

Getting to 2030: Decarbonization Pathways for New York City Office Buildings

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ABSTRACT

In 2019, New York City (NYC) passed the groundbreaking Climate Mobilization Act, featuring Local Law 97, which sets carbon emissions limits for buildings over 25,000 square feet (SF). The first compliance period takes effect in 2024, with carbon limits tightening severely in the second compliance period starting in 2030, which will require most large buildings to significantly reduce emissions. NYC's office building sector is the largest in the country, with nearly 550 million SF of existing space, and needs a massive scaling of retrofit activity to meet required 2030 limits. This requires new methodologies to address more buildings and raise awareness of opportunities and challenges, as quickly as possible.

This paper describes a study that: segments NYC's large office building stock into four typologies based on major HVAC system types, analyzes potential energy efficiency and electrification measures to reduce emissions for each, and recommends packages of retrofit measures based on required reductions by 2030: (1) less complex decarbonization measures for buildings that only require a 5-10% emissions reduction; (2) a mix of moderate to deeper decarbonization measures for buildings needing a 10-25% reduction; and (3) comprehensive suites of deep decarbonization measures, often including electrification of major thermal end uses, for buildings requiring reductions greater than 25%. Packages include base building, as well as tenant retrofit and new tenant measures. Findings show that while the specific measures most applicable to each building vary, some key retrofit solutions can get most office types at or below the ambitious 2030 carbon limits.

Introduction and Context

New York City Buildings

Buildings play a leading role in both New York City's (NYC's) economy and climate action strategy. New York's exceptionally diverse building stock includes everything from nineteenth century wood-framed rowhouses to twenty-first century glass spires. These buildings impact nearly every aspect of New Yorkers' lives, providing the places where they live, work, and play. Ensuring that NYC's buildings are safe, healthy, and comfortable spaces requires significant energy inputs from a combination of on-site fossil fuel combustion, grid electricity, and district steam systems. Together, these energy sources make buildings the leading source of greenhouse gas (GHG) emissions, with the city's 5.4 billion gross square feet (GSF) accounting for nearly 70% of NYC's total GHG emissions (NYC MOS 2016)

Earlier studies by Building Energy Exchange (BE-Ex) and its partners (BE-Ex 2015 and 2018) dug deeply into energy efficiency and retrofit opportunities for medium and large buildings in the multifamily residential sector, which represents over 40% of NYC's total built

floor area and accounts for nearly 30% of GHG emissions from buildings (NYC MOS 2016). For this study, we examined opportunities for medium and large non-residential buildings, which are much more diverse than those in the multifamily sector and account for a disproportionate share of total GHG emissions. For instance, commercial and institutional buildings together are responsible for 40% of citywide GHG emissions, despite making up only 26% of the city's floor area, with average energy use intensity (EUI) and GHG intensity significantly higher than those of similarly sized multifamily buildings (NYC MOS 2016).

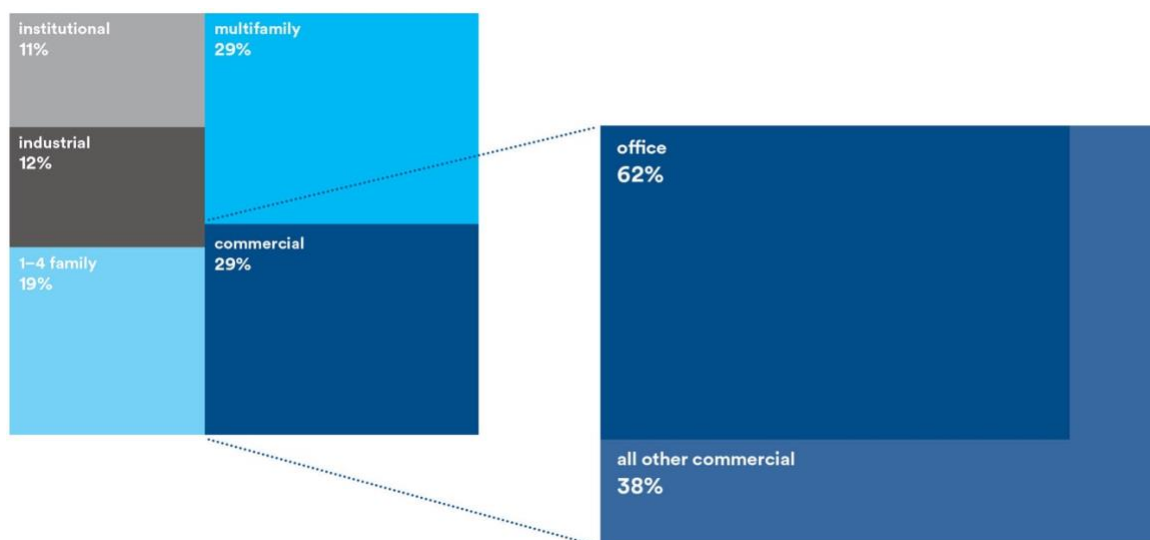


Figure 1. Share of GHG emissions by building sector, with inset showing offices as fraction of the total commercial building sector. Source: NYC MOS 2016

NYC Office Buildings

In this study, we focus on opportunities for office buildings, which are by far the largest non-residential building sector in NYC. Of the roughly 31,000 buildings that submitted energy and water benchmarking data for 2018, the breakdown of primary building types was: Multifamily: 21,600; Office: 2,700; and Hotels: 550 (NYC 2019). These three building types were followed by Warehouses, which feature relatively low EUI and GHG intensity. Outside of these four categories, remaining non-residential private building types each had less than 100 buildings, according to 2017 benchmarking data (NYC MOS 2017).

