ComStock Impact Analysis Workbook

How it Works and How to Responsibly Use the Data

The ComStock Impact Analysis Workbook was developed for users seeking to better understand their commercial building stock, evaluate upgrade potential, explore energy or emissions reduction strategies, and more. Programs that aim to characterize, direct, and measure strategies for reducing energy in the built environment often require extensive time and resources for data collection and analysis. Whether you're managing a portfolio as a jurisdiction, organization, or private entity, having a clear understanding of the state of existing building stock is critical—particularly in cases where benchmarking data is limited or unavailable. This workbook, based on the published ComStock 2024 Release 2, provides insights into baseline building stock and the energy and emissions impacts of upgrades to help inform decision-making and support commercial building programs.

In many cases, ComStock, which is based on numerous data sources, statistical sampling methods, and physics-based building energy modeling, likely represents the best available dataset of commercial buildings beyond benchmarked energy data. Note that the ComStock data set accounts for 64% of the energy use and 62% of the floor area of commercial buildings in the United States compared to the Commercial Building Energy Consumption Survey (CBECS). The remaining 36% of energy use not represented is due to several CBECS building types that are not yet included in ComStock, such as grocery stores and religious worship. For more information on buildings not included in ComStock, see https://nrel.github.io/ComStock.github.io/docs/resources/explanations/building_types_not_included.html.

Using the ComStock dataset filtered to a specific geographic region, users can gain valuable insights into their commercial building stock and assess the impact of over 30 modeled building upgrades featured in ComStock. These upgrades represent a wide range of energy efficiency measures and emerging technologies targeting heating, ventilation, and air conditioning (HVAC), envelope, lighting, equipment, demand flexibility, and bundled upgrade solutions. The ComStock Impact Analysis Workbook enables users to understand how energy and emissions are affected by each upgrade, helping them make informed decisions such as setting realistic square footage thresholds, evaluating energy or emissions reduction targets, prioritizing upgrades, or identifying building types with the highest impact potential to support their goals.

On each tab, there will be a Tab Description that outlines what data and plots can be found on that tab. Note that many of the tabs are based on pivot tables that must be refreshed if anything in the raw data tab is altered. If you plan on making any manual changes to the workbook or the raw data, make sure to navigate to Data >> Refresh All in order to refresh all pivot tables and plots in the workbook.

Please contact us at comstock@nrel.gov if you have feedback or any questions about the workbook.

Selecting Geography of Interest

Using the script provided and its embedded instructions, input your geographies of interest in the required format. If you are interested in an entire state, you must include all counties in the state. If your geography of interest spans multiple states (e.g. Kansas City), you need to include both states and their associated counties of interest in the script.

Behind the scenes, we will query and filter down the ComStock dataset to only the counties you've selected. In addition, we will remove extra columns that are not required for this analysis to reduce the size of the data file. There is a chance that the geography selected is too large to be analyzed due to Excel row limits. This will most likely only be an issue if you are interested in a full state or a large selection of counties. If this is the case, please reduce the size of your geography or contact comstock@nrel.gov to discuss alternative options.

Understanding the Excel Workbook

After you've run the script with your selected geography, a csv file will download to your computer at the location you selected in the script. Follow the instructions to copy and paste the data in the ComStock Impact Analysis Workbook and refresh the data. Once this process is complete, you will have an Excel workbook with the raw ComStock data for your geography, as well as a number of tabs with information about your building stock. This section will walk through the tabs and explain how you might use the data provided on each tab.

Table of Contents

Contains a list of all tabs in the workbook, including Tab Number, Tab Name, and a link to the tab for quick navigation.

Tab 1: This Workbook

Summarizes the purpose of the workbook, links to relevant data sources, and other important things to know before using the workbook.

Tab 2: Raw Data

This tab contains the raw ComStock data for all buildings in your selected geography, including the baseline and all upgrades. Each row represents a building model in ComStock. The "upgrade" column denotes which upgrade each row of data corresponds to. This tab feeds into the tables and plots on all of the subsequent tabs.

Tab 3: User Inputs – Set Targets

This tab allows the user to input Energy Use Intensity (EUI) and Greenhouse Gas (GHG) emissions targets by building type for their jurisdiction. EUI is a metric that measures the annual energy use of a building per square foot. The average EUIs by building type for the baseline stock are shown in Column B, which the user can use to estimate realistic EUI reductions for their target-setting. The default target EUI is the average EUI of the baseline (from Column B). Similarly, the total GHG emissions by building type for the baseline stock are shown in Column B. The user can then set emissions percent reduction targets that align with their goals. The default GHG reduction target is 10%. In tabs later in the workbook, the user will see which of the upgrades in ComStock will help them reach (or get closest to) their targets for each building type. The user can experiment with different values in this tab and the subsequent tabs and plots will be updated accordingly.

