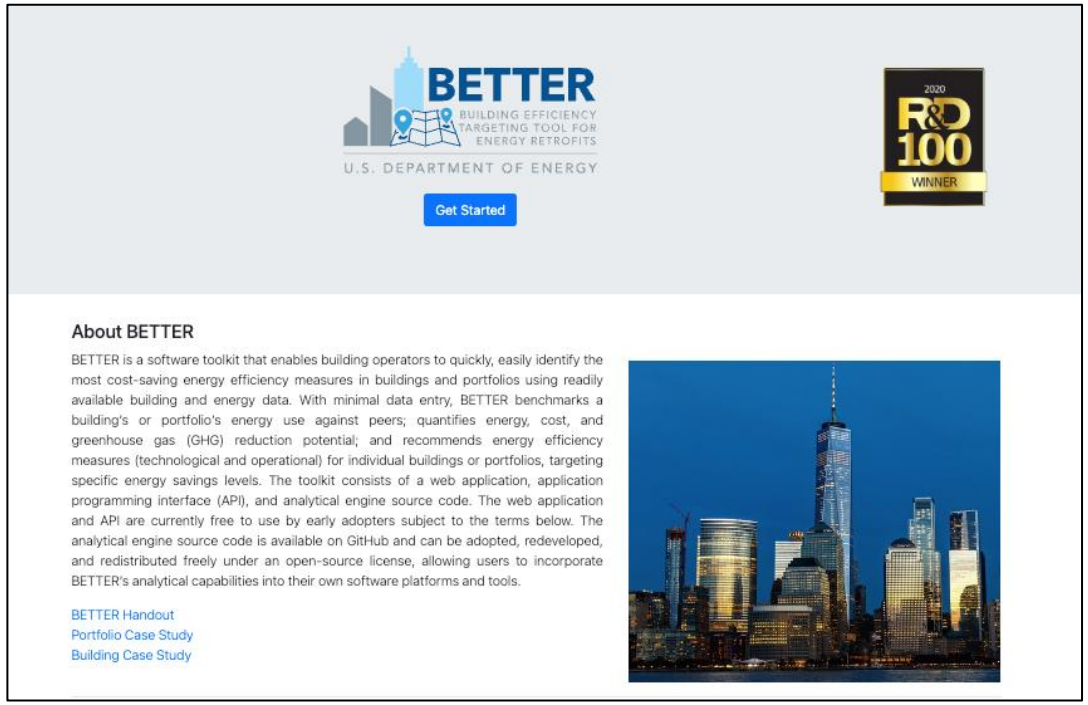
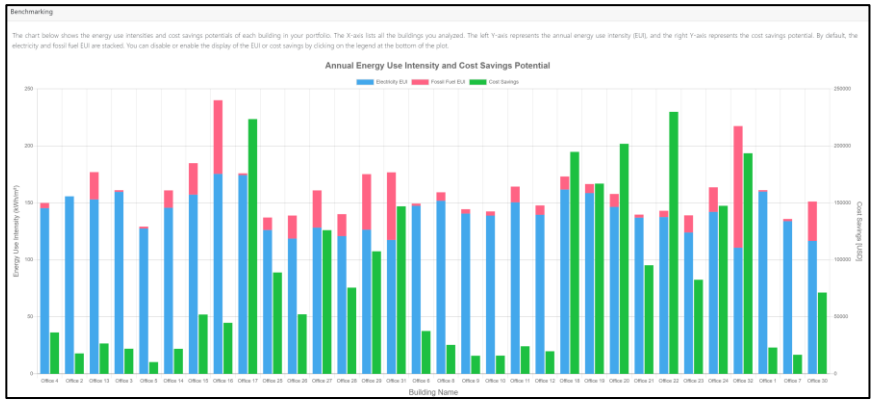
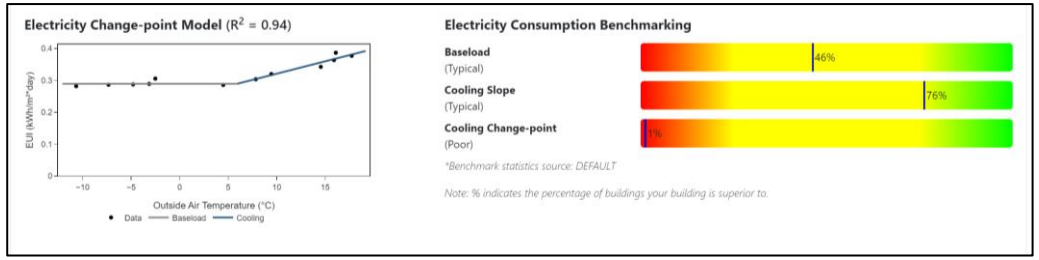
# Building Efficiency Targeting Tool for Energy Retrofits (BETTER)

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WBS# 2.5.3.40

# Project Summary

## Objective and outcome

The Building Efficiency Targeting Tool for Energy Retrofits (BETTER) is an on-line tool released in 2021 that identifies cost-saving energy and emissions reductions in buildings and portfolios, without site visits or complex modeling. This project enhances BETTER for U.S. small commercial buildings and K-12 schools.


