July 2025

Looking Forward: How Power Market Forecasts Can Improve Energy Efficiency Planning

FTI CONSULTING

Executive Summary

Corporate energy managers are under increasing pressure to reduce energy costs and carbon emissions across complex real estate portfolios. Energy efficiency upgrades remain among the most accessible and scalable strategies for achieving these goals. However, deciding which upgrades to pursue—and where, when, and how to deploy them—has become increasingly difficult.

Traditional tools for evaluating energy efficiency investments typically rely on historical data or static assumptions: average utility rates, baseline emissions factors, and single-year savings estimates. While these approaches can provide directional guidance, they fall short when applied to long-term planning. In particular, they do not account for the changing dynamics of electricity markets or the evolving carbon intensity of the grid. This is a critical blind spot, especially as regulatory, market, and technological forces accelerate change in the power sector.

This paper evaluates a methodology that combines detailed building-level energy use simulations from the National Renewable Energy Laboratory ("NREL") ComStock model with FTI Consulting's ("FTI") U.S. Power Market Outlook, a long-term forecast of hourly electricity prices and marginal emissions rates across 136 market zones in the continental U.S. Integrating these two models produces a high-resolution dataset that quantifies the cost and emissions savings of energy efficiency upgrades over a 20-year planning horizon, by building, region, and hour.

The combination of hourly building electricity use and modeled grid price and emissions data allows for a robust, scenario-based framework for evaluating commercial building energy efficiency investments. Energy managers can use this approach to:

- Prioritize upgrades based on projected financial and environmental returns, accounting for region-specific grid characteristics and future market dynamics.
- Compare savings outcomes across a range of forecast scenarios, improving visibility into the risks and sensitivities associated with long-term investments.
- Align internal capital allocation with broader company forecasts, assumptions, or policy outlooks—for example, incorporating expected fuel price paths or carbon policy developments into the analysis.
- Optimize building portfolio strategies for cost savings, emissions reduction, or both, depending on organizational priorities.

The following analysis describes the underlying data sources, models, and assumptions applied in FTI's evaluation of this methodology. It also presents illustrative use cases demonstrating how this approach results in more informed decision-making by supporting a data-driven, forward-looking strategy for managing energy performance in commercial buildings.

Figure 1 demonstrates the difference between valuing ComStock's energy efficiency upgrades using a static forecast and using the 2025Q1 update of FTI's long-term forecast[1]. Each building model was analyzed under two approaches:[2]

- Using a static forecast of 2025 wholesale power prices applied to building energy use reductions over a 20-year planning horizon.
- Using FTI's long-term forecast applied to building energy use reductions over the same 20-year planning horizon.

FTI calculated the aggregate cost savings ratio of the full forecast approach to the static pricing approach for each building and upgrade over a 20-year planning horizon.[3] If the ratio is less than 1, the static forecast overvalues the energy cost savings from a given upgrade. If the ratio is greater than 1, the static forecast undervalues the energy cost savings from a given upgrade. The range of these ratios in Figure 1 is driven by several factors inherent to each building model, including the shape of their energy consumption over time and the power market zone in which they reside.

Figure 1: Per-building energy cost savings ratio between FTI and static forecasts

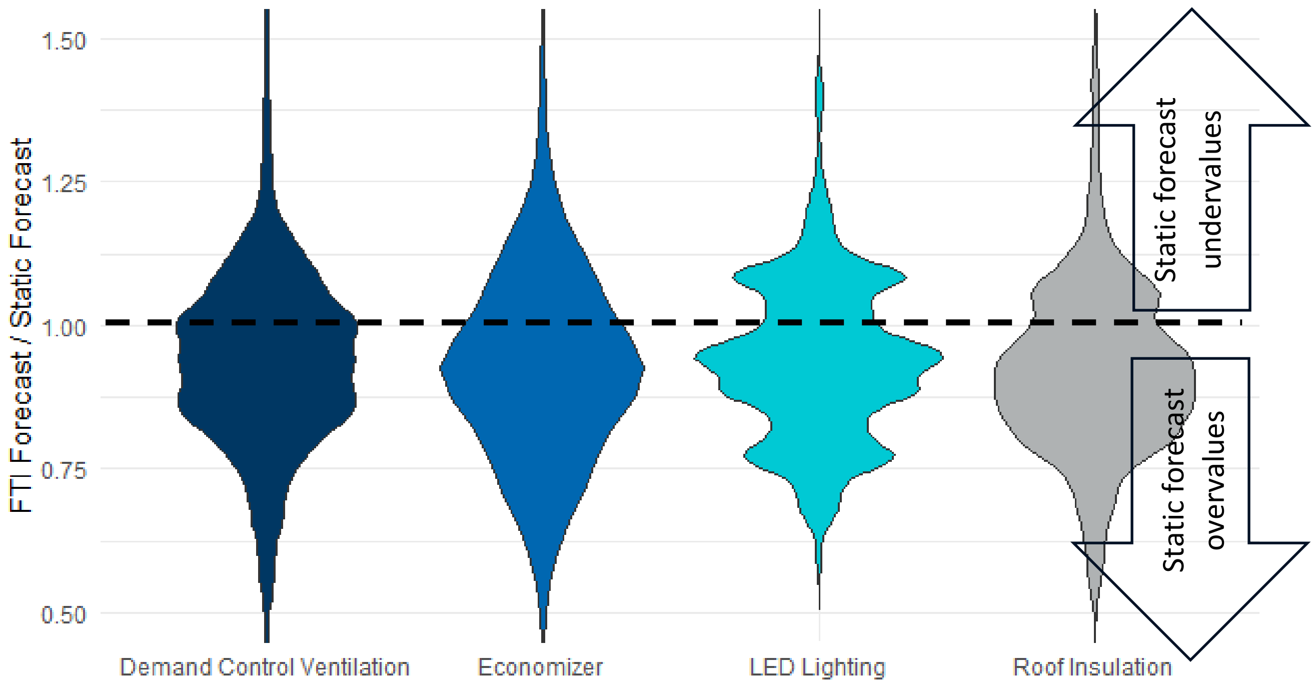


Figure 1 demonstrates that the static forecast tends to overestimate the long-term energy cost savings for each of the four selected energy efficiency upgrades. The 2025Q1 update of FTI's long-term forecast projected power prices across much of the country to decline over the next 20 years