Office buildings are significantly more energy intensive than multifamily buildings, with the average source EUI for offices being roughly 50% higher than that of multifamily buildings (NYC MOS 2017).¹ There is also a wide variance of EUI and GHG intensity among office buildings. Multifamily energy use is relatively uniform across buildings within the typology. Living accommodations have relatively consistent energy expenditures, even if there are different numbers of people using a given housing unit, or if units vary in size. This contrasts with non-residential buildings like offices, which feature many different occupancy patterns and uses across buildings of the same type, or even within the same building.

For example, an office building might contain mostly private offices, lightly occupied at only 40-50 hours per week, requiring average hours of comfort conditioning. Another office

¹ Average EUI is 186 kBtu/sf/yr for the office category vs. 125 kBtu/sf/yr for multifamily

building, however, might have financial trading floors, energy-intensive data centers, and staff working at all hours, with comfort conditions required around the clock. While classified under the same broad “Office” building category, EUI for the latter building will be much higher than that of the former. These differences in use among buildings grouped together under the same category results in very different distributions of EUI among the two largest types – Multifamily and Office – as shown in Figure 2.

For the purposes of this study, we are analyzing buildings that have self-reported “Office” as the primary property type within the U.S. Environmental Protection Agency’s ENERGY STAR Portfolio Manager, the platform used to submit energy benchmarking results, as required under NYC law for buildings over 25,000 square feet. Because extremely large buildings typically have a unique set of characteristics, occupancies, or mixed uses, we have limited our analysis to buildings between 25,000 and 500,000 square feet.

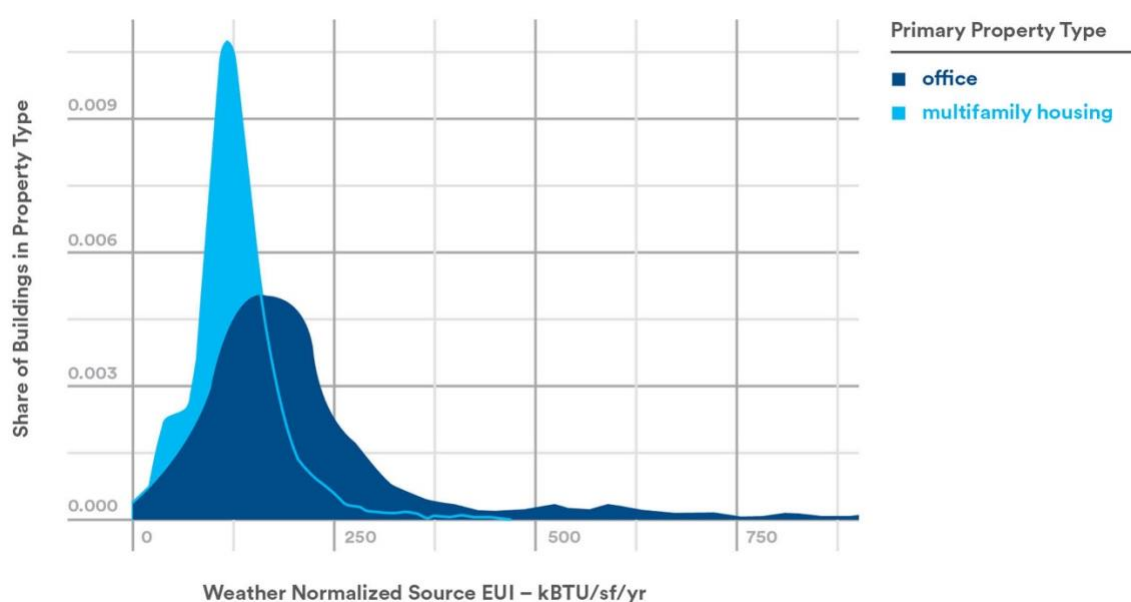


Figure 2: Range of Source EUI, by primary property type. *Source:* BE-Ex analysis, from NYC 2019.

NYC Policy Context

Passed by the New York City Council in 2009, the Greener, Greater Buildings Plan (GGBP) was the first suite of laws to address GHG emissions from NYC buildings. Originally impacting only buildings 50,000 square feet and larger, the scope was extended by new legislation in 2016 to include all buildings 25,000 square feet and above (except energy audit and retro-commissioning requirements under Local Law 87 – see below for details). Buildings that must comply with these laws are often referred to as “covered buildings.” The GGBP includes several laws aimed at reducing GHG emissions, including²:

- **Energy Benchmarking and Disclosure Law (Local Law 84):** Requires reporting and public disclosure of annual energy and water usage, beginning in 2010.

² NYC Local Laws are numbered by the year enacted, such that the Laws included in the GGBP are Local Law 84 of 2009, Local Law 87 of 2009, and Local Law 88 of 2009.

- Energy Audit and Retro-commissioning Law (Local Law 87): Requires an AHSRAE Level II energy audit and retro-commissioning once every ten years, starting in 2013.
- Lighting and Sub-metering Law (Local Law 88): Requires upgrading commercial lighting to meet current codes and installation of sub-metering for commercial tenants over 5,000 square feet, by 2025.

