



Data-Driven Analysis Tool Plays Critical Role in Climate Neutral Buildings Improving energy efficiency and reducing emissions

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A new web application that advances the science of data-driven, remote building energy analysis to increase the speed and scale of retrofits worldwide could play a key role in reducing greenhouse gas (GHG) emissions and meeting the Paris Agreement's targets. The multi-award-winning Building Efficiency Targeting Tool for Energy Retrofits (BETTER) is a public access web application (better.lbl.gov) sponsored by the U.S. Department of Energy (DOE) and developed by Lawrence Berkeley National Laboratory (Berkeley Lab) and Johnson Controls.

Buildings contribute substantially to GHG emissions, accounting for 39% of global carbon dioxide (CO₂) emissions when considering emissions from operations, materials, and construction [1]. In order to meet the 2°Celsius (C)/1.5°C global warming target in the Paris Agreement, reducing global CO₂ emissions from existing buildings needs to be a priority [2].

However, preparing buildings for retrofits traditionally requires expensive individual on-site audits or complex and time-intensive simulation models [3]. As a result, the vast majority of building owners fail to pursue cost saving retrofits, and according to Architecture 2030, less than 1% of buildings globally are retrofitted each year [4].

To address these barriers, BETTER offers an easy-to-use web interface and powerful, open-source analytical engine to estimate the size and make up of EE projects in buildings and portfolios. By analyzing easily-accessible building data and monthly energy usage in response to weather conditions, it quickly benchmarks a building's or portfolio's energy use against peers; quantifies actual energy, cost, and GHG reduction potential; and recommends EE improvements, targeting specific savings levels.

Compared with other widely used energy benchmarking and retrofit analysis tools, such as U.S. DOE's Asset Score, International Finance Corporation's (IFC) Excellence in Design for Greater Efficiency (EDGE), and U.S. Environmental Protection Agency's (EPA) ENERGY STAR® PortfolioManager®, BETTER introduces several promising new capabilities. First, with fewer data inputs than these tools, BETTER offers a way to analyze one building to several hundred buildings in a single analytical run. This scalability allows users to quickly and easily screen a portfolio to identify which buildings may require capital investments; which buildings' design, technology, and operational best-practices can



BETTER earned a 2020 R&D100 Award, the "Oscar of Innovation," and a 2020 Berkeley Lab Director's Award for Exemplary Achievement in Technology Transfer.

be shared across the portfolio; and which buildings are good candidates for operations and maintenance tune-ups. The EE recommendations for a portfolio also enable users to understand which systems or equipment upgrades can be implemented at scale and potentially qualify for bulk purchase or financing discounts. Second, BETTER's three target levels of energy savings provide users with flexible options to improve building and portfolio EE. Users can gradually increase the level of savings and investment in EE over time. Third, unlike the other building energy analysis tools, which are designed solely for the United States, or a limited number of countries, BETTER can be used globally. Fourth, BETTER can be used to calculate building and portfolio operating cost savings potential, a driving motivator for retrofit projects that other available tools do not provide. Finally, BETTER's analyses can all be provided without having to set foot in a building. Thus, EE workers can continue to plan EE retrofit projects even when on-site audits are not fea-

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sible. This can help preserve vulnerable EE jobs during the COVID-19 pandemic [5].

BETTER is in beta version and going through a rigorous two-step verification and validation process. First, the functionality of BETTER is being verified using EnergyPlus™, a whole building energy simulation tool. Researchers designate specific system deficiencies (e.g., inefficient lighting system or poor insulation) in an EnergyPlus simulation of a batch of buildings, and they then check to see if BETTER accurately diagnoses those designated deficiencies from simulation results. Second, researchers are validating BETTER by comparing its predicted savings and EE measures against actual savings and EE measures for retrofit projects.

Conservative estimates indicate BETTER will help reduce approximately 0.60 quads of site energy use and 58.9 megatons of carbon dioxide equivalent (MtCO_{2e}) by 2030 in the United States, with substantial additional reductions globally.¹ Compared to demolishing and reconstructing a building, retrofitting a building can save 50~75% in embodied GHG emissions, thereby providing additional GHG emissions reductions to accelerate decarbonization of the buildings sector [6].

Currently, BETTER is being piloted by a diverse set of stakeholders across 33 countries in Asia, Europe, the Middle East, North America, and South America. These include energy service companies, government agencies, multinational corporations, financial institutions, universities, and non-profit organizations. To date, BETTER has received monthly energy data from more than 5,000 buildings across 46 building types globally.

In 2020, BETTER earned a R&D100 Award (the “Oscar of Innovation”) recognizing it as one of 2020’s 100 most innovative and disruptive technologies (the only winner in the building science domain) and a Berkeley Lab Director’s Award for Technology Transfer in recognition of exemplary efforts in building relationships with industry.

The next version of BETTER (to be released in Spring/Summer 2021) will offer enhanced data and analysis views and storage; easy export of self-contained, interactive analytical reports; and increased interoperability (e.g., RESTful application programming interface (API) and BuildingSync^{®2} file read and write capabilities) with tools such as U.S. DOE’s Asset Score, Audit Template, and the Standard Energy Efficiency Data (SEED) Platform™. BETTER already analyzes data transferred from U.S. EPA ENERGYSTAR[®] PortfolioManager[®].

To begin using BETTER, please visit <https://better.lbl.gov/>.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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¹ U.S. commercial buildings consume approximately 6.963 quads of total site energy and emit 685 MtCO_{2e} annually from electricity and natural gas [7-9]. Approximately 50% of U.S. commercial buildings were built before 1980 and are in need of a retrofit [7]. By 2030, BETTER will be used by approximately 20% of the U.S. commercial building floorspace, achieving 15% energy savings per square foot annually. Using those assumptions, estimates yield 0.6 quads of site energy savings and projected emissions reductions of 58.9 MtCO_{2e} by 2030 in the United States. This is estimated with high confidence based on publicly-available data on adoption rates and energy savings levels for similar tools in the U.S. commercial buildings marketplace [7-9].

² Building Sync[®] (<https://buildingsync.net/>) is a common U.S. schema for energy audit data.