[1] The 2025Q1 forecast update was prepared prior to the "One Big Beautiful Bill" being passed into law and thus does not account for the market impacts of relevant changes, such as the eligibility of wind and solar plants for federal tax credits.

[2] For comparability, FTI selected only those building models applicable for each of the efficiency upgrades under analysis.

[3] The set of buildings represented here includes all large standalone retail buildings and warehouses located within the continental U.S. More details on building selection are provided in the methodology.

due to the replacement of older inefficient thermal generation with new thermal generation and fuel switching, and the deployment of nascent technologies.[4] Under an updated forecast with rising prices, as may occur as a result of the "One Big Beautiful Bill," we would expect to see the static forecast more often *under*-estimate the potential cost savings of the selected energy efficiency upgrades.

However, the distribution of these ratios is wide. Thus, for any given building model, FTI's forecast approach could result in much higher or lower energy cost savings than the mean of the distribution. In either case, this comparison shows the importance of both location and energy market evolution on the benefits of efficiency measures on corporate energy managers' buildings. An energy efficiency investment that looks economic today may not be profitable over its full lifecycle, and vice versa. Valuation of energy efficiency upgrades can therefore be improved by incorporating forecasts of power market prices and other relevant grid attributes.

FTI performed a similar analysis to project the expected reduction in CO2 emissions that result from energy efficiency upgrades. Figure 2 illustrates the ratio of CO2 emissions savings between FTI's long-term dynamic forecast and ComStock's default forecast.

Figure 2: Per-building CO2 emissions reduction ratio between FTI and default ComStock forecasts

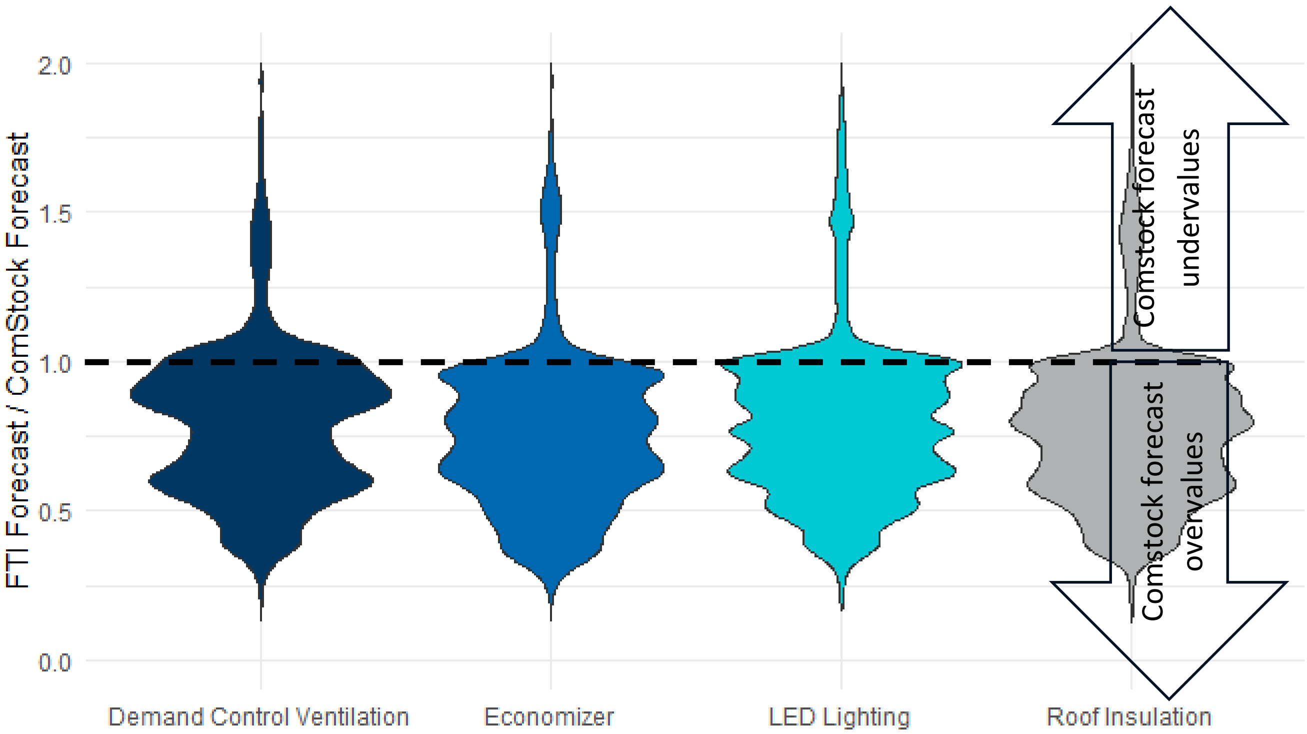


Figure 2 shows that using the default ComStock assumption tends to overstate the amount of emissions avoided by energy efficiency investments compared to the FTI modeling, which generally shows declining grid emissions rates over time. However, these results vary depending on the energy consumption profile of the buildings and grid decarbonization pathways.