## Team and Partners

Lawrence Berkeley National Laboratory

Johnson Controls, Inc.

McQuillen Interactive Pty. Ltd.

## Stats

Performance Period: October 1, 2022 to September 30, 2023

DOE budget: $200k, Cost Share: ~$100k from the U.S. Agency for International Development (USAID) for net zero energy analysis capability and language toggle (Spanish and French)

Milestone 1: Enhance and validate BETTER's analysis capabilities for K-12 schools and small commercial sectors.

Milestone 2: Add data visualization and K-12 normalization factors to BETTER.

Milestone 3: Add sector-specific energy efficiency measure (EEM) implementation resources and health guidance.

# Problem

- **U.S. small commercial buildings and K-12 schools are in need of equipment and operational upgrades.**
  - U.S. small commercial buildings account for almost half of U.S. commercial buildings; have natural gas intensities almost double that of U.S. large commercial buildings; and are in more energy-intensive categories, such as food service and sales.[1]
  - The 2021 American Society of Civil Engineers' 2021 Infrastructure Report Card rates U.S. school facilities in D+ condition, and a June 2020 GAO report found that about 50% of public school districts are struggling to upgrade and maintain key building systems that ensure facilities are free of health hazards.[2]

- **Preparing buildings for retrofits is complex and expensive process.**
  - In-person audits are costly, $0.08 to $0.24 per ft$^2$, and can pose health risks.[3]
  - Modeling typically requires domain expertise and detailed data on buildings.

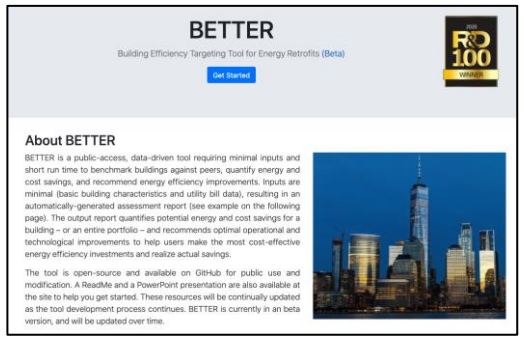
- **A free, on-line tool that maximizes use of monthly data to increase the speed and scale of energy efficiency and net zero energy retrofit projects for U.S. small commercial and K-12 schools.**

| No. of Buildings | Square Footage[1] | | Total Level I Audit Cost[2] |
|---|---|---|---|
| 10 | 164,000 | $ | 13,120 |
| 100 | 1,640,000 | $ | 131,200 |
| 1,000 | 16,400,000 | $ | 1,312,000 |

Portfolio audit costs.


Need in the marketplace.

# Solution: BETTER




https://better.lbl.gov/

- ✓ Replaces a Level 1 audit.[1]
- ✓ Streamlines a Level 2 audit.
- ✓ Uncovers no-/low-cost operational energy efficiency measures to cut energy use 5-10% portfolio-wide.
- ✓ Identifies buildings ready to achieve net zero energy.

## 1. Simple Data Inputs

Building Type

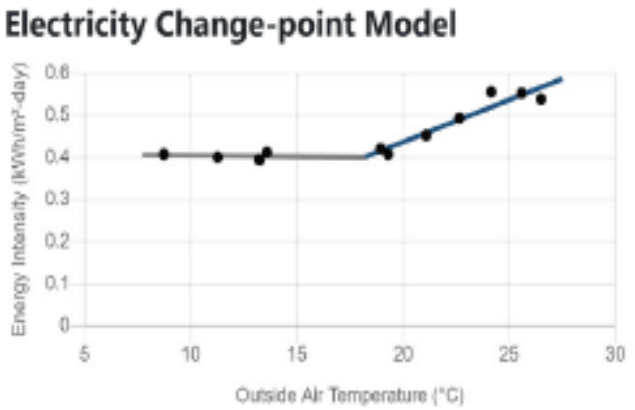
BuildingAddress

Gross Floor Area

Fossil

Electricity

## 2. Fast Analysis




## 3. Actionable Outputs

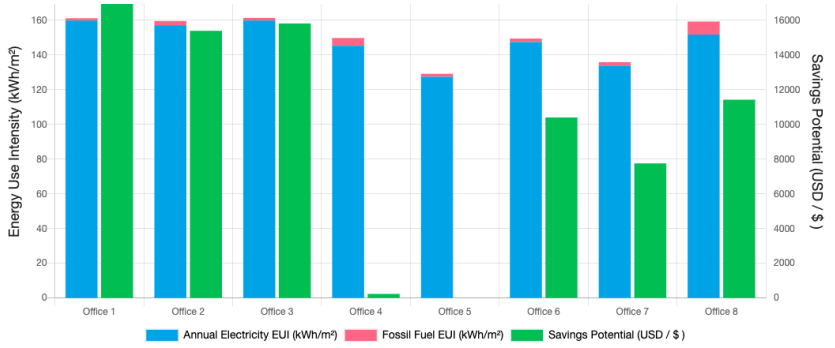
Cost Savings (USD / $ ):

