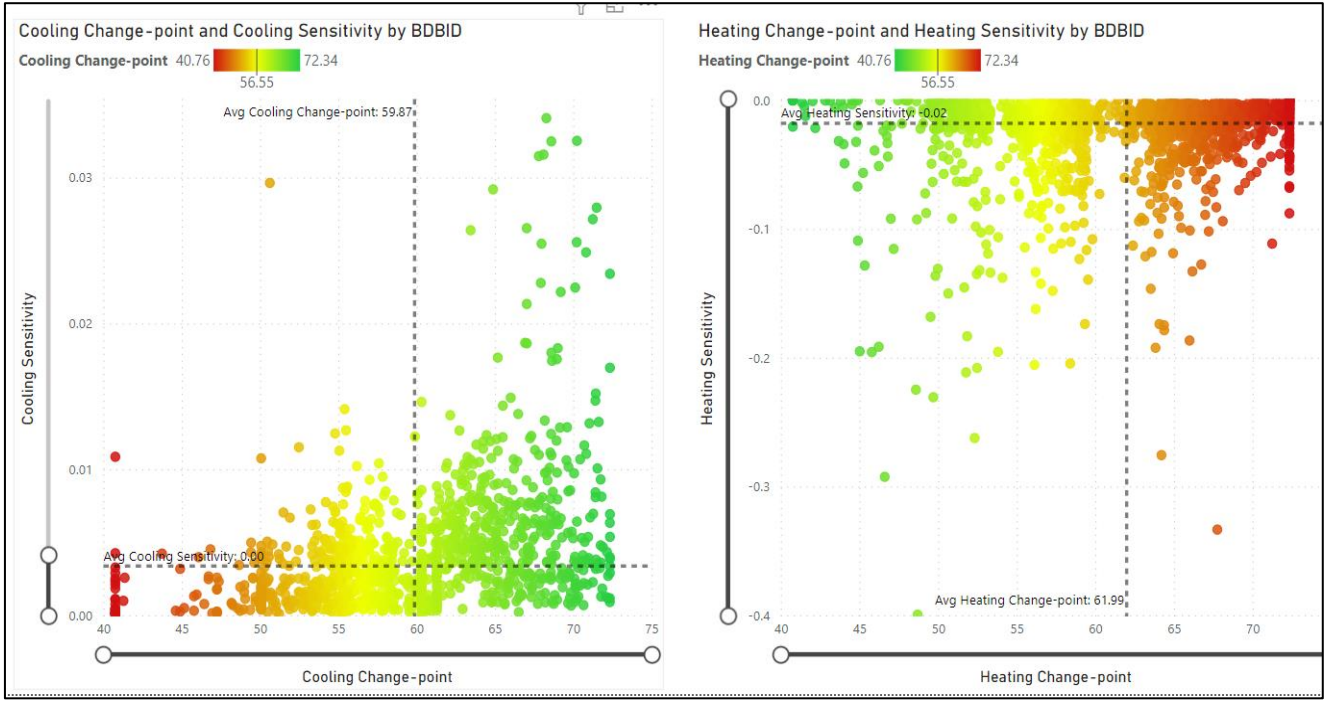
LEAN Segmentation

- 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			

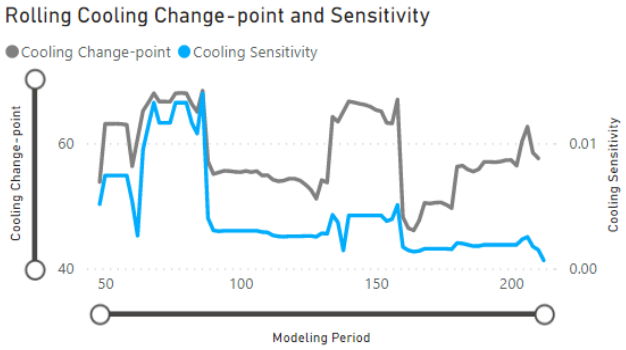
LEAN Quad Charts

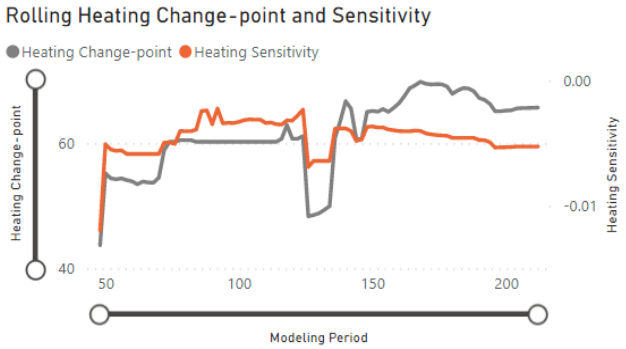
- Regression coefficients can also be segmented visually
- *Example:*
  - Cooling change-point vs. cooling sensitivity – worst performers have low change-points and high sensitivity
  - Identifies buildings where cooling energy starts at lower temperatures and rate of consumption is high