[4] These projections do not account for the impacts of the recently passed "One Big Beautiful Bill"

Existing Tools and Limitations

A number of software tools exist to help commercial building owners and operators assess energy performance and identify opportunities for efficiency improvements. These tools vary in their inputs, outputs, and underlying methodologies, but most are designed to provide estimates of energy use, cost savings, or emissions reductions based on existing building data and standard assumptions. While they can be useful for benchmarking or initial screening, they generally do not incorporate long-term, dynamic forecasts of electricity prices or emissions rates—factors that can significantly influence the true value of energy efficiency investments over time.

- **ComStock** uses physics-based simulations of building energy consumption to estimate energy consumption patterns and changes resulting from energy efficiency upgrades across the US building stock. ComStock then estimates the monetary value of energy efficiency upgrades using historical static utility rates from NREL's Utility Rate Database. ComStock estimates emissions savings using historical emissions rates from the EPA's Emissions and Generation Resource Integrated Database ("eGRID") and forecasted emissions rates from NREL's Cambium dataset. Although ComStock does use forecasted emissions rates, these forecasts are not aligned with the default ComStock price estimates and do not make use of scenario analysis.
- **ENERGY STAR® Portfolio Manager** allows users to input utility data and building characteristics to benchmark energy use and identify opportunities for efficiency improvements. The fate of this program is uncertain due to Trump administration cuts.
- **RETScreen®**, developed by the Canadian government, supports evaluation of building energy projects but does not appear to incorporate detailed power market forecasting.
- **Private real-estate energy management tools often** provide utility-bill-based recommendations to optimize building energy use, relying on existing consumption data and posted local utility rates.

While applicable in many contexts, these tools share a few limitations that reduce their utility for long-term planning:

- **Data dependency**: Most require access to historical utility bills and detailed building inputs, which may not always be available or easy to gather, particularly in early-stage planning or portfolio-level assessments.
- **Static assumptions**: Many methodologies rely on current or average power prices and emissions factors, limiting their ability to capture future trends and variability, especially at a sufficient temporal granularity to match a building's energy consumption profile.
- **Scenario constraints**: Few can model outcomes under alternative grid conditions or policy scenarios, even though such flexibility is increasingly important for investment planning.

These gaps point to the need for a more refined analysis that combines high-resolution building simulations with forward-looking, scenario-based power market forecasts. This approach supports more precise assessments of efficiency investments for use over long-term planning horizons.

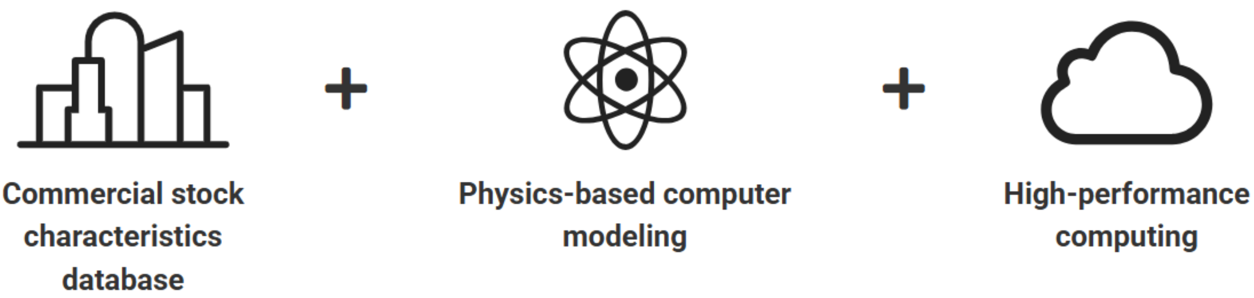
Methodology

To address these shortcomings, FTI integrated detailed building-level energy savings data from NREL's ComStock model with forward-looking power market forecasts developed for FTI's Power Market Outlook to evaluate the long-term financial and environmental outcomes of commercial building energy efficiency upgrades. This approach combines physics-based simulations of energy efficiency measures with granular projections of electricity prices and marginal emissions rates across U.S. power markets.

ComStock

The ComStock model, developed by NREL, is a high-resolution, bottom-up simulation platform designed to estimate energy consumption across the U.S. commercial building stock. It integrates diverse data sources, statistical sampling methods, and advanced building energy simulations to provide detailed energy use patterns and the potential impacts of energy-saving technologies.

Figure 3: ComStock Model Process



Source: ComStock Home Page (link)

Model Structure and Scope

ComStock encompasses approximately 350,000 unique building energy models, each representing a segment of the national commercial building stock.[5] These models contain detailed characteristics such as building type, construction year, HVAC systems, and occupancy schedules. This set of building models is calibrated to represent the actual distribution of building characteristics in the U.S. building stock. ComStock then adjusts applicable baseline building models to incorporate specific energy-saving measures. The simulation uses physics-based energy modeling to capture the nuances of energy consumption across different building types and regions.

ComStock is designed to represent a broad cross-section of the U.S. commercial building stock, capturing approximately 65% of total national commercial floor area.[6] The model includes detailed representations of key building types such as offices, retail stores, schools, hospitals, hotels, and warehouses—sectors that account for the majority of energy usage in the commercial sector.