In April 2019, the New York City Council passed the Climate Mobilization Act (CMA), signaling a tectonic shift in the regulatory environment for building emissions. While the GGBP created mandates for building energy use *tracking* and *auditing* – establishing comparative metrics and raising awareness of the benefits of energy efficiency upgrades – it did not include requirements for building owners to *implement* substantial improvements that would reduce GHG emissions. The GGBP did not even address emissions directly, focusing instead on reducing energy use. The CMA has changed that with Local Law 97 (LL97) – first-of-its-kind legislation that places limits on GHG emissions from existing buildings starting in 2024, with fines that can total millions of dollars each year a covered building exceeds its limit.

During the first LL97 compliance period, which runs from 2024 to 2029, GHG emission limits impact the lowest performing 25% of covered buildings. Limits in the second compliance period, which runs from 2030-2034, will be much more stringent, impacting approximately 75% of covered buildings (based on their current emissions levels), and potentially yielding a 40% reduction in covered building based GHG emissions, from 2005 levels (NYC MOS 2019). Many buildings may be under the emissions limits during the first compliance period or able to achieve compliance with relatively simple improvements to building operations and maintenance. To meet more stringent targets in the second compliance period, however, these same buildings will likely require more comprehensive, costly, and disruptive energy efficiency upgrades to significantly reduce emissions and avoid fines.

Understanding the Savings Gap – Meeting LL97’s Ambitious Goals

With nearly a decade of LL84 energy benchmarking data and LL87 audit data, we now have unprecedented insight into the performance and potential of NYC buildings. In this study, we build upon methodological approaches used in the previous BE-Ex studies, *Retrofitting Affordability* and *Turning Data into Action* (BE-Ex 2015 and 2018), which leveraged publicly available LL84 and LL87 datasets to identify energy efficiency opportunities for medium- to large-sized multifamily buildings.

In the time since those laws were passed and those studies were first conducted, however, the regulatory landscape that has grown increasingly restrictive, and many LL87 audit recommendations now fall short of what may be needed to meet current requirements under LL97. To address this challenge, this study examines energy efficiency measures and building upgrade opportunities that go beyond audit recommendations (including electrification of major thermal end-use systems), to identify cost-effective strategies that reduce energy use and emissions, helping buildings comply with LL97 emissions limits and avoid annual fines.

Rather than attempting to identify energy savings for every type of covered commercial building and building system, we instead focus on the most predominant building types within the commercial sector – offices. Office buildings are the largest commercial building typology in NYC, not only by building count, as previously noted, but also by floor area, representing 18% of citywide covered commercial building area (NYC 2019). To generate actionable

recommendations for as many buildings as possible, we examine data from LL87 energy audits, including information on buildings' major heating and cooling systems, along with auditor recommended Energy Conservation Measures (ECMs) and potential energy saving estimates. This information was used to identify four specific office building typologies for analysis, based on common heating and cooling systems, as reported in audits. The four selected office³ building typologies represent 71% of citywide covered office square footage:

- **Typology 1:** Central Chiller Systems⁴ with District Steam Heating⁵
- **Typology 2:** Packaged Cooling Systems⁶ with Steam Heating⁷
- **Typology 3:** Decentralized Cooling Systems⁸ with Hot Water Heating⁹
- **Typology 4:** Decentralized Cooling Systems with Steam Heating

Table 1, below, shows the breakdown of NYC offices by these four typologies. The typologies were based on building heating and cooling system data that is only reported in LL87. The available data allows for good representation of the different system types among offices for our selected typologies.

Table 1. Number, Size, and GHG Emissions of Selected Office Typologies

	Office Typology	# Buildings	% Total Office Buildings	% Total Office Gross Floor Area	% Total Office GHG Emissions
1	Central Chiller Systems with District Steam Heating	313	15%	26%	33%
2	Decentralized Cooling Systems with Steam Heating	799	39%	30%	34%
3	Decentralized Cooling Systems with Hot Water Heating	102	5%	3%	4%
4	Packaged Cooling Systems with Steam Heating	467	23%	12%	13%
-	Unassigned Office (not in one of the above 4 typologies)	366	18%	29%	16%

Source: BE-Ex analysis of LL84 data, from NYC 2019.

By further analyzing a combined and cleaned LL84 and LL87 dataset, we can see more clearly the gap between GHG emissions savings potential identified in audits and the reductions

³ For the purposes of this study, “office” is defined as a building containing at least 50% of an office space use (among the three top identified space types) as reported in LL84 data.

⁴ “Central Chiller Systems” include chillers and cooling towers, regardless of fuel source.

⁵ “District Steam Heating” refers to high pressure steam supplied from the Con Edison District Energy System.

⁶ “Packaged Cooling Systems” include DX and packaged rooftop units.

⁷ “Steam Heating” includes local boilers, or the NYC district steam system operated by the utility Con Edison.

⁸ “Decentralized Cooling Systems” include DX units, split systems, PTACs, window A/C, and through-wall units.

⁹ “Hot Water Heating” includes systems with any fuel type.

required by new LL97 legislation. Figure 3, below, illustrates the relationship between the average emissions reduction potential identified from LL87 audit recommendations for each of our four selected office typologies, compared with mandated LL97 2030 emissions limits. While LL87 audit recommendations provide notable GHG emissions savings, they clearly do not offer enough reductions to avoid incurring annual fines ensure long-term LL97 compliance.