2,506,975

21.4 %

- Reduce Equipment Schedules
- Reduce Lighting Load
- Reduce Plug Loads
- Decrease Heating Setpoints
- Increase Cooling System Efficiency

Building Portfolio Savings Comparison



# Alignment and Impact

- **Contribute to a net-zero U.S. building sector by 2050 while centering equity and benefits to communities:**
  - Recommend low-to-no cost operational upgrades for community serving buildings without immediate upfront capital for system upgrades.
  - Address school facility deterioration which has negative impacts on both student and teacher health and performance.[1]
  - Help preserve energy efficiency jobs and accelerate the post-COVID-19 economic recovery.
  - Avoid 50-75% of additional embodied greenhouse gas (GHG) emissions in each case where a building is retrofit instead of demolished and reconstructed.[2]

| EERE/BTO Objective | Target Reduction (compared to 2005) | BETTER Contribution (compared to 2018) |
|---|---|---|
| Reduce on-site energy use intensity in small commercial and K-12 schools | 30% by 2035 | ~5% (52 trillion Btu) by 2035 |
| Reduce on-site fossil-based CO2 emissions in small commercial and K-12 schools | 25% by 2035 | ~5% (10,834,230 tCO2e) by 2035[3] |

# Innovative Approach

## Awards for Innovation

2020 R&D 100 WINNER

"Oscar of Innovation"

DIRECTOR'S AWARDS

Lawrence Berkeley National Laboratory Director's Award for Tech Transfer

EarthX CLIMATE TECH STARTUP PRIZE

Earth X E-Capital Summit Climate Tech Prize Semi-Finalist

| Where Current Solutions Fall Short | BETTER |
|---|---|
| **Complex, detailed data inputs** | ✓ **Lean.** Uses <50% of data inputs of other benchmarking / retrofit analysis tools. |
| **Lengthy run time** | ✓ **Fast.** Analysis per building of 5 to 10 seconds. |
| **Single building analysis** | ✓ **Scalable.** Portfolio and building analysis in a single analytical run. |
| **Significant domain expertise required** | ✓ **Easy to use.** Tools that provide an equivalent analysis require modeling/simulation domain expertise. |
| **Focus on Capex/Opex opportunities** | ✓ **Underserviced market application.** BETTER uses simple, readily available inputs and can recommend 25+ no-cost/low-cost EE measures. |

**"BETTER offers a possibility of delivering efficiency retrofits in underserved markets faster and cheaper by orders of magnitude."**

*— Tom Strumolo, Founder, Energy General*

# Bridges the Gap between ENERGY STAR® and Asset Score

"BETTER has helped our school division identify substantial energy cost savings, which can be redirected into the classroom. With its simple data inputs and powerful analytics, we believe BETTER is poised to help hundreds of school districts across the country to improve their energy, financial, and environmental performance."

*— Bryan Conrad, Energy Education Coordinator for Prince William County Public Schools*

Prince William County PUBLIC SCHOOLS *Providing A World-Class Education*

# Plan to Deliver Intended Outcomes

| Task | K-12 School | Small Commercial |
|---|---|---|
| 1. Develop database | *Preliminary results (but will be enhanced)* | Not started |
| 2. Develop reference benchmark statistics | *Preliminary results (but will be enhanced)* | Not started |
| 3. Add monthly data visualization to BETTER | Complete | Complete |
| 4. Add normalization factors for K-12 schools | Not started | Not applicable |
| 5. Add energy efficiency measure (EEM) implementation resources and health guidance | *Near complete* | Not started |
| 6. Stakeholder outreach and validation | *In process* | Not started |