---

[5] Parker, Andrew, et al. 2023. ComStock Reference Documentation. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5500-83819. https://www.nrel.gov/docs/fy23osti/83819.pdf.

[6] Ibid.

However, the model does not currently include certain building categories such as laboratories, data centers, refrigerated warehouses, agricultural buildings, and some forms of mixed-use space. These exclusions reflect either the lack of sufficient national data for accurate modeling or the highly specialized nature of energy use in those facilities. As a result, while ComStock offers robust coverage for most conventional commercial buildings, it is not intended to capture energy patterns in niche or highly specialized building types.

Energy Efficiency Measures

ComStock allows the user to assess the potential energy savings across different building types and regions by simulating a wide array of energy efficiency upgrades. The model's detailed outputs support the evaluation of measures such as envelope improvements, HVAC system upgrades, lighting retrofits, and building system control strategies.

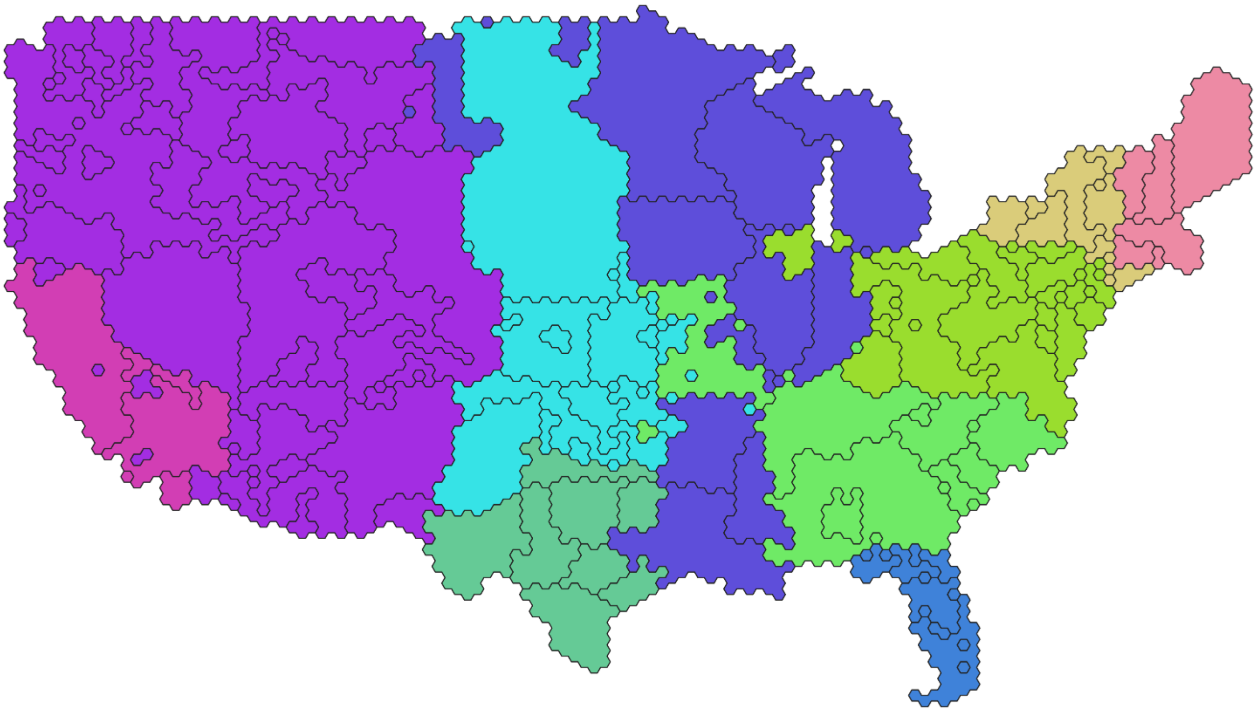
Simulation Outputs

ComStock outputs energy consumption data at 15-minute intervals for a representative weather year (AMY2018), enabling granular analysis of building load profiles. This high temporal resolution allows the user to assess load profiles and evaluate the impacts of energy efficiency measures under varying conditions. The simulation outputs include end-use load profiles that distinguish between energy consumption across various systems, such as heating, cooling, lighting, and plug loads.

FTI’s Power Market Forecast

This analysis relies on FTI Consulting’s U.S. Power Market Outlook, a long-term forecast of electricity prices and marginal emissions rates across the continental U.S., to assess the future value of energy efficiency investments. FTI’s proprietary U.S. Power Market Outlook provides hourly forecasts through 2050, covering 136 market zones and offering a detailed view of regional power dynamics.

Figure 4: Map of FTI's U.S. Power Market Outlook model zones



Forecasting Framework

FTI builds zonal power market datasets using a combination of public and private data. These datasets serve as inputs for PLEXOS®, a widely adopted platform for simulating electricity markets, to solve capacity expansion and production cost modeling problems.[7] The FTI datasets and PLEXOS® simulations employ a fundamental, bottom-up approach to model the dispatch and operation of power systems, incorporating detailed representations of generation units, transmission networks, and market rules. The model solves for least-cost dispatch while respecting operational constraints, such as generator ramp rates, minimum up/down times, transmission limits, policy constraints, state renewable portfolio standards, or participation in regional emissions markets. This allows for the simulation of market outcomes under various scenarios, including changes in fuel prices, demand growth, and policy interventions.

Key Inputs and Assumptions

The FTI Power Market Outlook incorporates a range of inputs and assumptions to capture the complexities of the evolving energy landscape:

- **Generation Fleet Data**: Detailed information on existing and planned generation units, including capacities, heat rates, fuel types, and emission rates.
- **Demand Profiles**: Hourly load forecasts reflecting regional consumption patterns, economic growth, and electrification trends, based on the most current forecasts from grid operators.

