Guide to Strategic Decarbonization Planning

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GUIDE FOR STRATEGIC DECARBONIZATION PLANNING WORKING GROUP

ASHRAE CENTER OF EXCELLENCE FOR BUILDING DECARBONIZATION

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Preface and Acknowledgments

This guide results from collaboration between three organizations: ASHRAE, U.S. Green Building Council (USGBC), and New York State Energy Research and Development Authority (NYSERDA).

The three organizations have separately developed decarbonization resources, and these prior efforts have helped shape this guide. ASHRAE's Center of Excellence for Building Decarbonization (CEBD) is developing technical resources regarding decarbonization and is hosting decarbonization conferences. USGBC, through its new Leadership in Energy and Environmental Design® (LEED®) v5 Operations and Maintenance (O+M) Energy and Atmosphere (EA) Credit Decarbonization and Efficiency Plans (USGBC 2025), has codified the process of plan development and created a workbook that organizes plan information and provides visualizations of plan impacts. Meanwhile, NYSERDA has helped develop and refine the planning process as part of the Empire Building Challenge (NYSERDA 2024), an initiative to jump-start large existing building decarbonization in New York State.

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Introduction

1.1 About This Guide

This *Guide to Strategic Decarbonization Planning* has been developed to help project teams establish plans for deep reductions in carbon emissions from energy use in existing buildings, also known as *operational carbon emissions*. By incorporating different and deeper measures into traditional real-estate planning practices (long-term capital planning, making the business case, and budgeting), this guide will aid engineers and building professionals in hastening the transformation of the real-estate market toward a decarbonized state. This guide also provides an overview of fundamental concepts related to financial planning in the real-estate sector as they pertain to the implementation and execution of strategic decarbonization planning.

Though buildings are responsible for multiple streams of carbon emissions, including refrigerant leaks and construction-based emissions (i.e., embodied carbon), this guide focuses on plans to reduce operational energy-related carbon emissions as the largest lifetime source of existing building emissions and a significant portion of total global emissions.[1] This guide does not endeavor to address comprehensive whole-life decarbonization planning including embodied emissions and end-of-life implications. Planners should also take care to follow the most up-to-date guidance about using refrigerants with low global warming potential (GWP) and about reducing embodied carbon emissions.[2]

This guide was developed as a collaboration among three organizations: ASHRAE, U.S. Green Building Council (USGBC), and New York State Energy Research and Development Authority (NYSERDA). These three organizations recognize the need to drive the building sector toward carbon neutrality by mid-century and that decarbonizing the energy consumption of existing buildings will be key to this transition. Since the building sector must begin sector-wide decarbonization immediately, there is an urgent need to create and normalize foundational concepts, tools, and processes to support building professionals in this work. In addition to this guide, ASHRAE, USGBC, and NYSERDA have separately developed other decarbonization resources in response to this industry-wide need. Overlap between these resources and this guide has been noted herein.

1. See emissions statistics in ASHRAE Position Document on Building Decarbonization (ASHRAE 2024).
2. This guide uses the word *carbon* as a shorthand for carbon dioxide and all other relevant greenhouse gases.

1.2 What Is Strategic Decarbonization Planning and Why Is It Necessary?

Strategic decarbonization is an approach that champions integrating budgeting and execution of decarbonization strategies into the typical planning and business cadence of a real-estate asset. This combination of technical and real-estate insight enables decision-makers to achieve more significant decarbonization with less capital by executing strategies in tandem with interventions already identified in capital expenditure (CapEx) planning.

Two key components make this process "strategic": First, it requires optimizing the technical or engineering plan for the most important long-term real-estate events relevant to capital planning—tenant and lease changes, repositioning, recapitalization, financing, etc. These are primarily financial but determine the phasing and implementation schedule of the technical plan. The plan cannot be agnostic of these real-world constraints; they must be directly integrated. Second, it seeks the most financially advantageous path to decarbonization rather than considering the payback of measures or the aggregate impact of the plan. This requires a cost analysis of a realistic business-as-usual scenario that incorporates replacement and maintenance costs of key equipment along with potential building performance policy fees. The cost of inaction is not zero, as is often assumed in a conventional simple payback analysis.