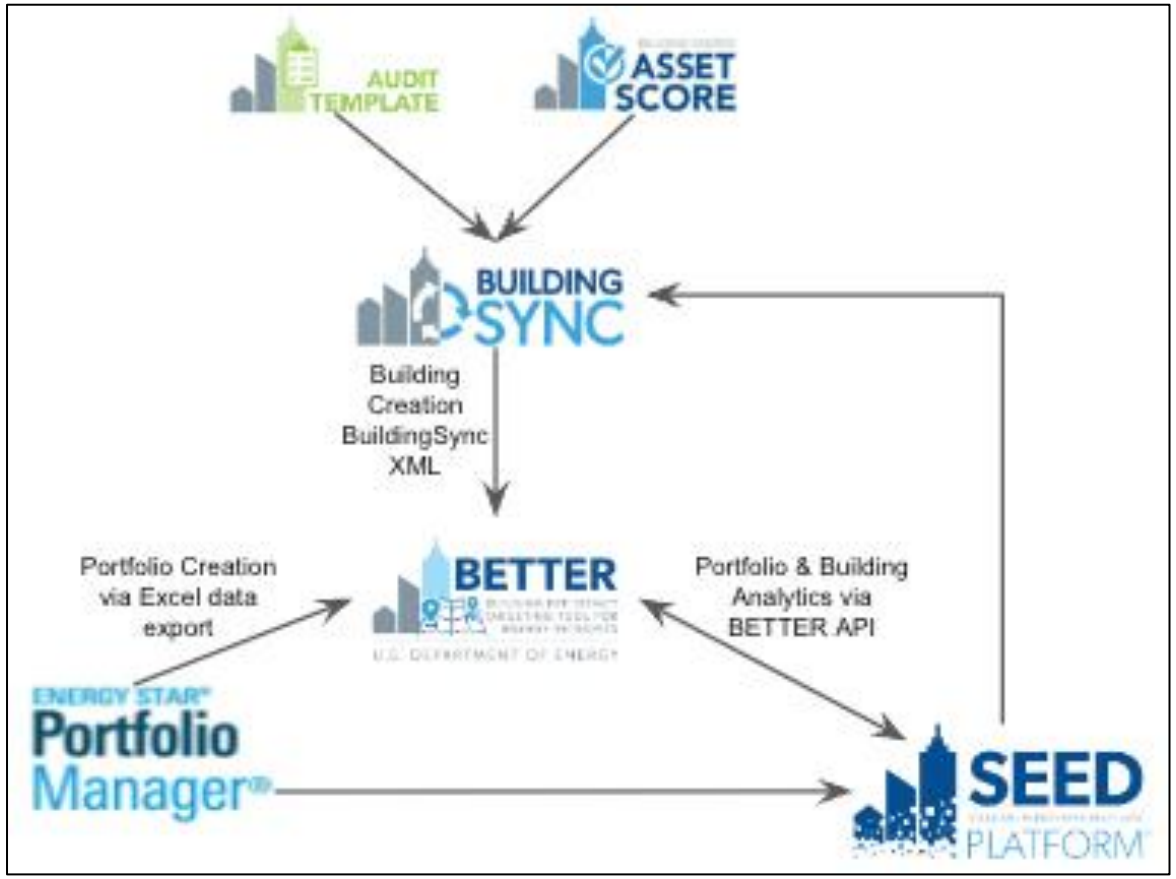
# Challenges and Mitigation Strategies

| Challenge | Mitigation Strategy |
|---|---|
| • Lack of access to nationally-representative data set to develop reference benchmark statistics for K-12 school and small commercial buildings. | • Partnership for data sharing with U.S. DOE Building Performance Database (BPD) and Better Buildings teams. |
| • Functioning interoperability with the existing DOE suite of building data and analysis tools. | • Co-development of interoperability mechanisms and bi-weekly coordination calls with other DOE building data tools. |

BPD BUILDING PERFORMANCE DATABASE

Better Buildings U.S. DEPARTMENT OF ENERGY

**Data sharing.**




**BETTER equipped for data and analytics transfer.**

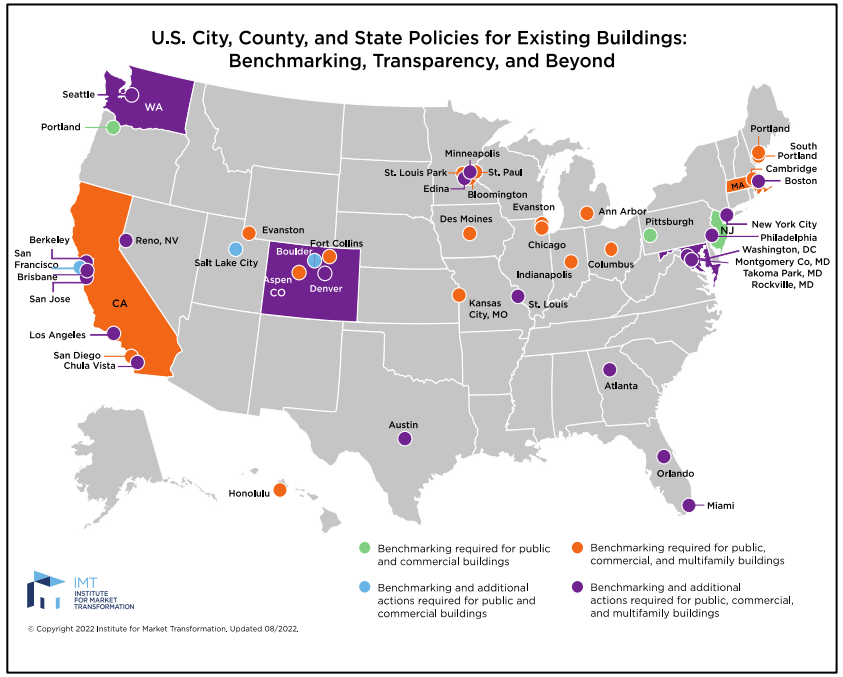
# Stakeholder Engagement Plan

*Since release in June 2021, **900** users, **~7000** buildings, and **550M ft²** across **16 sectors** entered. **22** new users, **~325** buildings, and **25M ft²** entered each month on average.*