[7] https://www.energyexemplar.com/plexos

- **Policy and Regulatory Scenarios**: Incorporation of renewable portfolio standards, carbon pricing mechanisms, and other regulatory frameworks that influence market dynamics.
- **Transmission Constraints**: Modeling transmission network limitations and planned expansions, affecting interregional transmission capacities.

Outputs Relevant to Energy Efficiency Analysis

The key outputs from the power market modeling, used in conjunction with the ComStock data, are:

- **Electricity Prices**: Hourly price forecasts that reflect the marginal cost of electricity supply, accounting for fuel costs, generator dispatch, and transmission constraints.
- **Emissions Rates**: Hourly estimates of CO_2 emissions per unit of electricity generated, capturing the average carbon intensity of generation.
- **Scenario Analyses**: Evaluation of alternative futures that reflect changes in market factors, such as declining capital costs for generating technologies or higher load growth, and policy factors, like new emissions regulations or state technology-specific capacity targets, to assess the robustness of energy efficiency investments under varying conditions.

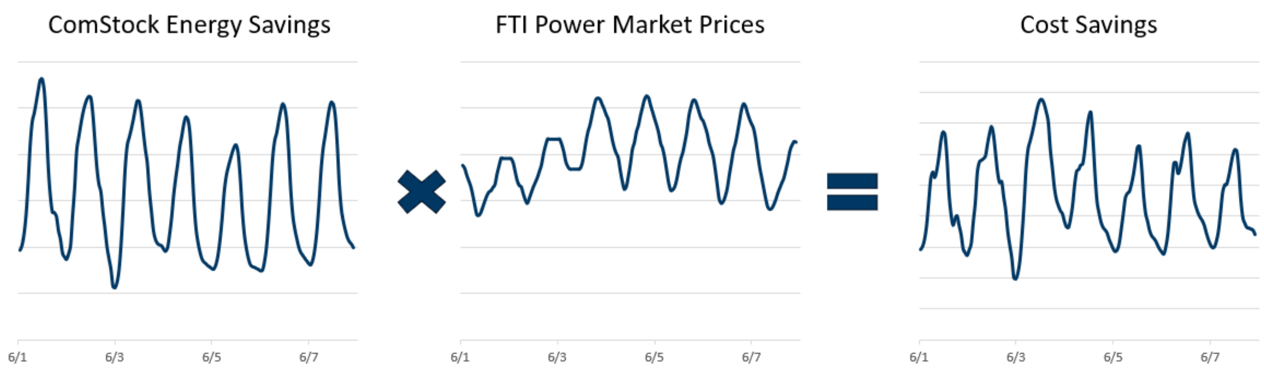
By aligning building energy savings profiles with these detailed market forecasts, FTI can quantify energy efficiency upgrades' temporal and locational value. This approach facilitates informed decision-making, investment prioritization, policy compliance, and sustainability strategies.

Model Integration

Each building in the ComStock dataset is geographically mapped to a corresponding power market zone in the FTI model. The hourly energy savings profile for each building is then matched to the hourly forecast of electricity prices and emissions factors for its zone and each forecast year. The result is a multidimensional dataset that quantifies:

- **Hourly cost savings** from avoided electricity purchases
- **Hourly emissions reductions** from avoided grid consumption
- **Annual and cumulative impacts** across buildings, regions, and planning years

Figure 5: Demonstration of model integration methodology



This framework allows energy savings to be expressed in kilowatt-hours, dollars, and metric tons of CO_2, incorporating time-of-use and location-specific factors.

Upgrade Measures

ComStock analyzes the energy savings from several energy efficiency upgrade measures. For this white paper, we consider the following upgrades that impact electricity consumption:

- **LED Lights:** This measure replaces existing interior lighting systems with Generation 5 LED lighting, targeting models without LED installations.
- **Roof Insulation:** This measure enhances roof insulation by increasing the R-value to meet the specifications outlined in ASHRAE's Advanced Energy Design Guide (AEDG) for the respective climate zone.
- **Air-Side Economizer:** This measure adds economizer controls to air handling units (AHUs) that do not already have this functionality. Economizers increase outdoor ventilation air during periods when the system requests cooling, and the outdoor air is sufficiently cool to be beneficial.
- **Demand Control Ventilation (DCV):** This measure implements DCV by modulating ventilation rates based on occupancy, reducing the rate at which outdoor air is delivered during periods of low occupancy.

Building Model Scope

This white paper considers a subset of all building energy models available in ComStock. To ensure comparability of results among building models, this paper considers only retail standalone buildings and warehouses in the continental U.S. of size greater than 25,000 square feet and less than 100,000 square feet for which all of the aforementioned energy efficiency upgrades are applicable.[8] This filtered set comprises over 8,200 building models from a total available set of over 346,000 building models.

Use Cases

The analysis presented in this report is relevant to energy planners, sustainability officers, and real estate portfolio managers seeking to minimize the operating costs and environmental footprint of their assets.

Minimizing Costs/Emissions

Organizations aiming to reduce energy expenditures face similar questions. Because electricity prices vary significantly by location, time of day, and season, and are expected to continue evolving, traditional static payback calculations may not provide a comprehensive financial picture.