The value of a strategic decarbonization plan (SDP) is not limited to projects that intend to reach full decarbonization in the near future. While the ultimate goal is getting to zero emissions by 2050, some buildings may not be able to immediately pursue these strategies; but even for these buildings, strategic decarbonization planning will prove immensely valuable. Sometimes, avoiding choosing the wrong path today can be more economically impactful than selecting the right path in the future. Things change over time and the future is impossible to predict; much of the value of a decarbonization planning exercise is the understanding of what a building should and should not do to decarbonize, what barriers make specific strategies impossible to implement now, and what factors might change in the coming years to make them possible. Every building needs a plan, even if immediate action today is infeasible.

Once the technical challenges associated with decarbonization are addressed, the practical problems of costs and retrofit phasing in the real world come to the forefront. Good retrofit designs will inevitably meet cost constraints, physical limitations, and risk aversion. An SDP is not just a technical solution, a thoughtful design, or an ideal future system configuration—it is a plan that incorporates these decidedly real-world, nontechnical considerations. Where an engineer may be able to identify "the right thing to do" from a technical perspective, it remains the responsibility of a building's ownership or long-term management to find "the smart way to do the right thing."

1.3 Defining Decarbonization

For the purposes of this guide, decarbonizing an existing asset means significantly reducing or eliminating on-site combustion such that, by 2050, when the electric grid is largely decarbonized, the building will produce no to low carbon emissions from energy use.

Decarbonizing is not an exercise in carbon accounting focused on achieving the number zero. It does not entail achieving zero emissions immediately by fully electrifying and then purchasing renewable energy credits (RECs) to offset the emissions from the current electrical grid. Nor does it entail continuing to burn significant amounts of fuel for basic heating needs and then using a carbon offsetting methodology to nominally erase the emissions from those fuels.

Instead, decarbonization planning should focus on the core operations of the building itself, with the goal of making the building capable of operating on clean electricity most of the time. If this is the outcome of the implementation of the decarbonization plan, then the building has largely been decarbonized, in the opinion of the authors. As is emphasized throughout this guide, project teams should not be rigid in their approach to on-site combustion or strategies like electric resistance heating. Instead, they should focus on the big picture of carbon reduction without letting the perfect be the enemy of the good.

Energy efficiency remains an essential strategy for reducing the cost of decarbonization in three basic ways. The first is by enabling the new electrified heating and cooling equipment to be downsized by reducing peak loads. Heating and cooling equipment must be sized to meet a building's peak thermal loads; if those loads are lowered, typically through improvements to a building's envelope and/or heat recovery, the size of the new electrified equipment can be reduced accordingly, lowering capital costs. In fact, heat recovery enables a broader conception of efficiency as not just the equipment and systems using energy but also the building as a whole become more efficient. The second is by ensuring that the new equipment itself is efficient, which will decrease long-term operating costs. Finally, pursuing all cost-effective efficiency measures as part of an overall decarbonization plan will improve the financial case for the plan. All three of these energy-efficiency strategies will deliver additional cost savings in buildings subject to building performance standards (BPS) (local ordinances that impose fines when buildings exceed energy or carbon caps) by lowering the excess energy consumption or emissions subject to fines.[3]

Efficiency has additional, nonmonetary benefits. Efficiency makes buildings more resilient in the face of grid outages and extreme weather events—this is particularly true of building envelope improvements that enhance survivability. Efficiency also reduces a building's cumulative carbon emissions by reducing electricity consumption during the period before 2050 when the grids will be substantially decarbonized. It also contributes to overall grid reliability by reducing the load on the grid.