"Baseline" Tabs

There are 9 tabs that begin with "Baseline" which characterize the baseline (or existing) commercial building stock of the selected geography. These tabs break out the baseline stock by various characteristics, including building size, building type, energy end use, and more. These tabs help users understand which segments of buildings are contributing most to their energy use and emissions across the entire building stock, which can help prioritize and inform targets and policy decisions. A brief summary of each tab is below:

Tab 4: Baseline – Floor Area Totals

Summarizes the breakdown of buildings included in the selected geography by county. The "Number of Buildings in ComStock" is the number of building models in ComStock for the selected geography. Because ComStock does not model every single commercial building in the U.S., a weighting factor is applied to scale up the number of buildings and the floor area represented by the models in ComStock. The "Number of Buildings Represented" and "Total Floor Area" columns represent the totals after the scaling factors are applied.

Tab 5: Baseline – By Size

Shows the breakdown of buildings by size, separated into floor area bins. The four plots show the number of buildings represented, floor area, site energy, and emissions all broken out by building size. Often, this tab will reveal that small buildings (<50k sqft) will make up a large fraction of buildings by count, but a much smaller fraction of total floor area, site energy, and emissions.

Tab 6: Baseline - By Size & Type

Shows the breakdown of total site energy by building size and building type.

- "Warehouse and Storage" includes conditioned and unconditioned warehouses.
- "Office" includes small, medium, and large offices.
- "Mercantile" includes strip malls and standalone retail (excluding grocery stores).
- "Lodging" includes small hotels/motels and large hotels.
- "Healthcare" includes hospitals and outpatient clinics.
- "Food Service" includes fast food restaurants and sit-down restaurants.
- "Education" includes primary and secondary schools.
- All other building types are not modeled in ComStock. See https://nrel.github.io/ComStock.github.io/docs/resources/explanations/building_types_not_included.html for more information on building types not included in ComStock. The most substantial building types not in ComStock include colleges/universities, religious worship, and grocery stores.

Tab 7: Baseline – By End Use & Fuel

Shows the breakdown of site energy use by end use and fuel type. End uses include HVAC, lighting, interior equipment, water systems, and refrigeration. Fuel types include electricity, natural gas, other fuel (includes propane and fuel oil), and district heating and cooling.

Tab 8: Baseline – HVAC

Shows the breakdown of total energy use by end use, then further breaks down HVAC energy use by HVAC system types. HVAC systems in ComStock are broken out into 5 categories – Multizone Constant

Air Volume/Variable Air Volume (CAV/VAV), Small Packaged Unit, Zone-by-Zone, Residential Style Central Systems, and Other HVAC. Also includes HVAC energy use by building type and HVAC system type.

Tab 9: Baseline – Interior Equipment

Shows the breakdown of total energy use by end use, then further breaks down Interior Equipment energy use by fuel type (natural gas, electricity). Electric interior equipment refers to a vast range of electric plug and process loads, including (but not limited to) computers, office equipment, data centers, medical equipment, clothes washers and dryers, electric cooking equipment, and more. Gas interior equipment primarily refers to cooking equipment, as well as a small fraction of gas clothes dryers or medical equipment. Also includes Interior Equipment energy use by building type and fuel type.

Tab 10: Baseline – Lighting

Shows the breakdown of total energy use by end use, then further breaks down Lighting energy use by lighting type (i.e. "lighting generations"). Lighting types in ComStock are broken out into 5 generations – Generation 1: T12/Incandescent, Generation 2: T8/Halogen, Generation 3: T5/CFL, Generation 4: LED, and Generation 5: LED. Also includes Lighting energy use by building type and lighting generation.

Tab 11: Baseline – Water Systems

Shows the breakdown of total energy use by end use, then further breaks down Water Systems energy use by fuel type (natural gas, electricity, district heating, other fuel). Also includes Water Systems energy use by building type and fuel type.

Tab 12: Baseline – Segments

Shows the breakdown of total energy use by "addressable segment". The 9 unique stock segments are common combinations of building types and HVAC systems, which are useful when identifying stock segments that can be addressed by similar types of upgrade measures. More information about the segments and how they were defined can be found here: https://www.nrel.gov/docs/fy22osti/83063.pdf.