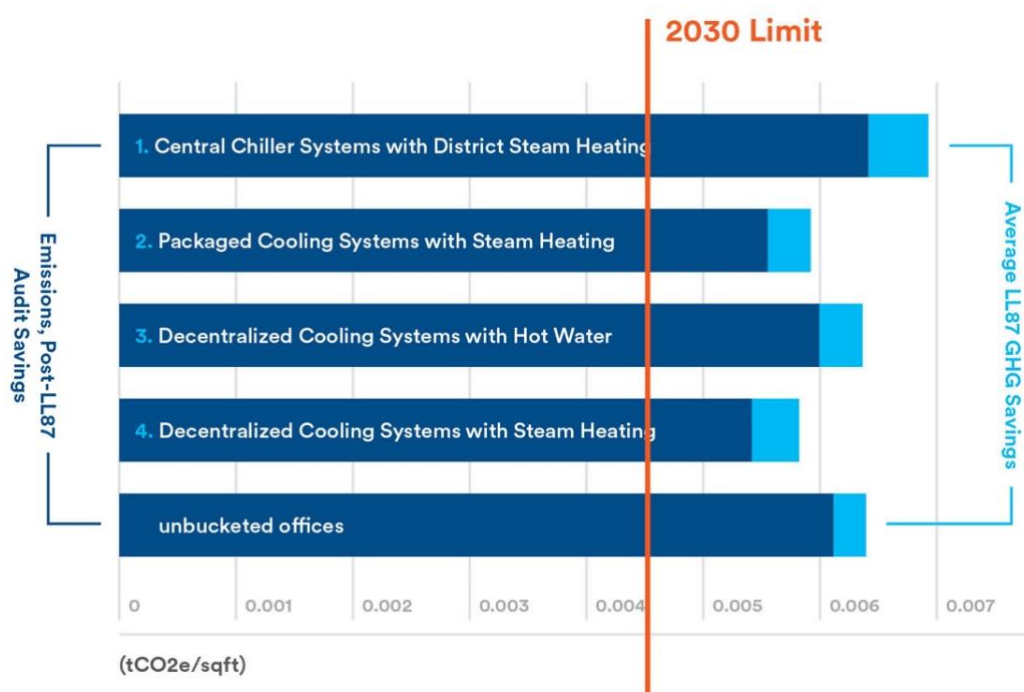


Figure 3: GHG emissions intensity by office building typology, showing LL87 audit savings potential vs mandated LL97 limits starting in 2030. *Source: BE-Ex analysis of 2018 LL97 data, NYC 2018.*

Part of the reason why the savings potential identified in LL87 audits falls short of LL97 requirements is that the audits focus on savings from base building systems, without identifying opportunities in tenant spaces, or for reducing tenant energy use. Most audits also only look at measures that are currently considered cost-effective, as determined by building owners. Owners often require quite a short payback period – generally within a three to five-year range, or less. To meet LL97 limits, deeper energy savings beyond what has historically been identified by auditors will be needed – including both with reduced tenant energy use and deeper base-building retrofit solutions. This is focus of the recommended decarbonization pathways identified in our study, which are outlined in the next section of this paper.

Decarbonization Pathways & ECM Packages

Getting to 2030

NYC LL97 introduces a regulatory framework around building GHG emissions for the first time, compelling building decision makers to grapple with energy efficiency upgrades through an emissions-reduction lens. Although alternative compliance measures, such as the purchase of renewable energy credits (RECs) and GHG offsets may be potential options,

increasing energy efficiency, implementing strategic retrofit projects, and reducing the use of fossil fuels provides a pathway to compliance that also includes non-energy benefits, such as reduced operating costs, improved asset value, and increased occupant comfort.

As previously noted, most NYC commercial office buildings are already below the limit for the law's initial compliance period, starting in 2024, which will impact only the lowest performing 25% of covered buildings. Additionally, many of the buildings with GHG emissions currently in excess of the 2024 limits, may be able to implement relatively simple and low-cost improvements, including those identified in LL87 audits, to avoid penalties. However, during the law's second compliance period, starting in 2030, emissions limits will become significantly more stringent, moving from a 20% to a 40% mandated reduction in citywide building based GHG emissions, from 2005 levels.

These more aggressive limits are expected to impact nearly 75% of covered buildings. Avoiding penalties will often require much more substantial upgrades to improve building performance. Meeting the 2030 limits will be more costly – in some cases much more costly – than the relatively low-cost improvements required of most buildings for 2024 compliance. In many cases, these improvements may also be quite disruptive to tenants. With these strict requirements taking effect in less than ten years, decision-makers must start planning *now* to take advantage of project phasing opportunities that will allow them to minimize both cost and disruption, while maximizing emissions reduction.

Building a Decarbonization Master Plan

Once a building decision-maker has calculated their property's annual GHG emissions and determined their target percent emissions reduction required for LL97 compliance, they must next develop a decarbonization master plan for long-term phasing and implementation of energy efficiency retrofits and capital improvements. A forthcoming report by this paper's authors includes a set of resources, called "Tearsheets," that outline key building blocks – including base building system improvements and tenant energy reduction measures – to help owners develop a decarbonization master plan. There are four Tearsheets – one for each of the office typologies identified in this study.