This big-picture approach toward decarbonization leaves room for hybrid solutions that retain fuel-fired equipment for use under special conditions, making them effectively backup capabilities available when the electric equipment is not suitable (for example, during very low winter temperatures or during peak demand events in any season). Such hybrid systems can also be more financially feasible. For example, relying on existing fossil-fuel heating below 30°F could enable the installation of a smaller and cheaper heat pump system to serve the building for most hours of the year, achieving 80% to 90% of the carbon reductions at perhaps 30% to 50% of the initial cost.

1.4 A Suite of Strategic Decarbonization Planning Tools

This guide introduces, explains, and provides a framework for strategic decarbonization planning, but it is just one of three integrated tools being developed by USGBC, ASHRAE, NYSERDA, and others to jump-start progress on strategic decarbonization planning. The other tools are the USGBC Strategic Decarbonization Workbook (2025b) and the Leadership in Energy and Environmental Design® (LEED®) v5 Operations and Maintenance (O+M) Energy and Atmosphere (EA) Credit Decarbonization and Efficiency Plans (USGBC 2025a). The three tools work together.

1.4.1 USGBC Strategic Decarbonization Workbook

The USGBC Strategic Decarbonization Workbook (2025b; hereafter *the Workbook*) is a spreadsheet tool in Microsoft Excel format that standardizes the data collection entailed in strategic decarbonization planning and provides simple visualizations to aid project teams. Developed by USGBC to support projects pursuing the LEED v5 O+M EA Credit Decarbonization and Efficiency Plans (USGBC 2025a) and then piloted by NYSERDA as part of the Empire Building Challenge (NYSERDA 2024), the Workbook is intended to support any project pursuing strategic decarbonization planning anywhere in the world. Through a series of forms and simplifying

3. ASHRAE's Center of Excellence for Building Decarbonization (CEBD) has published a free guide intended to provide the technical basis and several resources for developing and implementing BPS titled *Building Performance Standards: A Technical Resource Guide* (2023b).

assumptions, the Workbook collects the main information necessary to develop and document an SDP and for third parties to review or interpret an SDP. The output visualizations help show, at a glance, the impact of the plan and/or the different options under consideration.

The Workbook serves two purposes. First, at the project level, it enables a user to capture the essential elements of an SDP (including plan and context) and share it with a third party for review. Second, at the industry level, it defines and standardizes the minimum information that must be documented in the planning process. The Workbook is not intended to be comprehensive but rather to collect the core data in an SDP. It is expected that third parties (such as city governments, investors, and certification entities) may require supplementary information. Such stakeholders are encouraged to use the Workbook to collect the core data, augmenting it as required with additional data collection modules, rather than reinvent the entire data collection structure.

At the time of this writing, it is envisioned that the Workbook will be made available to all project teams through several channels. First, it exists as an Excel workbook, which can be accessed directly from USGBC by all projects, whether or not they are pursuing LEED certification. Second, it is part of USGBC's LEED submission infrastructure. Finally, the team at Pacific Northwest National Laboratory (PNNL) has developed a USGBC-specific template within its web-based Asset Score/Audit Template Tool (PNNL n.d.). This template aligns with the data requirements of the Workbook; generates comparable visualizations; and incorporates a standardized format, a comprehensive list of BuildingSync measures to select from, and robust data validation features.

1.4.2 LEED v5 O+M EA Credit Decarbonization and Efficiency Plans

LEED O+M typically rewards existing buildings that have already achieved high performance, but in recognition of the critical importance of decarbonization planning, LEED v5 O+M is introducing a four-point Energy and Atmosphere (EA) credit, Decarbonization and Efficiency Plans (USGBC 2025a), to encourage projects to develop 20-year SDPs. More points are awarded to projects with plans that achieve increasingly deeper reductions in on-site combustion and site energy use, with the full four points being awarded for plans that achieve 100% reduction in on-site combustion and 30% reduction in site energy (or 15% for buildings that are already efficient).