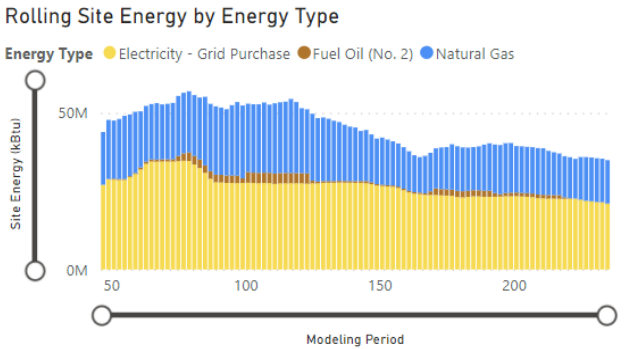


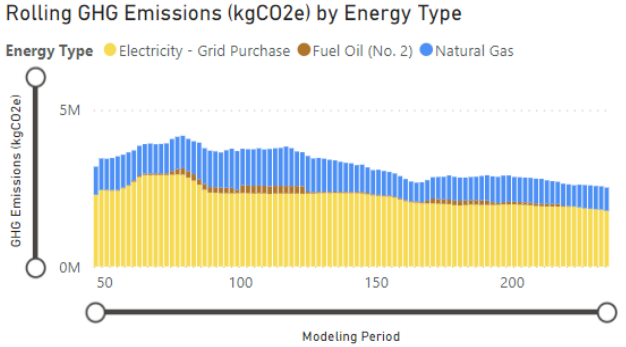
Track Performance Over Time

- 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





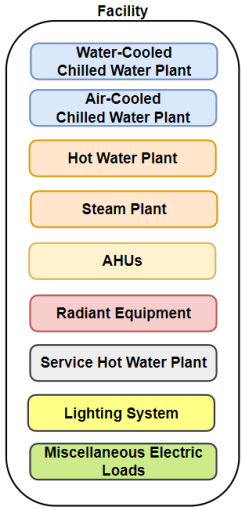


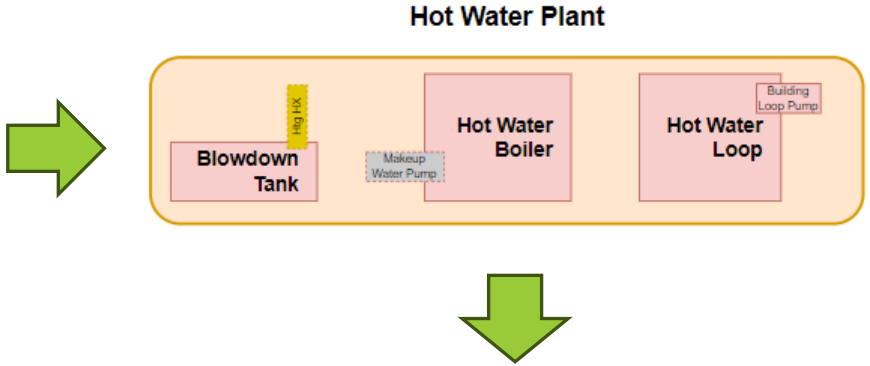


Energy Analysis by End-Use

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





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

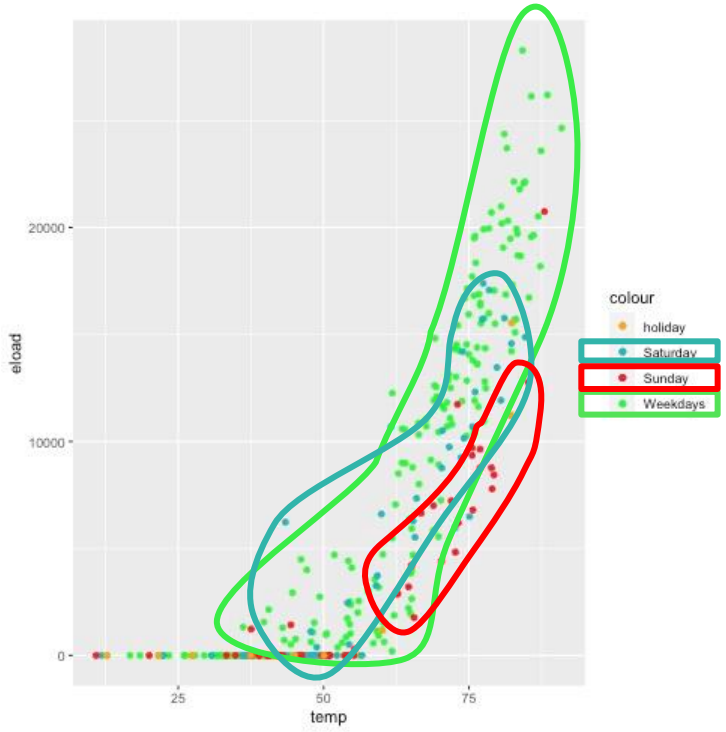
Collected data from real-time energy management (RTEM) systems installed in NYC and NYS under the NYSERDA RTEM program