Figure 4, below, depicts a decision tree included in the Tearsheets to assist building decision-makers in selecting a viable retrofit pathway to meet their LL97 requirements. The three pathways identified on the Tearsheets are distinguished from one another by the range of GHG emissions percent savings possible from a building's baseline. Each savings pathway directs building decision-makers to a menu of relevant retrofit "packages," or groups of ECMs.¹⁰ By combining relevant packages of ECMs, building decision-makers can build out a decarbonization master plan and customize their pathway to LL97 compliance.

¹⁰ ECMs are specific improvements and upgrades to various building systems, such as heating, cooling, lighting, etc.

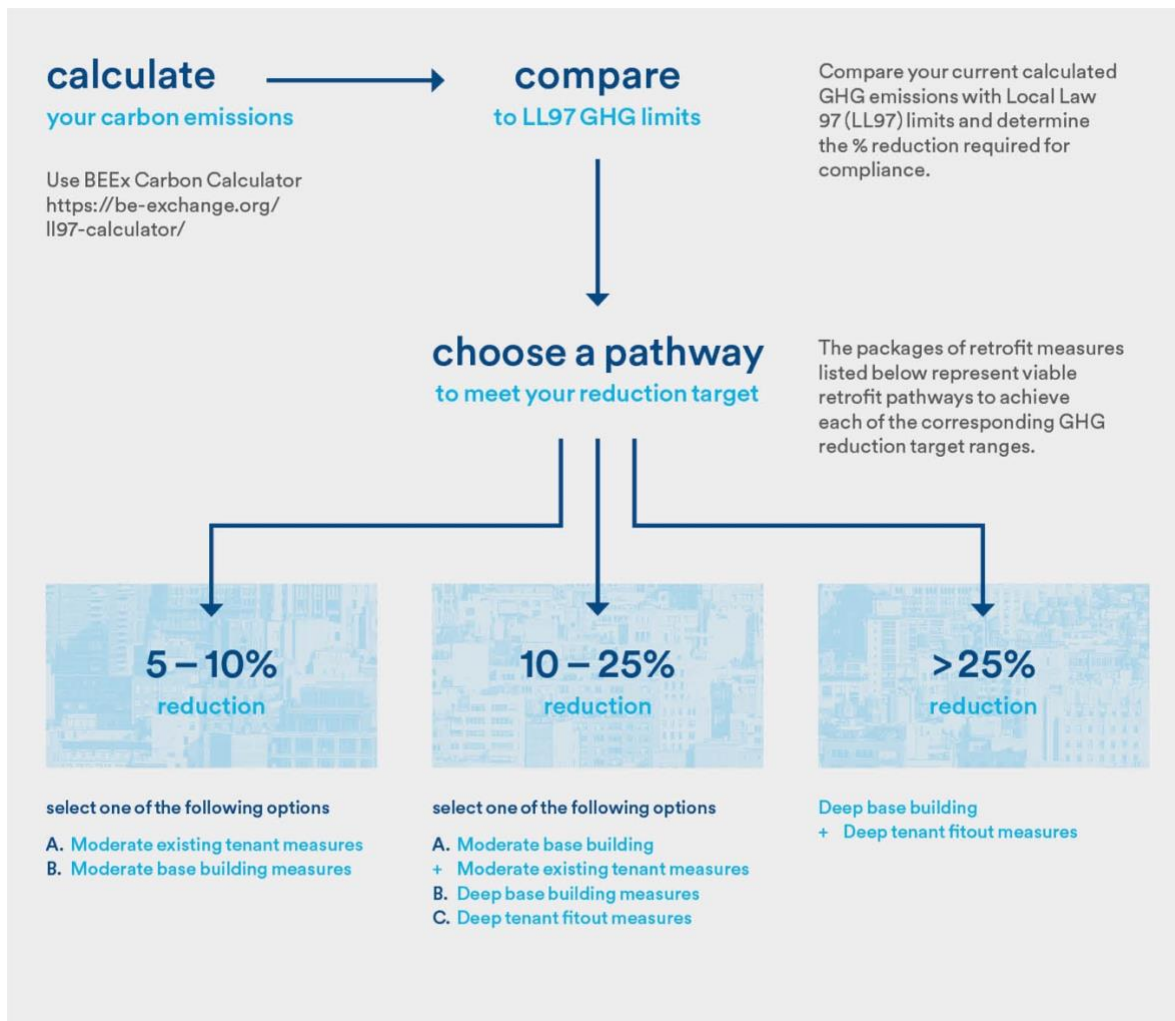


Figure 4: Decision tree from the Tearsheets included in the authors' forthcoming report, which are designed to assist building decision-makers in selecting a viable retrofit pathway to achieve the level of GHG emissions reductions required for NYC LL97 compliance.

Decarbonization Pathways

While 75% of buildings are expected to require GHG emissions reductions to avoid penalties under their 2030 limits, there is a wide range in the degree to which each building will need to reduce its emissions. Some buildings will need to reduce emissions by 5% to 10% to comply, whereas others will need to reduce by 30% or more. As noted above, the forthcoming report outlines three Pathways for each of the four office typologies,¹¹ allowing decision makers to select packages of ECMs based on their GHG emissions reduction needs. Pathways group ECMs into packages configured to deliver a range of potential energy and GHG emissions savings. These packages range from operational tune-ups and low-cost retrofit measures with low to moderate savings potential, to major system upgrades and replacements, including potential electrification of heating and water heating end-uses currently using fossil fuels, that offer deeper possible savings.