This credit requires projects to follow a process similar to the one outlined in this guide and to document the planning process and final plan using the Workbook.

1.5 Creating Common Nomenclature for Strategic Decarbonization Planning

As for any new field, the terminology around decarbonization has not been standardized and may not be for some time. To add to the confusion, professionals from different disciplines who must collaborate on SDPs often use alternative terms for very similar concepts. This guide does not purport to standardize the language for the industry. However, in the interest of clarity and consistency, the main terms, as they are used in this guide, are defined here.

An ***emissions reduction measure*** (ERM) is any intervention that reduces carbon emissions. This constitutes a broader category than *energy efficiency measures*, *conservation measures*, and *retrocommissioning measures* because, for example, efficiency measures that reduce energy use will also ultimately reduce carbon, but not all measures that reduce carbon emissions also reduce energy.

A ***scenario*** is a possible future state or set of conditions that may arrive from outside the project's control, impacting the financial analyses or viability of the various decarbonization plan options. Conditions that might be considered when defining a scenario include the cost of energy, carbon fees, or the state of grid decarbonization. Project teams should test the relative viability of different decarbonization plan options by analyzing them across various scenarios. For example, a scenario where natural gas rates and operational costs escalate rapidly due to decreasing numbers of ratepayers utilizing the gas network should be considered when weighing the decarbonization plan options.

A ***decarbonization plan*** is a series of ERMs that will achieve substantial decarbonization along with a timeline for their implementation. In this guide, *decarbonization plan* is a generic term for any such plan, independent of its level of rigor or refinement. This guide lays out a three-part model for understanding how the plans iterate and improve, proceeding from a rough, back-of-the-envelope conceptual plan, expanding to include multiple decarbonization plan options, and finally evolving into a detailed strategic decarbonization plan. The SDP is followed by a more refined capital plan that details the specific actions to be undertaken during the first five years of the SDP. The increasingly rigorous plans developed along the way are defined as follows:

- A ***conceptual plan*** is the first draft and the least rigorous. Created at the end of the preplanning stage, a conceptual plan is a rough sketch of a decarbonization plan that lays out a package of ERMs with ballpark estimates of its impact on carbon emissions and costs and its coordination with major trigger events. Conceptual plans are not meant to be definitive. Instead, they are meant to be presented during the charrette that launches the planning phase, to get the planning team thinking about the big, strategic, fork-in-the-road decisions.
- Creating a set of ***decarbonization plan options*** is the next task, and as the name suggests, several decarbonization plan options should be considered during the planning phase. Each option should be developed with sufficient rigor to allow the planning team to compare the options and to choose the best one to be developed into an SDP. Each decarbonization plan option consists of a series of measures to be undertaken on a particular timeline and includes an analysis of the impacts on carbon, energy use, and costs. Prior to the development of the SDP, the options are studied for appropriateness, effectiveness, and financial impact and are evaluated against and compared to one another.

  Developing multiple decarbonization plan options that take different approaches is a key piece of strategic decarbonization planning. Ideally, these decarbonization plan options are mutually exclusive and represent distinct points of departure to enable project teams to see which large decisions are likely to result in the most viable SDP, and under what conditions. If an ERM is suggested in one decarbonization plan option, then implementing that measure sooner or doing more of that ERM is insufficient to define another decarbonization plan option, as they are not mutually exclusive actions.
- A ***strategic decarbonization plan*** is the final iteration in the strategic decarbonization planning process. It is the long-term plan for achieving deep decarbonization that the owner intends to pursue after having considered multiple decarbonization plan options across a variety of scenarios. Documentation of the SDP should include an overall narrative, individual ERM descriptions, target implementation year and measure life, implementation cost, ongoing annual costs, and impacts on energy and carbon. The costs and carbon impacts of an SDP should be of sufficient rigor to provide the basis for good planning decisions. An SDP should be a living document that is reviewed and adjusted over time.
- A ***five-year capital plan*** includes more detailed analyses of the first five years of the ERMs from the SDP so that they can be budgeted and pursued. The five-year capital plan is the relatively fixed part of the SDP that a project is actively pursuing, while the full SDP represents the long-range road map for achieving deep decarbonization goals over the long term and is more subject to change as conditions evolve. While the capital plan and the full SDP may seem similar, the cost and impact estimates detailed in the five-year plan are developed to an "implementation ready level" and funding and financing sources have been defined or obtained.