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

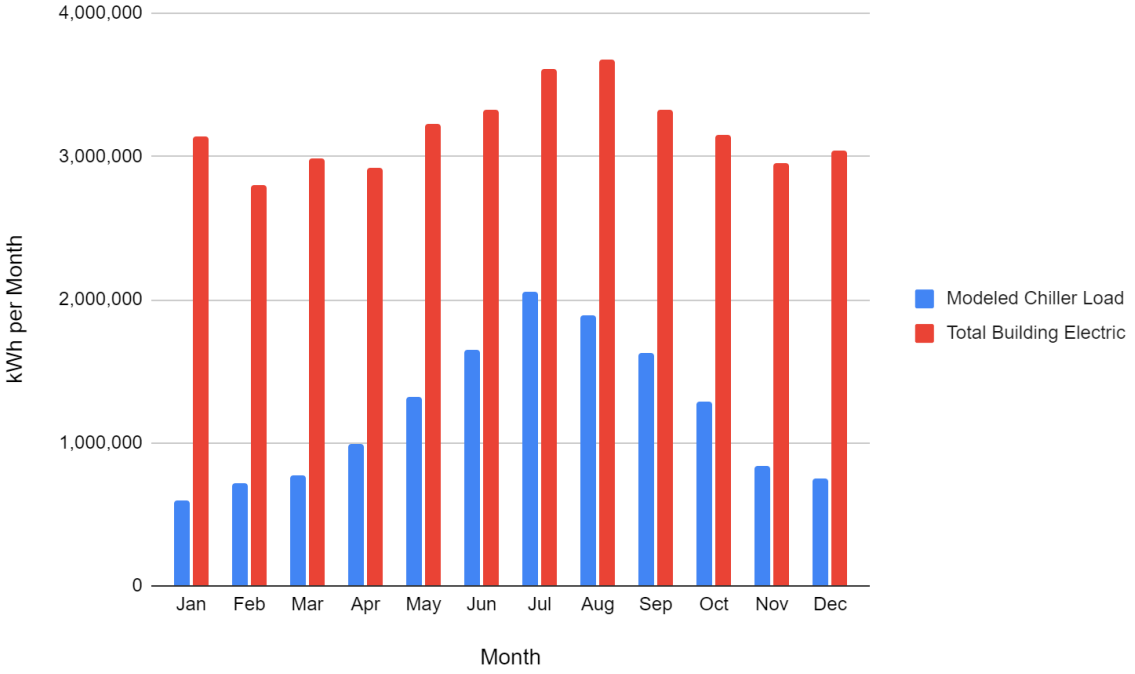
- Compared contribution of measured plant, system or component to whole building energy consumption

- Evaluated various regression approaches
  - Linear change-point regressions
  - Time-of-week and temperature

R package by kW labs (https://github.com/kW-Labs/nmecr)



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?)

Final Reporting being published on OSTI
Target date September 30, 2024

dprahl@ccny.cuny.edu

Questions?