FTI's modeling framework enables a more sophisticated evaluation of energy efficiency upgrades by aligning projected energy savings with long-term, hourly electricity price forecasts. This allows users to compare the expected cost savings of upgrades across different buildings and regions under a

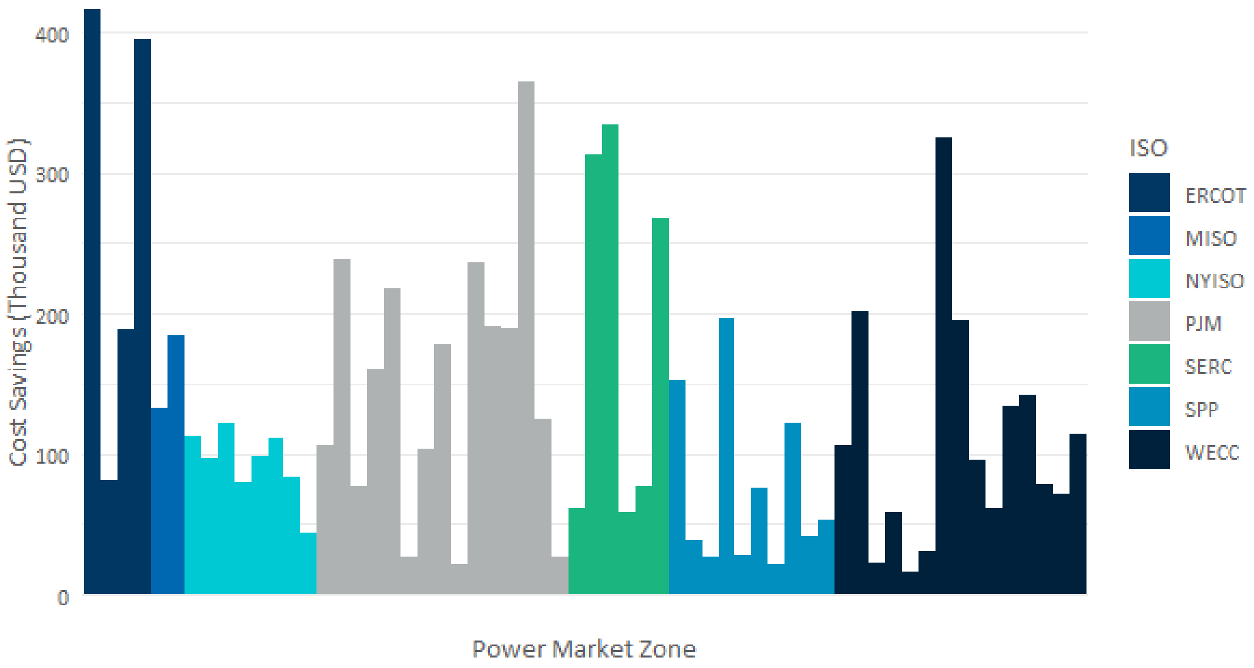
[8] Energy efficiency upgrades may not be applicable to certain buildings based on their physical attributes (e.g., restaurants may not use demand-control ventilation because they have a need for ventilation even during periods of low occupancy) or because the building already features the upgrade.

consistent set of future price scenarios. Because the forecasts incorporate temporal and geographic variations in electricity prices, users can move beyond simple energy savings metrics and instead prioritize upgrades based on projected avoided costs, factoring in time-of-use price dynamics that may vary substantially across market zones.

In addition, the framework supports scenario-based analysis, enabling users to test how upgrade performance changes under different policy or market trajectories. For example, users can examine how cost savings might vary under scenarios that assume carbon pricing, accelerated renewable energy deployment, or changes in peak demand patterns due to extreme weather. This flexibility allows organizations to better understand the range of possible investment outcomes and to plan accordingly under conditions of uncertainty. This approach supports more informed capital allocation across building portfolios, especially when budgets are constrained and investment decisions must be justified over long time horizons.

Figure 6 shows the average annual cost savings realized by upgrading roof insulation across power market zones and ISOs. Notably, variation within ISOs can be as significant as variation across ISOs. For instance, the average annual building cost savings from a roof insulation upgrade in PJM is much higher than the average cost savings realized in WECC. However, some power market zones in PJM see average annual cost savings of around $5,000, which is around the average cost savings within WECC, while other PJM zones see annual cost savings as high as $30,000.

Figure 6: Average Annual Roof Insulation Building Cost Savings by Market Zone[9]



For companies with carbon reduction targets, identifying the most effective deployment of capital across a distributed building portfolio is not as easy as comparing current emissions rates across geographies. By pairing ComStock simulations with emissions rate forecasts, FTI's framework allows