A ***business-as-usual (BAU)*** **carbon projection** forecasts the future annual carbon emissions of a building assuming it continues using energy as it has, from the same fuel sources. This is a new requirement of the carbon era that was not necessary in the energy-efficiency era because energy use does not change in the BAU scenario. In a BAU carbon projection, carbon emissions from electricity are expected to decline over time due to electricity grids decarbonizing. Meanwhile, a building's emissions from on-site combustion will remain constant. A best practice for a BAU carbon projection is to include the upgrades that would have occurred due to regular wear and tear and the equipment's end of useful life, but even simplified BAU carbon trajectories that do not include this level of granularity can prove useful throughout the process.

A ***BAU financial projection*** collects the future costs and benefits of a building, assuming it will proceed with its current systems and equipment, including maintenance costs and replacement-in-kind costs at the end of useful life. Non-energy costs may need to be included, depending on the project; including them as relevant is a best practice. The BAU financial projection must encompass fines or fees that may be incurred for exceeding the carbon or energy caps that some jurisdictions have begun to set for buildings. Project teams may also want to consider the financial implications of potential carbon regulations in the future ("regulatory risk"), including loss of value, revenue, or fees.

Trigger events are strategic points in the life cycle of a building that can influence decarbonization planning in different ways. Some offer the potential to reduce project costs by aligning the timing of a decarbonization measure with other work. For example, by replacing a fuel-fired hot-water heater with a heat pump unit when the existing heater has reached the end of its useful life, one can avoid the replacement cost. Other trigger events take advantage of windows of opportunity, such as insulating the exterior walls of a tenant space at the time of tenant turnover or purchasing heat pumps while a utility is offering a rebate. More examples of trigger events and how they can impact decarbonization planning are presented in the Compile a Building Profile subsection of Chapter 3.

2

The State of Decarbonization in the Building Sector

2.1 The Paradigm Shift

The basic existing-building decarbonization strategy discussed in this guide reflects the paradigm shift the real-estate industry has experienced as a result of the urgent need to decarbonize the building sector. This paradigm shift has four components.

1. **The shift from energy to carbon.** Since the energy crises of the 1970s more than half a century ago, building professionals have focused on reducing energy use by making buildings more efficient, and great gains in building efficiency have been achieved over the ensuing decades. But as the urgency to mitigate climate change becomes ever more pressing, the building industry's primary goal has shifted to reducing carbon emissions, not reducing energy. Energy efficiency remains a crucial tool in achieving that end, but it is no longer the sole tool.
2. **The shift from modest improvements to deep reductions.** To stabilize the climate, the industrialized world must reduce anthropogenic carbon emissions to near zero by 2050. This includes emissions from energy used in buildings. Relatively modest, incremental improvements in efficiency—which have effectively delivered on energy policy goals to date—cannot deliver the deep and absolute reductions necessary to achieve carbon neutrality. The building industry cannot "efficiency" its way to zero.
3. **The shift away from the old, predictably positive cost-energy equations.** Energy efficiency measures reduce annual energy costs, so after a sufficient period of time, energy savings will pay back the up-front cost of each measure. Hence, for energy efficiency, the question has been not whether the measures pay back but how long that payback will take (unless the measures wear out too quickly). Shorter payback measures were deemed more cost-effective and were therefore prioritized. Unfortunately, such simple cost-effectiveness analysis is not the right lens for reducing carbon and minimizing decarbonization costs. Some decarbonization measures may not reduce annual energy costs, and others may have small recurring benefits, but they may need to be pursued anyway to achieve deep reductions, avoid costly penalty for inaction, obtain a better performance outcome, or enable a shift to a new system configuration or conditioning strategy. The new lens for decarbonization is not "short payback equals cost-effectiveness" but rather "what is the lowest-cost and highest-value path for achieving the deep carbon reductions necessary?"
4. **The shift in the dimension of time.** Energy efficiency can be implemented in the short term, but project teams must plan over a longer time horizon to deliver deep carbon reduc-