## 1. Stakeholder Working Group and New Users:

| | |
|---|---|
| Engineering / Finance | Johnson Controls, citi, esg energy systems group, Honeywell, TRANE, SIEMENS, Brightly, Carrier |
| Owners / Managers | Microsoft, CUSHMAN & WAKEFIELD, CBRE, JLL, sodexo |
| Non-Profit / Consulting | PowerOptions, C40 CITIES, WORLD RESOURCES INSTITUTE, ASHRAE, McKinsey & Company, GREENPLACE ASSETS, Nexant |
| City / State Government | DEPARTMENT OF ENERGY & ENVIRONMENT, CITY OF BERKELEY, CAMBRIDGE CDD@344, CITY OF PORTLAND OREGON, CITY OF ORLANDO, COLORADO Energy Office, CITY OF Alexandria VIRGINIA |
| Other Public Sector | Prince William County PUBLIC SCHOOLS, NASA, JUDICIAL COUNCIL OF CALIFORNIA, SAN MATEO COUNTY COMMUNITY COLLEGE DISTRICT, Santa Clara Unified School District |
| Research Universities | FLORIDA GULF COAST UNIVERSITY, Stanford University, FANSHAWE, UNIVERSITY OF MICHIGAN, UNIVERSITY of LOUISIANA, TEXAS The University of Texas at Austin, MIT Massachusetts Institute of Technology, HARVARD, OHIO STATE |

## 2. BETTER - SEED API Calls:




## 3. K-12 schools (*underway*):

EFFICIENT AND HEALTHY SCHOOLS

## 4. Small commercial (*planned*):

Better Climate™ CHALLENGE U.S. DEPARTMENT OF ENERGY

Better Buildings® U.S. DEPARTMENT OF ENERGY

# Validation Plan

## BETTER Analysis

## Level 2 Audit Comparison

### BETTER Analysis Results

#### BETTER Change-Point Models and Benchmarks

**Figure 1.** Electricity Results

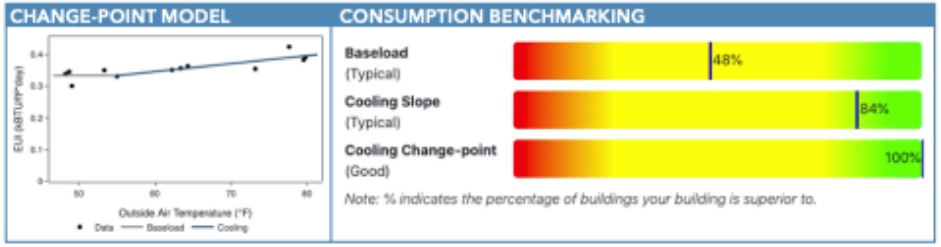



**Figure 2.** Fossil Fuel Results

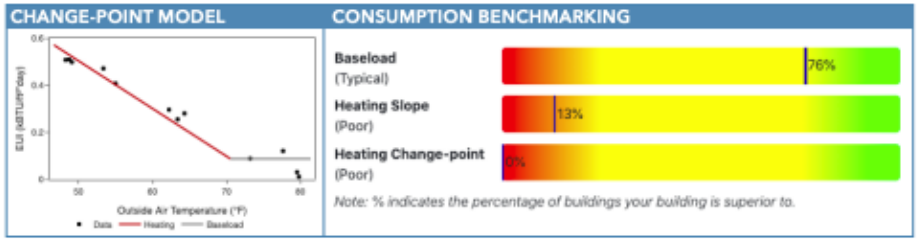



**Table 2.** BETTER and Level 2 Audit EE Recommendations Compared

| BETTER EE RECOMMENDATIONS | LEVEL 2 AUDIT RECOMMENDATIONS |
|---|---|
| Reduce lighting load | Upgrade lighting to low-emitting diodes (LED) |
| Reduce lighting & plug load | Install occupancy sensors |
| • Ensure adequate ventilation rates<br>• Reduce equipment schedule | Optimize fan variable frequency drive |
| Reduce equipment schedule | • Optimize chiller controls<br>• Install air-handling unit cold coil valves<br>• Install chilled-water pump variable frequency drive |
| Decrease heating setpoints | Implement hot water reset |
| • Add wall/ceiling insulation<br>• Decrease infiltration<br>• Increase heating system efficiency | Install Insulation |
| None | • Implement chilled water setback<br>• Install high-performance windows |