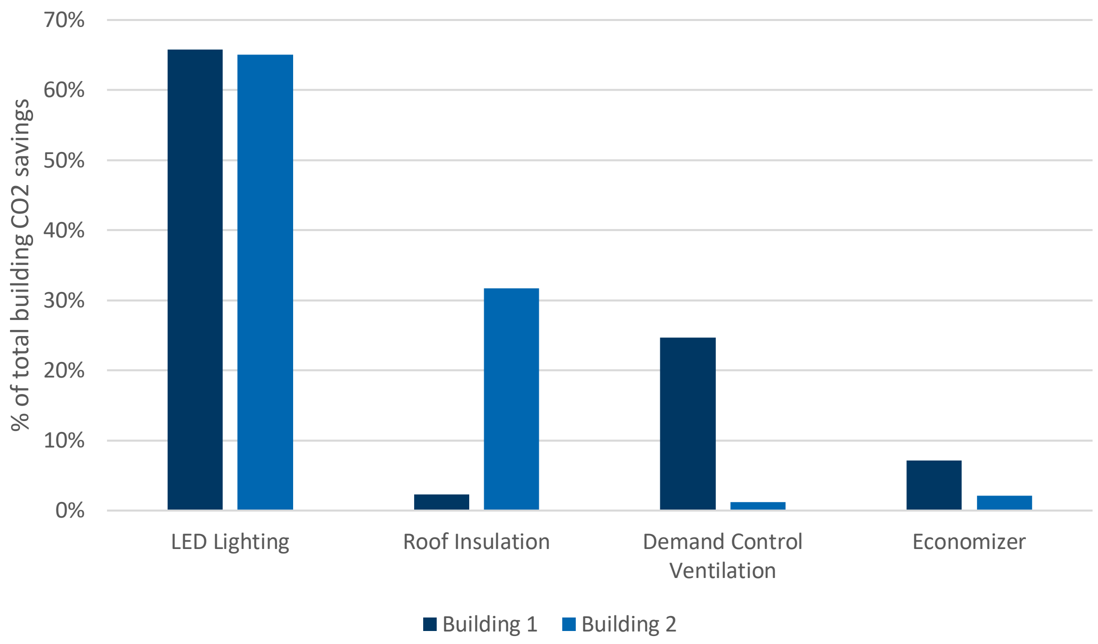
[9] Individual columns represent specific zones within each ISO.

users to identify where emissions reductions will be greatest, highlighting effective upgrades as well as the optimal location and timing for implementation of efficiency measures.

Prioritizing Efficiency Investments

FTI's approach also allows users to rank buildings or upgrade technologies by total projected savings or emissions reductions over a defined time horizon, supporting capital allocation decisions across an extensive portfolio. To illustrate that point, Figure 7 below shows an example where the annual average cost and emissions savings from 2025 to 2030 were calculated for each upgrade measure across two buildings selected at random from within the PG&E service territory.

Figure 7: Share of total energy savings by building (2025-2030)



In the example above, both Building 1 and Building 2 are retail standalone and operate within the same type of climate zone. They differ among many other characteristics, however, including their size. Building 2 is within the 50,000-100,000 square foot building size grouping, while building 1 is within the 25,000-50,000 square foot building size grouping.

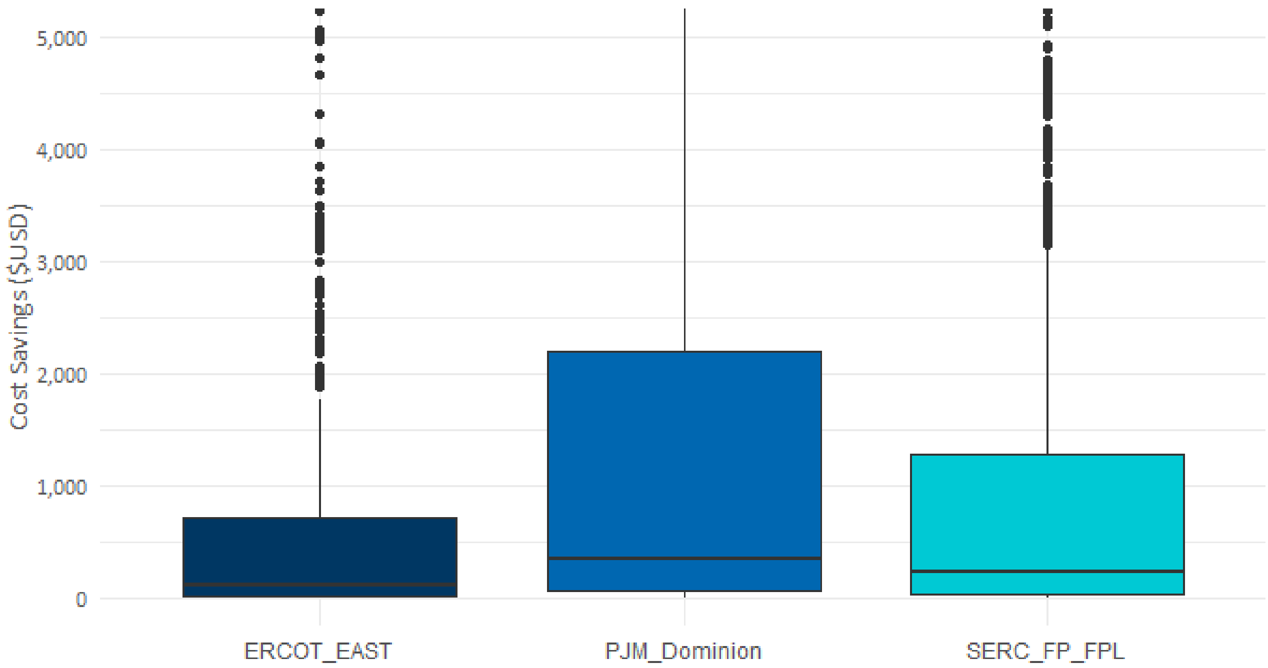
As can be seen from the chart, Building 1 sees a much greater CO2 savings impact from demand control ventilation than roof insulation, while Building 2 sees a greater effect from roof insulation. These results incorporate the different emissions intensities of each region, the interaction of hourly energy savings with hourly emissions intensity patterns, and the differing energy savings potentials of specific buildings. The building energy savings realized for each upgrade are also subject to the particular characteristics of the building model itself, and the large impact from the roof insulation upgrade for Building 2 may be a result of its larger square footage.

Regional Comparison

Power market zones vary in their hourly grid emissions intensities and power prices. An upgrade that fares well in one power market zone is not guaranteed to do so in another.