¹¹ see Section 2 for discussion of the four typologies

The Pathways are organized to help building decision-makers select energy efficiency upgrades, based initially on their emissions reduction needs relative to Local Law 97. From there, decision-makers can create a comprehensive capital improvement plan, which will likely include a combination of both moderate and deep retrofit measures, as relevant to the specific conditions and needs of their building systems and tenants.

Decarbonization Pathway 1 (5 - 10% emissions reduction). Packages of ECMs grouped under this pathway include relatively simple base building tune-ups and improvements, as well as ECMs that can be implemented while existing tenants remain in place.

As discussed, NYC LL87 mandates that buildings undergo energy audits and retro-commissioning once every ten years. Prior to the passage of LL97, however, there was little incentive for decision-makers to implement recommended ECMs primarily for the purpose of reducing emissions, and a review of most energy audits to-date finds that they primarily recommend low-cost ECMs that provide energy savings resulting in short payback periods.

The base building measures recommended under Decarbonization Pathway 1, perhaps combined with some tenant improvement measures, offer an appealing combination for buildings already close to meeting their LL97 emissions budgets to achieve sufficient emissions reductions to comply with the first round of compliance, and to realize notable cost savings. Figure 5, below, provides an example “menu” of recommended ECM packages for office buildings in Typology 1: Central Chiller Systems with District Steam Heating. Note that implementing every package of moderate decarbonization ECMs on this menu would yield an estimated 13-17% savings, on average, well over the 5-10% target range for Pathway 1. This margin of savings provides building decision-makers the flexibility to select a custom combination of ECM packages best suited to meeting their needs, constraints, and targets.

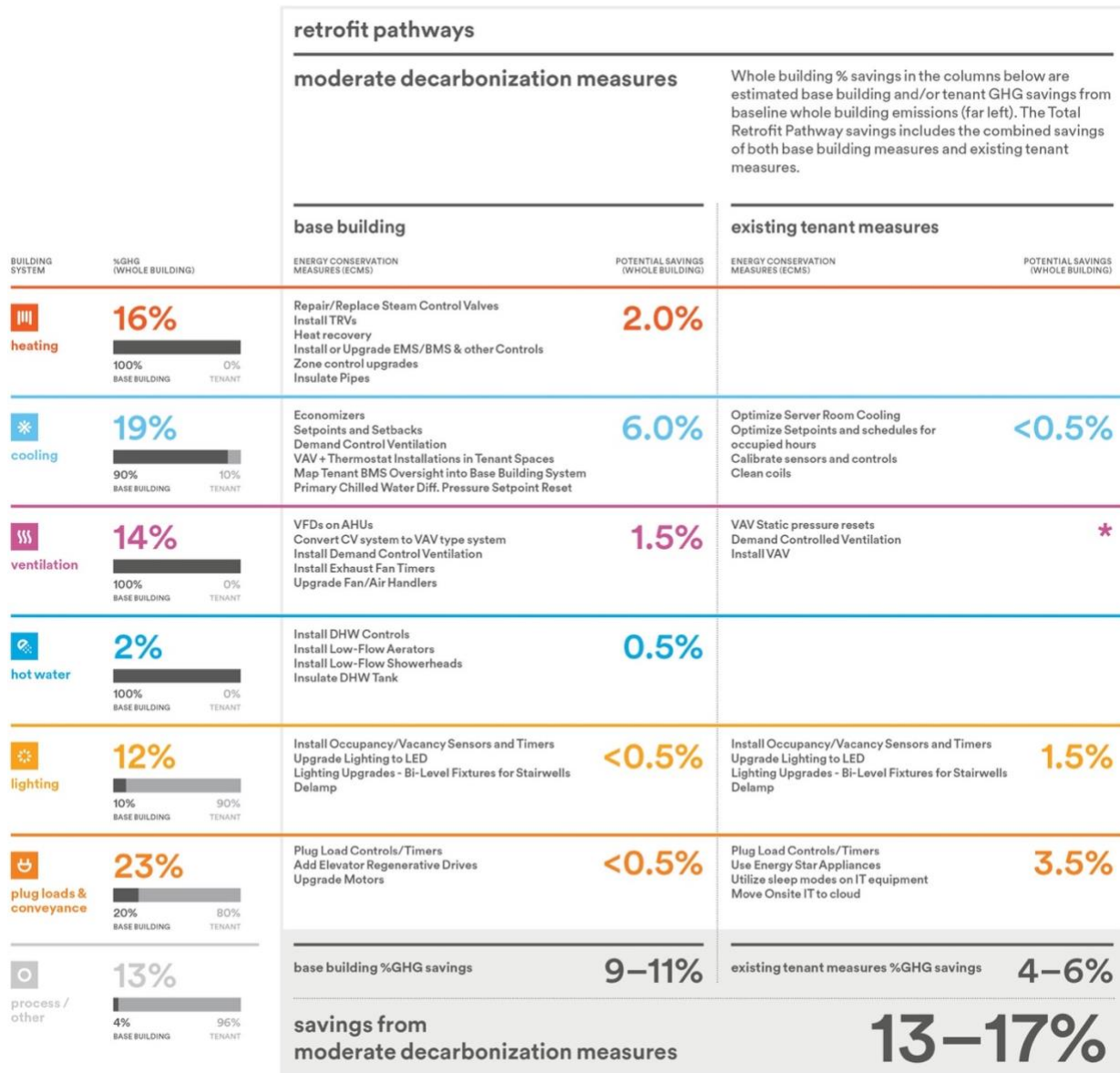


Figure 5: Sample Tearsheet for office buildings with central chiller systems and district steam heating, featuring ECMs packaged together by end-use system. Decision-makers can combine these packages to create and customize a viable pathway to meet their emissions reduction targets.