"Upgrade" Tabs

There are 6 tabs that begin with "Upgrade" which demonstrate the impacts of ComStock's modeled upgrade measures in the selected geography. These tabs focus on energy, EUI, and emissions impacts of the 39 upgrade measures in the ComStock 2024 Release 2 dataset against the baseline commercial building stock. A list of the measures in ComStock, along with links to their full measure documentation, can be found here:
https://nrel.github.io/ComStock.github.io/docs/upgrade_measures/upgrade_measures.html

Some of the tabs show the impacts of the full stock in the selected geography, while others split out the impacts by building type. In addition, the targets set in the "User Inputs – Set Targets" tab are used in the "Upgrade" tabs so the user can visualize which upgrades will meet their EUI or emissions targets by building type. The user can go back and modify their targets, and the plots in the "Upgrade" tabs will automatically update based on the adjusted targets.

The goal of the "Upgrade" tabs is for the user to understand which upgrades will have the largest impact on their building stock and begin to prioritize building types or upgrades that will help achieve their energy or emissions goals. A brief summary of each tab is below:

Tab 13: Upgrades – Lookup Table

Provides a list of all upgrades included in the ComStock dataset, along with the Upgrade ID and the percent of stock floor area that each upgrade is applicable to. Applicability of each upgrade is determined during the modeling process and is documented in the published measure documentation for each measure. Upgrade applicability is meant to represent realistic retrofit scenarios and therefore can be based on numerous factors such as building type, HVAC system type, or baseline system performance of each building. Applicability percentage varies from ~10% to 100% of the stock, so this can have a drastic impact on the savings and impact potential of each upgrade. The Upgrade ID (rather than the full upgrade name) is used in the plots on subsequent tabs for brevity; therefore, this tab serves as a mapping from the Upgrade ID to the full upgrade name. Please note, it is not advised to add the savings of multiple upgrades together to assume the combined effects. The upgrade packages shown in the workbook do take into account the combined measure interactions, so the savings from the packages should be used to understand the impacts of some common measure combinations. See this page for more details:
https://nrel.github.io/ComStock.github.io/docs/resources/explanations/combining_measure_results.html.

Tab 14: Upgrades - EUI Targets Met

Shows the fraction of building floor area under each upgrade scenario that meets the user's EUI targets by building type (specified in Tab 3). Plots adjust dynamically if the user modifies the EUI targets. Because of the diversity of building characteristics modeled, buildings of the same type can have drastically different EUIs and therefore it can be difficult to achieve 100% EUI compliance with a given upgrade. However, this tab helps the user understand which upgrades can get a vast majority of the stock to adhere to the EUI targets, as well as identify which upgrades are most effective in which building types.

Tab 15: Upgrades – Site Energy

Shows the total site energy of the selected geography under each upgrade scenario. Upgrades are color coded by category – envelope, HVAC, lighting, equipment, demand flexibility, and upgrade packages. This tab allows users to quickly see which upgrades save the most site energy in their building stock.

Tab 16: Upgrades – EUI by Building Type

Shows the average EUI by building type under each upgrade scenario. Upgrades are color coded by category – envelope, HVAC, lighting, equipment, demand flexibility, and upgrade packages. This tab allows users to identify which upgrades are most effective in reducing EUI in which building types.

Tab 17: Upgrades – Total Emissions

Shows the total greenhouse gas emissions across all fuels under each upgrade scenario. Upgrades are color coded by category – envelope, HVAC, lighting, equipment, demand flexibility, and upgrade packages. ComStock calculates the greenhouse gas emissions from the building stock and savings from upgrades.

Two grid scenarios are presented – eGRID 2021 and Cambium 15 Year Mid-Case. The choice of grid scenario impacts the grid emissions factors used in the simulations. The eGRID 2021 dataset represents the emissions factors for the grid as of the year 2021. The Cambium 15-year scenario represents a future grid scenario, which makes projections related to the cost and grid penetration of renewable energy sources, in addition to other assumptions. In order to evaluate the isolated emissions impacts of an upgrade measure compared to the current baseline stock, the eGRID emissions scenario should be used. The Cambium scenario, on the other hand, results in substantial emissions reductions (often 50% or higher) even before upgrade scenarios are considered, because the projections assume higher penetration of renewable sources on the grid. Therefore, additional caution must be exercised when evaluating emissions reductions for goal planning. For more information on the emissions factors used in the ComStock and ResStock tools, see this publication: https://www.nrel.gov/docs/fy24osti/86682.pdf.

Tab 18: Upgrades – Emission Targets

Shows the total greenhouse gas emissions by building type under each upgrade scenario, along with a dotted line representing the emissions reduction target set in Tab 3. Plots adjust dynamically if the user modifies the emissions reduction targets. The plots shown in this tab use the eGRID 2021 emissions scenario, which represents the state of the grid as it was in 2021. This way, the impacts of each upgrade against the baseline can be isolated and independent of any future grid projections. This tab helps the user understand which upgrades can help achieve their emissions reduction targets, as well as identify which upgrades are most effective in which building types.