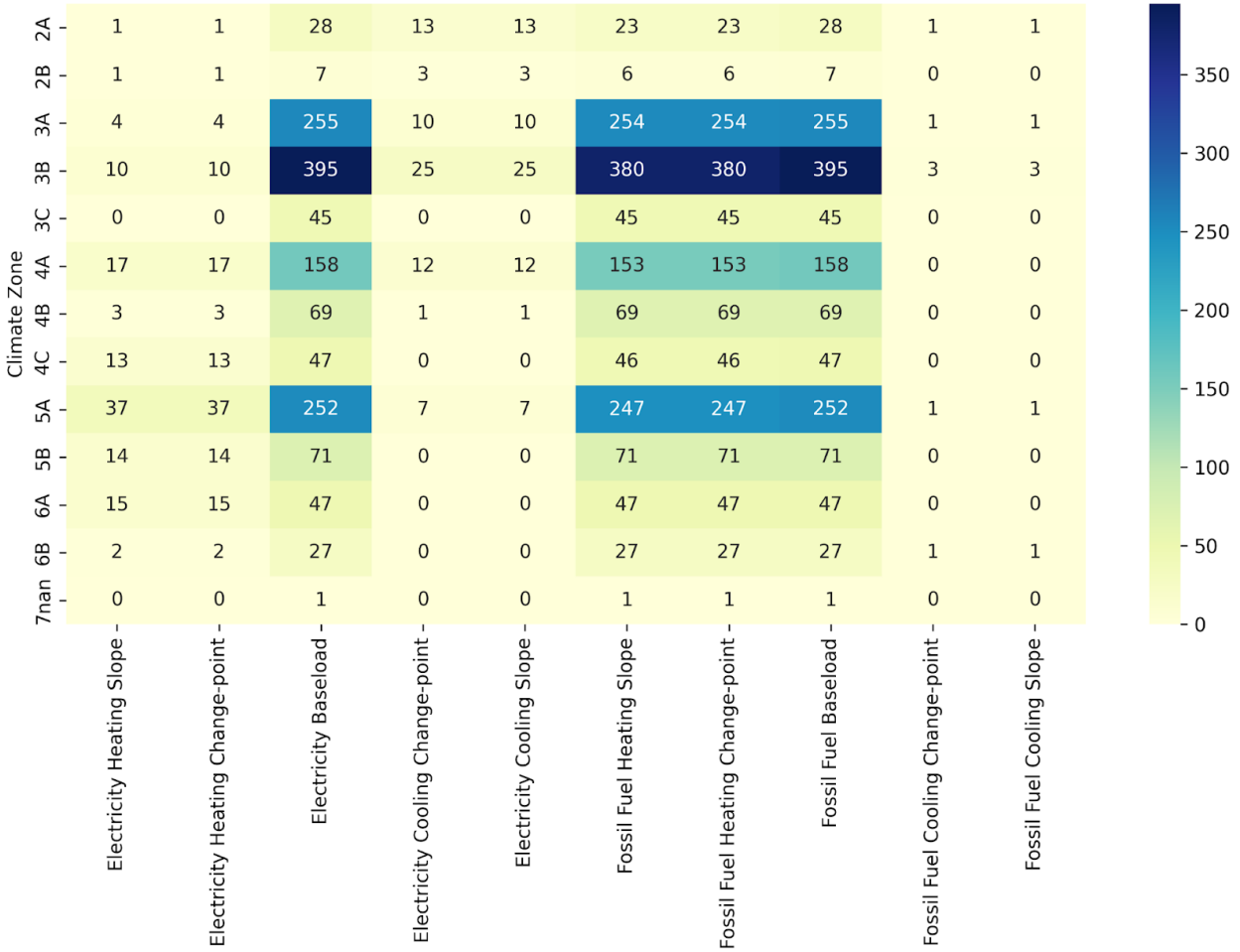
**able 3.** BETTER and Level 2 Audit Annual Energy, Cost, nd GHG Emissions Reductions Compared

| | BETTER ESTIMATE | AUDIT ESTIMATE |
|---|---|---|
| ENERGY SAVINGS | 5,093,770 kBtu/year | 5,097,811 kBtu/year |
| ENERGY COST SAVINGS | $66,687/year | $149,800/year |
| GHG EMISSIONS REDUCTIONS | 275.5 $MtCO_2e$/year | None provided |