Decarbonization Pathway 2 (10-25% emissions reduction). To meet LL97 requirements, particularly the more stringent 2030 emissions limits, many buildings will need to reduce emissions beyond what can be achieved by ECMs recommended under past LL87 energy audits. Pathway 2 combines packages of moderate decarbonization ECMs with packages of deep decarbonization ECMs. This middle pathway includes measures for *either* the base building systems *or* new tenant fit-outs, which can further reduce emissions up to 25%.

Deep decarbonization measures will typically require some degree of advanced planning, and decision-makers should take advantage of normal building operations and life cycle opportunities, like tenant fit-outs, to maximize energy savings under this pathway.

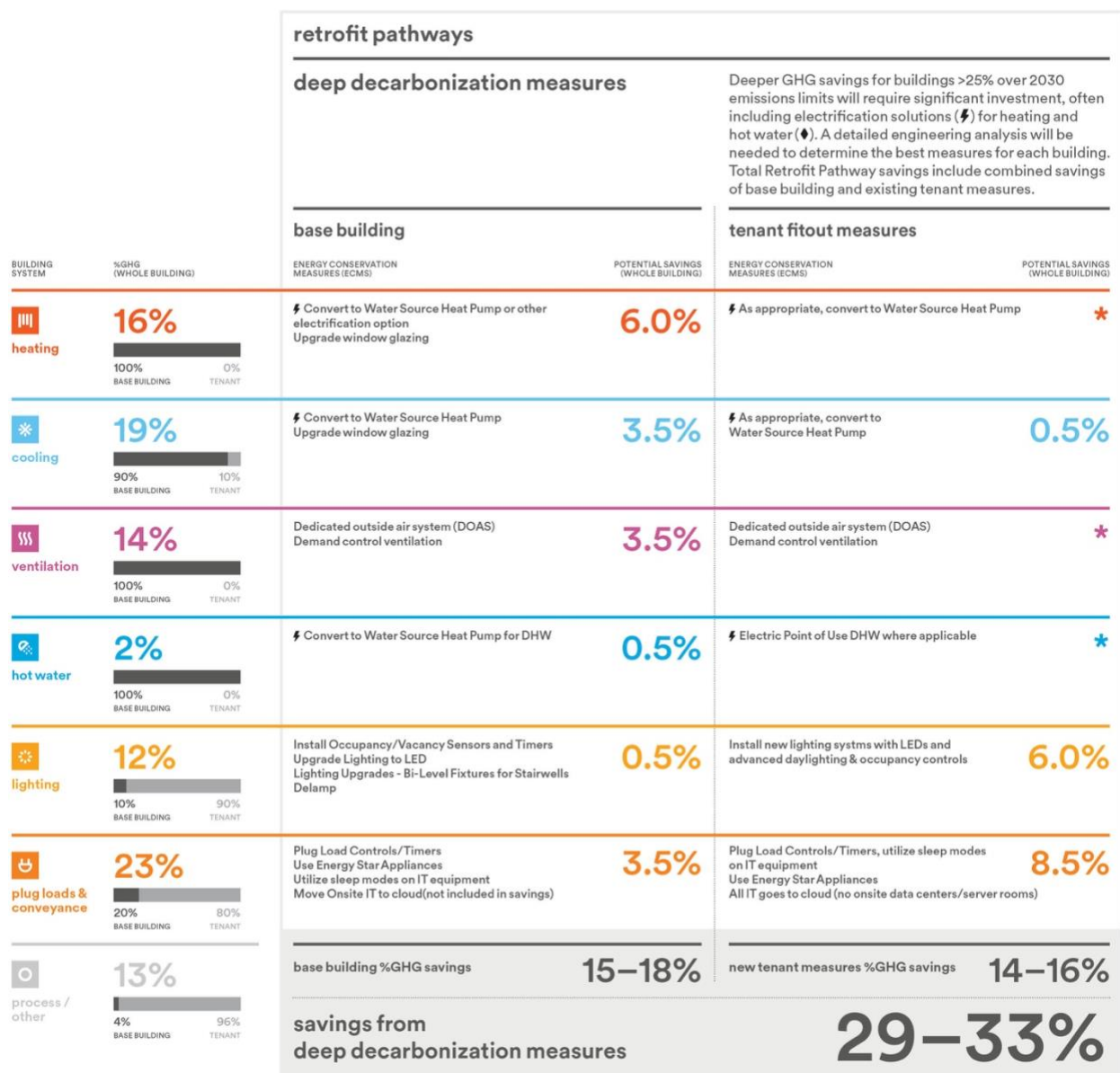


Figure 6: Sample Tearsheet for office buildings with central chiller systems and district steam heating. Building owners pursuing Pathway 2 can select from these deep decarbonization packages, and/or combine them with items on the moderate decarbonization menu, to develop a viable pathway to a 10-25% reduction in GHG emissions. Owners pursuing >25% reduction under Pathway 3 are advised to consider all deep decarbonization measures.