Figure 8 shows the distribution of building cost savings from a DCV upgrade across three market zones. The PJM Dominion zone sees the greatest median building cost savings of the three zones analyzed and a long tail of high annual cost savings. Average zonal cost savings differences are driven here not only by differences in zonal power prices, but also by hourly price shapes, which may increase or decrease total savings depending on the timing of upgrade energy savings. The nature of the upgrade will also affect the geographic distribution of building energy savings, with technologies such as economizers introducing value in mainly cool, dry climates.

Figure 8: Annual Building Savings Distribution from Vent Control by Region (2025)



Scenario Sensitivity

Recent regulatory developments, including changes to renewable energy tax credits introduced under the Inflation Reduction Act, underscore the uncertainty inherent in long-term power market projections and the sensitivity of electricity prices and emissions to policy shifts. To address this, FTI's forecasting framework includes a range of scenario analyses, including variations in fuel prices, renewable energy deployment, carbon policy adoption, and load growth.

Figure 9: Building Hourly Energy Cost Savings by Scenario

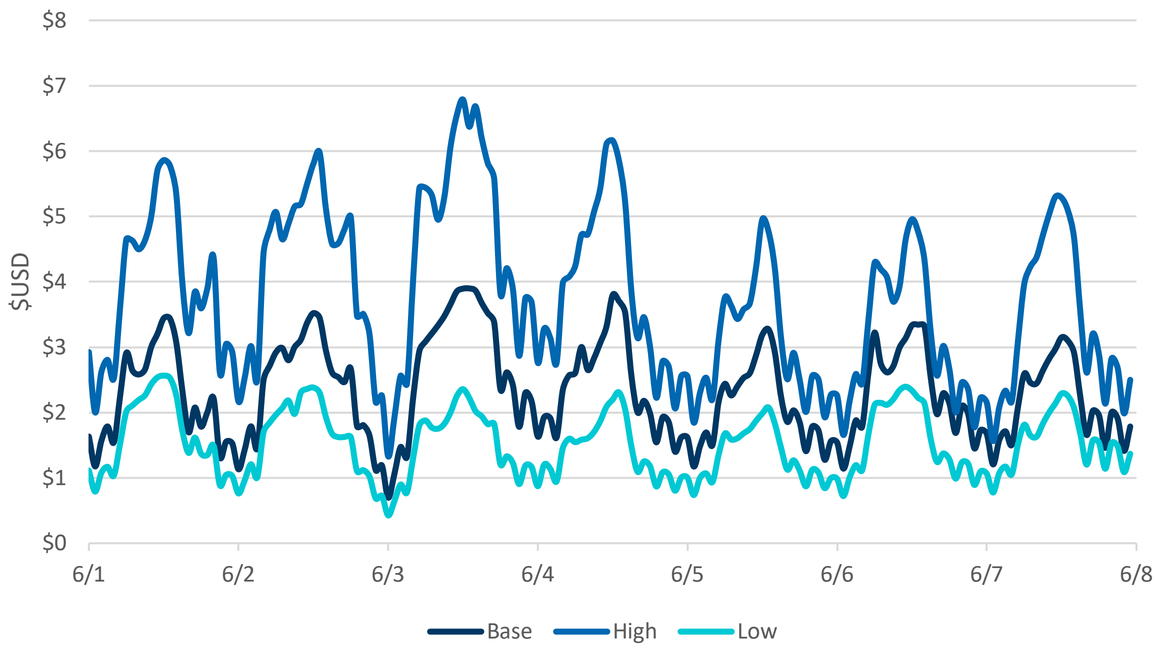


Figure 9 demonstrates a sample of these scenarios, demonstrating the differences in building energy savings among a high-, low-, and base price scenario. These scenarios offer a structured approach to evaluating how energy efficiency investments might perform under varying future conditions. By modeling a wide spectrum of outcomes, this approach supports planning that is resilient to market volatility and ensures that upgrade strategies remain effective even as external conditions evolve.

Conclusions

As companies continue to navigate an increasingly dynamic grid and expectations for environmental performance, data-driven planning methodologies, like the one outlined in this paper, will be critical.

Integrating hourly building energy use data with FTI's Power Market Outlook represents a more sophisticated and accurate approach for commercial energy managers who assess and prioritize energy efficiency investments. Rather than relying on static prices or average emissions rates, FTI's approach captures the nuance of real-world variability by hour, region, and across evolving market conditions. As shown in this analysis, the value of efficiency upgrades can vary significantly depending on how future grid dynamics unfold. Under traditional evaluation methods, investments that appear marginal or unattractive may have a high impact once the temporal and locational context is correctly accounted for and vice versa.

FTI's modeling framework allows users to:

- **Compare cost savings across buildings and regions** under multiple future price scenarios.

- **Prioritize upgrades based on projected avoided cost**, not just energy saved, accounting for time-of-use price dynamics specific to the relevant geography.
- **Evaluate performance under multiple price trajectories**, including regulatory or market-driven scenarios (e.g., carbon pricing, increased renewables penetration, extreme weather impacts).

FTI's approach facilitates more accurate valuation and more strategic action. Organizations can prioritize upgrades that best align with their cost reduction or decarbonization goals using robust simulations rather than simple assumptions. They can compare opportunities across their portfolios using a common framework and make investment decisions resilient to regulatory shifts, market volatility, and changing business needs. Perhaps most importantly, this framework allows energy and sustainability teams to translate kilowatt-hours into avoided costs and emissions into avoided risk or progress towards goals.

F T I CONSULTING