Energy &
Homeland Security

BUILDING ENERGY MODELING

Sandia National Laboratories conducts energy efficiency and resilience studies for communities, cities, and institutions using building energy modeling (BEM), building system data, and climate data. Combined with analyses of the electric grid and other networks, Sandia's studies provide a holistic view to improve sustainability and resilience.

BUILDINGS: EMISSIONS & RESILIENCE

According to a review published by the Department of Energy, buildings account for around 76%[1] of electricity use in the United States. As much as 40% of total U.S. energy consumption has been attributed to commercial and residential buildings.[2] Building energy use and construction materials produce 39% of global greenhouse gas (GHG) emissions[3] and building GHG emissions are increasing despite energy efficiency and electrification efforts.[4] The buildings sector presents a major area of opportunity to mitigate climate change and its impacts.

Achieving Net Zero

Reversing increased emissions and attaining net-zero emissions from buildings will require a multi-disciplinary, system-wide approach and innovation. More energy efficient technologies such as light emitting diodes (LEDs) and high efficiency air conditioning (A/C) are essential to reversing increased building GHG emissions but are unlikely to fully eliminate them. Additional energy savings can be realized by smart systems that block unproductive energy use. Renewable energy sources are likely to offset GHG, but will also require large amounts of energy storage and advances in efficient electrical power delivery and conversion. Achieving net zero will require a complex combination of energy efficiency efforts, clean energy generation, and energy storage. When tightly integrated into infrastructure analysis, building energy modeling (BEM) enables realistic tradeoffs between competing approaches to reduce emissions.

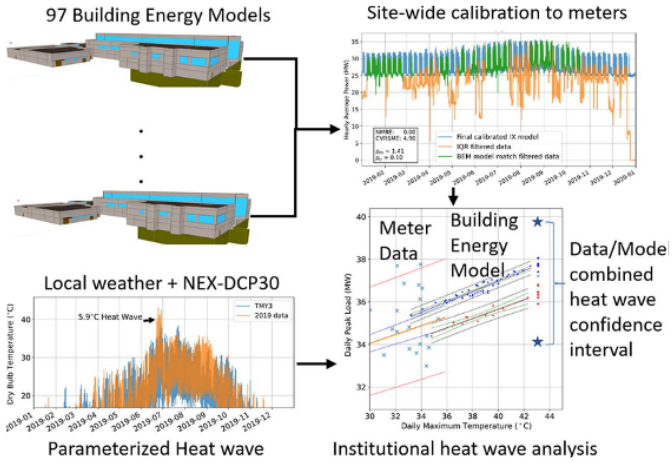
Enhancing Resilience

In addition to mitigating GHG emissions, buildings will play an essential role in adapting to the effects of climate change. Extreme weather, such as heat waves, can increase the demand for power and put power grids under pressure. Power outages can put individuals' health at risk in a community, such as when A/C becomes unavailable during extreme heat in summer or a building loses heat during dangerously cold temperatures in winter. The interplay of the resilience of the electric grid and the thermal resilience of buildings is another important consideration when planning for the effects of climate change.

SANDIA'S ROLE

BEM has mostly been used for building design and to assess building technologies. In collaboration with several Department of Energy offices and other national labs, research at Sandia is increasing the applications of BEM via detailed analysis of existing buildings, multi-sector infrastructure analysis, and studies of the effects of extreme weather on energy consumption.

Sandia has invested in 120 building energy models (BEMs) of its own site that have been repeatedly used for studies such as the site-wide heat wave sensitivity study pictured below.



Fusing BEM, historic data, and climate projections helps planners identify opportunities to reduce GHG emissions and improve resilience—such as in this analysis, which examines buildings' sensitivity to heat waves.

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An asset to Sandia, Sandia's BEMs have established new ways to evaluate energy efficiency for Sandia's New Mexico and California sites. Plans to establish Sandia's California site as a net-zero energy and emissions campus is one upcoming use of the 23 BEMs created for Sandia's California location.

Research at Sandia includes coordinated BEM and electric grid studies, thermal systems studies for connected communities for New Mexico residential development, software development to enable extreme weather analyses, and tiered circuits effects evaluations for combined building-microgrid analyses.

Sandia's work using BEM in multi-sector infrastructure analysis can help identify how the U.S. might address climate change and enhance energy security into the future. BEM advances benefit from coupling when useful to relevant device or system innovation activity at Sandia, including energy generation, storage and conversion.

FEATURED STUDIES

Villa, Daniel et. al. "Low Cost Community Microgrids by Efficiency and Reduced Availability." Paper to be presented at the ASHRAE Summer Meeting, Toronto, CA, June 25-29, 2022.

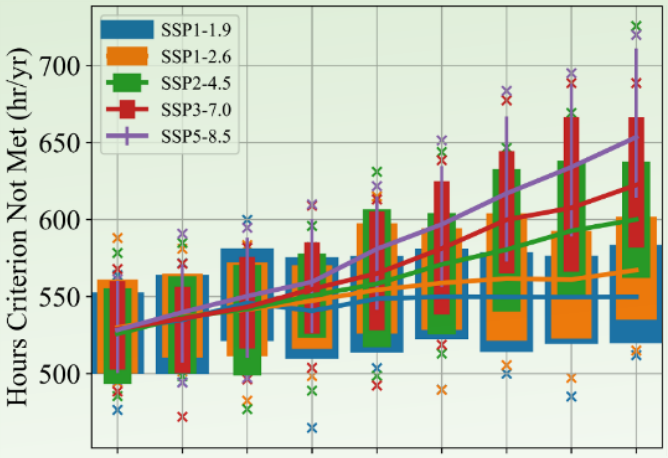
Villa, Daniel et. al. "Multi-Scenario Extreme Weather Simulator Application to Heat Waves." Paper to be presented at the Building Performance Modeling Conference and SimBuild, Chicago, IL, September 14-16, 2022.

Villa, Daniel, 2021. "Institutional Heat Wave Analysis by Building Energy Modeling Fleet and Meter Data." *Energy and Buildings* 237 (April 2021). doi: 10.1016/j.enbuild.2021.110774

FEATURED TOOLS

Multi-Scenario Extreme Weather Simulator (MEWS)

A tool called the multi-scenario extreme weather simulator (MEWS) has been developed for extreme weather boundary conditions on building energy models. MEWS uses historical weather and climate projections from the Intergovernmental Panel on Climate Change (IPCC) to output weather files for BEM.
www.github.com/sandialabs/MEWS



An analysis produced by MEWS projects thermal resilience in an office building considering acute heat waves and gradual climate change trends for IPCC scenarios.

Tiered Energy in Buildings (TEB)

A tool called Tiered Energy in Buildings (TEB) has been created in collaboration with a microgrid design analysis for the El Caño community in San Juan, Puerto Rico. As part of the analysis, the TEB tool helped illustrate how tiered configurations of residential and community center loads could reduce the cost of microgrids while increasing microgrids' ability to reliably supply critical loads.
www.github.com/sandialabs/TEB

1. https://www.energy.gov/sites/prod/files/2017/03/f34/qtr-2015-chapter5.pdf
2. https://www.eia.gov/tools/faqs/faq.php?id=86&t=1
3. https://architecture2030.org/why-the-building-sector/
4. https://www.iea.org/reports/tracking-buildings-2020

CONTACT:

Daniel L. Villa
dlvilla@sandia.gov
(505) 321-1269

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