Decarbonization Pathway 3 (> 25% emissions reduction). Relatively few buildings will need to follow Decarbonization Pathway 3 to avoid penalties during the first two LL97 compliance periods in 2024 and 2030. However, all building decision-makers should be aware of the significant GHG emissions reduction opportunities that will be required to meet more stringent compliance periods in the future. The packages of deep decarbonization ECMs offered under this pathway – including measures to replace some base building energy systems, as well as tenant fit

out measures – are generally quite costly. However, these packages also realize the highest possible emissions savings, making them a good option in cases where a building needs to dramatically reduce emissions.

ECM packages under Pathway 3 are best considered when major building systems are reaching the end of their useful life, during a building’s financial repositioning, during tenant turnover and fit out events, or during major tenant renovations. Additionally, deep tenant savings for office buildings must often include moving significant IT systems to cloud-based operation, and drastically reducing onsite energy use from plug loads.

Considerations for all pathways. Creating a pathway to compliance will require a new level of cooperation between building owners and their tenants. Tenant spaces represent a substantial opportunity to reduce the energy consumption of commercial buildings. Tenants in leased office spaces typically consume more than half of the building’s energy (NYC MOS 2016).¹² Without specifically addressing tenant energy use, it will be nearly impossible for most commercial buildings to attain the deep, long-term carbon reductions called for in this ground-breaking legislation.

Over a decade ago, as part of the GGBP, New York City passed legislation to help advance tenant energy efficiency. Local Law 85 (LL85) of 2009 now requires buildings to meet the most current energy code for any renovation or alteration project, removing compliance exceptions for partial building renovations (i.e., most tenant improvement projects). LL88 requires large non-residential buildings to upgrade lighting to meet current NYC Energy Conservation Code standards, and to install electrical sub-meters for each large non-residential tenant space and provide monthly energy statements. Taken together, these laws have spurred dramatic reductions in tenant, and, consequently, whole-building energy use. Building owners have reported up to 30% building reductions just by their largest tenants upgrading lighting and renovating their spaces to current codes. But there is much more work to be done. Opportunities to save energy are available throughout the lifecycle of a commercial office tenant’s leasing cycle, from pre-lease activities – including site selection and project planning – to new space fit out and renovations, as well as throughout occupancy and at lease renewal.

It is also crucial to note that every office building has unique features and a different baseline of energy consumption. Not every measure will apply to every situation. Suggested ECMs for each building typology and decarbonization pathway are representative, and not necessarily applicable to every building. Variety in specific building systems and the condition of equipment must be considered in determining the appropriate pathways and packages of ECMs for individual buildings. It is important for decision-makers to work with a qualified service provider in developing a comprehensive decarbonization plan and scope of work appropriate for their building.

Conclusion

While meeting emissions limits for the second compliance period of NYC’s LL97 will not be easy, this study demonstrates that it is achievable for most office buildings. Reducing GHG emissions by 25% or more will likely require significant shifts in the ways that many building decision-makers approach building upgrades – including electrification of major fossil-

¹² The energy use in interior offices and leased space accounts for between 40-60% of end use in a typical commercial office building.

fuel powered systems, closer collaboration with tenants, and long-term planning to implement retrofit projects at key moments in time, such as major capital events.

Despite the significant effort and cost that will be required to dramatically reduce GHG emissions and achieve NYC's ambitious 2030 climate action goals, building owners stand to reap major benefits. These include reduced operating costs and utility expenses, as well as an edge in an increasingly competitive real estate market. Building stakeholders and commercial tenants, along with their boards and customers, are raising expectations for climate action and making Environmental, Social, and Governance (ESG) commitments that address the impacts of their office footprints. Furthermore, in a post-COVID world, tenants increasingly are demanding healthier and more comfortable spaces – attributes that typically go hand in hand with high performance, low-carbon buildings. As building codes and performance standards continue to grow tighter, not only in NYC but in cities around the globe, implementing deep decarbonization measures today will allow building decision-makers to future-proof their investments.

This study – and the associated, forthcoming report and Tearsheets– demonstrate that each of the four office building typologies analyzed – and every individual building within those typologies – will need to develop its own pathway, select specific packages of energy conservation measures, and create a long-term capital plan appropriate to their unique needs and constraints, in order to reduce carbon emissions to the degree required by NYC law. However, this study also shows that many of the most impactful decarbonization measures are common across the majority of buildings – including replacing onsite fossil-fuel burning systems with electric-powered equipment, installing automated controls to manage lighting, plug loads, and HVAC equipment, and moving energy-intensive business operations – like onsite management of IT and data centers – to the cloud.

Despite uncertainty that may persist in the legislative landscape in NYC and beyond – such as details of energy codes and climate policies that may evolve over time – it remains clear that market demand and local, state, and federal regulations are all moving towards deep decarbonization of the built environment. This study offers guidance for office building decision-makers to start taking action to meet these demands, begin realizing the benefits of high-performance upgrades, and lead the industry in building a safer, healthier, and more sustainable future for all.

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