# Task 1: Preliminary K-12 School Database

***2,995*** K-12 schools (1% of national stock); ***238M ft²*** (2% of national stock)[1]

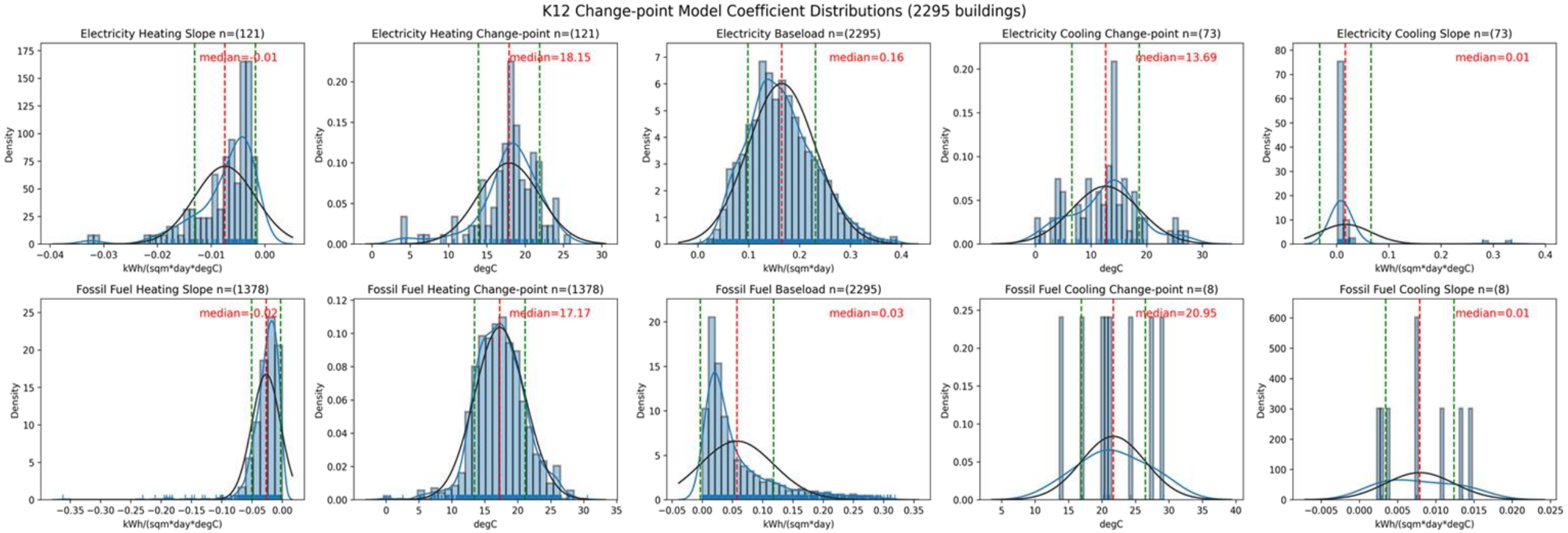
**Distribution of BETTER Model Coefficients by 2021 International Energy Conservation Code (IECC) and DOE Building America Climate Zones[4]**




| U.S. DOE Building America Climate Regions[2] | Corresponding IECC 2021 Climate Zone[3] | BETTER Data Coverage by DOE Climate Regions * |
|---|---|---|
| Hot-humid (e.g., Southeast, East Texas) | 0A, 0B, 1A, 2A | Minimal |
| Mixed-dry / hot-dry (e.g., Southwest) | 1B, 2B, 3B, 4B | Good |
| Mixed-humid (e.g., Mideast) | 3A, 4A | Good |
| Very cold / cold (e.g., Northeast, Upper Midwest) | 5A, 5B, 6A, 6B, 7 | Good |
| Marine (e.g., West Coast) | 3C, 4C, 5C | Good |
| Subarctic | 8 | None |

*Good = there is data for >30 buildings for that DOE Building America Climate Region.

# Task 2. Preliminary K-12 School Reference Benchmark Statistics




Real data

Normal distributions fitted from data

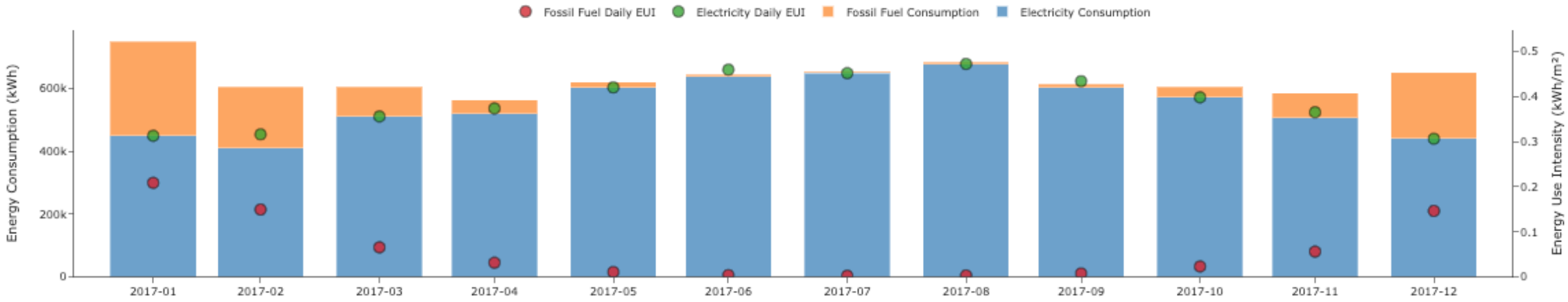
Sample median

One standard deviation from median

Note: For fossil fuel cooling change-point and slope, the sample size is less than 30, which suggests fossil fuel is not typically used for cooling in U.S. K-12 schools.

# Task 3: Final Energy Data Visualization

- Visualize monthly energy use by fuel type (or grouped by electric and fossil use)
- **Identify missing utility bills or outliers**
- Identify average daily electric and fossil energy use intensity (EUI) (by calendar month), which is regressed against average daily outdoor air temperature (by calendar month) and used for benchmarking and identification of energy efficiency measures (EEM).



