# Modeling Buildings to Propel Decarbonization

How PNNL's modeling capabilities inform critical decisions and enable building owners to maximize energy performance and meet decarbonization goals.

Buildings use 75 percent of the nation's electricity and 40 percent of its total energy. They also account for 35 percent of the country's carbon emissions. Buildings are such a major component of our nationwide energy landscape, optimizing their energy performance can substantially drive our collective decarbonization goals. **The challenge—and the key to success—is aligning the needs of stakeholders, identifying effective and feasible paths toward meeting decarbonization targets, and informing policy accordingly.**

Government, academia, and industry are actively pursuing solutions to this challenge. To meet such ambitious building energy goals, the policy landscape is evolving and driving technology innovation. Building owners, operators, and managers are ultimately tasked with navigating and complying with many changing requirements while managing operational costs and complexity. They must also consider rapidly advancing technology and a dynamic landscape that requires them to adapt quickly and invest thoughtfully. It is increasingly critical to understand and select optimal pathways for complying with requirements, while maximizing building energy performance, short- and long-term cost impacts, and occupant comfort. The complexities can become a deterrent to progress across the spectrum of stakeholders.

Teaming with Pacific Northwest National Laboratory (PNNL) can be a solution. PNNL helps stakeholders analyze and improve the energy performance of buildings. By applying high-performance computing and our real-world building domain expertise, **PNNL can model decarbonization pathways, including energy efficiency, electrification, and demand flexibility for residential and commercial buildings across a range of scales.**

This capability underpins and drives holistic advancement in the building energy ecosystem, offering critical data to policy makers and tremendous relief to building owners with tools to guide successful improvements in building energy performance.

## PNNL LEVERAGES ENERGY MODELING CAPABILITIES TOWARD HIGHLY INTEGRATED SOLUTIONS

### Grid-Interactive Building Energy Management

Energy modeling experts at PNNL are studying the benefits and feasibility of a transactive energy system that would partner energy consumers and utilities to dynamically control big energy users like heat pumps and water heaters in buildings. This agreement between energy consumer and utility would allow better balance between grid supply and demand by offering additional flexibility in scheduled charging times and power consumption. To test such a system, PNNL recently completed the largest ever simulation of a transactive energy system. Modeled on the Texas power grid, the **study** concluded that consumers—including building owners—could save about 15 percent on their annual electric bill, helping maintain grid stability without sacrificing comfort or convenience.

PNNL's work can also be applied to other non-transactive, grid-interactive approaches.

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## NAVIGATING POLICY COMPLEXITY AFFECTING BUILDING OWNERS

Building owners are already navigating a complex web of energy-related requirements to propel building energy performance toward decarbonization. For example, building energy use benchmarking policies require annual reporting to measure energy performance relative to the same building over time or to other similar buildings. Auditing ordinances require periodic energy audits on certain buildings and implementation of recommended energy conservation or retro-commissioning measures. Building performance standards are a third, emerging class of localized policies that set energy performance and emissions levels that existing buildings must reach over specific timeframes, with measures in place to drive compliance.

Within this increasingly complex landscape, building owners are pressured to choose optimal pathways toward improved building performance. This requires a clear understanding of how to meet requirements while making the best long-term and economically sound investments in their buildings.

Building experts at PNNL have consulted with building owners nationwide to understand the intricacy of challenges, including policies and restrictions in their areas. PNNL translates the breadth and depth of this collected insight—paired with notable experience with energy systems and technologies at a range of scales, extensive data access and analytics, and relationships across the spectrum of stakeholders—into unmatched processes, tools, and recommendations to maximize building energy performance.

When making key energy decisions, policy makers, building owners, and other industry stakeholders strive toward maintaining building system efficiency, resilience, operating costs, and occupant comfort while balancing the impacts their actions have on decarbonization. With accurate building energy modeling and simulation and expert analysis of extensive data, they can be armed with an understanding of appropriate actions that can lead to better energy performance in new and existing buildings.

PNNL helps transform building energy performance by providing the extensive modeling data and analysis required to identify, contextualize, codify, adopt, and implement impactful efficiency measures at local to national scales. In fact, PNNL is a leading national laboratory in building energy codes, a critical subset of building codes that regulate 80 percent of a building's energy load and contribute to substantial energy savings nationwide. Applying its broad portfolio of advanced modeling capabilities and deep energy domain expertise, PNNL has even informed the development of new energy codes proposals and related policies that lead to more efficient buildings. This work includes extensive analysis of sensor-based and other data, modeling of past and future carbon impacts, and the development of intricate modeling tools to simplify code compliance for building owners.