# Task 4. Near Complete K-12 School EEM Implementation and Health Guidance

- BETTER provides implementation guidance for hundreds of energy efficiency measures (EEM) across 12 BuildingSync™ technology categories:
  - Boiler Plant Improvements
  - Building Automation Systems
  - Building Envelope Modifications
  - Chilled Water Hot Water And Steam Distribution Systems
  - Chiller Plant Improvements
  - Conveyance Systems
  - Lighting Improvements
  - Electric Motors And Drives
  - Heating Ventilating and Air Conditioning (HVAC)
  - Plug Load Reductions
  - Refrigeration

Across all technology categories, BETTER is being updated with nearly 100 technical assistance resources (guidebooks, case studies, etc.) and health guidance specific for K-12 schools from DOE, EPA, ASHRAE, and others.

**Reduce Lighting Load**

Your building lighting load is higher than that of a typical building. Lighting load is a significant portion of any building's energy consumption, but lighting efficiency and controls have a big impact on lighting system performance. Consider upgrading bulbs and fixtures to improve efficiency and check existing (or upgrade to) controls that dim and turn off the lights appropriately. Take advantage of natural daylighting whenever possible. Lights near existing windows or skylights can be controlled to dim or turn off for maximum daylight utilization. Renovations to the building envelope and internal space configurations are good opportunities to improve lighting system performance.

*General Resources*

- U.S. DOE: Better Buildings® Interior Lighting Toolkit
- U.S. DOE: Better Buildings® K-12 School Lighting Toolkit
- U.S. DOE: Better Buildings® High-Efficiency Troffer Lighting Toolkit
- U.S. DOE: Better Buildings® Integrated Lighting Campaign
- U.S. DOE: Better Buildings® IoT Upgradable Lighting Challenge
- U.S. DOE: Better Buildings® Lighting & Electrical
- U.S. DOE: Better Buildings® Outdoor Lighting Toolkit
- U.S. DOE: Better Buildings® Outdoor Lighting Technical Resources

DOE Better Buildings® K-12 School Lighting Toolkit


*Lighting Improvements*

Retrofit with CFLs, T-5, T-8

- U.S. DOE: Energy Asset Score Recommendations Guide, pp. 8-10

Install spectrally enhanced lighting

- U.S. EPA: ENERGY STAR® Building Upgrade Manual Chapter 7: Supplemental Load Reduction, pp.13

Retrofit with fiber optic lighting technologies

- U.S. EPA: ENERGY STAR® Building Upgrade Manual Chapter 13: Facility Type: Retail Stores, pp.8

# Future Plans

## Through End of Project:

- ***No major changes to project plan***
  - Finalize representative databases
  - Finalize benchmark statistics
  - Add normalization factors to BETTER K-12 schools algorithms to account for school calendar (e.g., occupancy/schedule)
  - Update EEM implementation resources and health guidance
  - Conduct validation and stakeholder engagement

## After End of Project

- ***Focus on underserviced space types***
  - Conduct promotion and training through Better Buildings®, Better Climate Challenge™, Efficient Healthy Schools, etc.
  - Develop case studies
  - Add new space types (e.g., museums, libraries, courthouses, detention centers)
- **Global application with USAID in Spanish and French-speaking countries**

# Thank You

Performing Organization(s)
Lawrence Berkeley National Laboratory
McQuillen Interactive Pty Ltd.
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WBS# 2.5.3.40

# REFERENCE SLIDES

# Project Execution

| | FY2023 | | | | FY2024 | | | | FY2025 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Planned budget | $200k | | | | TBD | | | | TBD | | | |
| Spent budget | $65k | | | | | | | | | | | |
| | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| **Past Work** | | | | | | | | | | | | |
| Q2 Milestone: Monthly energy data vizualization | ◆ | | | | | | | | | | | |
| **Current/Future Work** | | | | | | | | | | | | |
| Q3 Milestone: K-12 database completed | | ◆ | ◆ | | | | | | | | | |
| Q3 Milestone: K-12 statistics completed | | ◆ | ◆ | | | | | | | | | |
| Q3 Milestone: K-12 EEMs added to BETTER | | ◆ | ◆ | | | | | | | | | |
| Q4 Milestone: Normalization factors for K-12 | | | | ◆ | | | | | | | | |
| Q4 Milestone: K-12 outreach / validation completed | | | | ◆ | | | | | | | | |
| Q4 Milestone: Small commercial database completed | | | ◆ | ◆ | | | | | | | | |
| Q4 Milestone: Small commercial statistics completed | | | ◆ | ◆ | | | | | | | | |

- Slipped milestones due to: (a) FY22 carryover work to add multifamily benchmark statistics and window upgrade measures (completed end of Q1); (b) cost-shared work from USAID to add net zero energy analysis capability and language toggle (to be completed end of Q3); and (c) request from DOE to delay development of small commercial benchmark statistics until May/June 2023. Permission was gained from DOE for all slipped milestones.

# Team

**Carolyn Szum**
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**Robin Mitchell**
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- Staff Software Developer, LBNL

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- Software Developer
- Founder, McQuillen Interactive Pty. Ltd.