## PROVIDING ACCESS TO POWERFUL TOOLS

Today's building owners need tools as sophisticated as their facilities—high fidelity modeling and highly detailed simulations of building systems and their increasingly complex interdependencies and behavior to make important planning, investment, and operational decisions.

PNNL has developed several tools that can assist stakeholders with different aspects of the energy performance requirements for new and existing buildings. This includes tools to evaluate and propose improvements to energy efficiency in existing residential and commercial buildings and help building owners comply

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with applicable benchmarking and auditing requirements. These tools come with standardized reporting formats that provide consistent data to cities, consumers, and other stakeholders and integrate with existing, widely adopted reporting tools. PNNL also develops and leverages tools to evaluate and improve energy efficiency and resilience in federal buildings, including to identify efficiency improvements that maximize life-cycle energy savings, optimize water use, and improve air quality.

Additional tools developed at PNNL help building owners verify compliance with energy codes and standards. This complex challenge requires extensive whole-building and system-based modeling capabilities coupled with the ability to reconcile building-specific energy performance data with available compliance pathways.

## PNNL LEVERAGES ENERGY MODELING CAPABILITIES TOWARD HIGHLY INTEGRATED SOLUTIONS

### Innovative Building Controls

At PNNL, another emerging focus area for improving energy performance is in optimizing building controls to improve energy use while maximizing occupant comfort and health. This includes evaluating technologies that trigger system adjustments based on changing environmental conditions and modeling their efficiency impacts.

PNNL experts have developed a variety of tools that can be used to build custom solutions—including models, predictions, and recommendations. Click the links or use the QR code to navigate to a page with more information on each tool.

| IMPACT QUANTIFICATION | ENERGY MODELS | COMMERCIAL ENERGY EFFICIENCY SCORE | COMMERCIAL BUILDING AUDIT |
|---|---|---|---|
| *GridPIQ* | *UrbanBEM* | *Asset Score* | *Audit Template* |
| Evaluates impacts of grid projects (photovoltaics, electric vehicles, storage, flexible loads). | Prototypical energy models to simulate loads for analysis. | Evaluates the “as-built” energy efficiency of a commercial building. | Collects, standardizes, and reports a building’s energy audit data. |

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| **UNIQUE BUILDING IDENTIFICATION**<br>***UBID***<br>Pinpoints the exact location and extent of space a building occupies for reliable information about spatial characteristics. | **ENERGY EFFICIENCY OPPORTUNITIES**<br>***FEDS***<br>Identifies energy efficiency improvements that maximize life-cycle savings. | **RESIDENTIAL ENERGY EFFICIENCY SCORE**<br>***Home Energy Score***<br>Evaluates the "as-built" energy efficiency of a residential home. |
| **ENERGY CODE COMPLIANCE**<br>***ResCheck™***<br>Determines if a new residential building meets energy codes. | **ENERGY CODE COMPLIANCE**<br>***ComCheck™***<br>Determines if a new commercial building meets energy codes. | **HVAC SYSTEM EFFICIENCY**<br>***TSPR***<br>Compares the heating and cooling load of a building to the energy consumed by the buildings entire HVAC system. |
| **INDOOR AIR QUALITY**<br>***H-BEST***<br>Evaluates building indoor environmental quality and cost/benefits of improvements. | **INTEGRATED GRID CO-SIMULATION**<br>***DSO+T***<br>Co-simulation of electrical grid, from generation to distributed energy resources and individual building loads. | **TRANSACTIVE ENERGY CONTROL**<br>***VOLTTRON™***<br>Flexible and extensible platform for distributed controls. |

## ABOUT PNNL

Pacific Northwest National Laboratory advances the frontiers of knowledge, taking on some of the world's greatest science and technology challenges. Distinctive strengths in chemistry, Earth sciences, biology, and data science are central to our scientific discovery mission. PNNL's research lays a foundation for innovations that advance sustainable energy through decarbonization and energy storage and enhance national security through nuclear materials and threat analyses. PNNL collaborates with academia in its fundamental research and with industry to transition technologies to market.

## CONTACT

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