tions at the lowest cost. Such long-term planning enables teams to maximize total value and reduce costs by planning around unavoidable future capital events such as the equipment's end of useful life, tenant turnover, and market repositioning. For example, if a boiler has reached the end of its useful life and requires replacement, the incremental cost increase of installing a new carbon-free heating system rather than replacing the combustion-based system in kind may be only slightly greater. Because boilers only need to be replaced every 40 or 50 years, planning teams will need to phase plans over years of implementation; they will need to think strategically over the long term.

2.2 Decarbonization Strategy for Existing Buildings

As the need to decarbonize the existing building stock has become increasingly urgent, the basic strategy for achieving a decarbonized building stock has emerged, at least for operational emissions. That basic strategy includes three main components:

1. Reduction or elimination of on-site combustion of fossil fuels
2. Energy efficiency and demand reduction
3. Generating or purchasing of carbon-free power

2.2.1 Reduction or Elimination of On-Site Combustion of Fossil Fuels

In the United States, roughly 60% of operational energy carbon emissions in the building sector come from electrical use in buildings, with the other 40% resulting from the on-site combustion of fuels, largely for heating end uses (space heating, service hot water, cooking, and drying)[4]. The roughly 60% from electricity should diminish to near zero by 2050 because grids everywhere are rapidly decarbonizing. Part of the reason for this is economic—it has become less expensive to build and operate renewable-energy power plants than fuel-based ones. The other part is policy based: many countries, cities, and states have committed to a zero-emissions power sector by 2050 or sooner.

The building sector can address the remaining 40% by ceasing to burn fossil fuels on-site. This is now possible because there are efficient technologies that provide heat through electricity, most notably heat pumps.[5] So, as buildings electrify (i.e., replace their fossil-fuel-based heating systems with electrical heating systems) and the grid decarbonizes, these emissions will decrease.

2.2.1.1 Grid Emission Intensity

There is some concern that the electrification of heat and hot water in buildings could increase rather than decrease carbon emissions because some electrical grids currently emit large amounts of carbon per unit of energy because their energy mix includes a high percentage of fuel-powered plants. However, this is not expected to be a widely experienced problem, even in the near term, because most grids in the United States are already clean enough that a modestly efficient heat pump system will result in lower emissions than an equivalent boiler or furnace. And as the grids decarbonize further, electricity-based heating will become cleaner than fuel-based heating everywhere.

Projects in regions with grids that still have higher levels of emissions may reasonably consider delaying electrification of heating equipment that has not yet reached the end of its useful life, but installing new fuel-based heating equipment when old equipment wears out is not prudent. Because the lifespan of much heating equipment can be upwards of 30 years, projects should aim

4. See U.S. building-sector emissions statistics at the United States Environmental Protection Agency's Commercial and Residential Sector Emissions webpage (EPA 2025a).
5. See *Decarbonizing Building Thermal Systems: A How-to Guide for Heat Pump Systems and Beyond* (NREL 2024b).

to replace their failing heating equipment with electrical options because they will not have another chance to electrify before mid-century. Buildings should be setting themselves up for a future world of near-carbon-neutral grids.

To help project teams visualize how the decarbonizing grids will impact their carbon emissions, the carbon projections in the Workbook (USGBC 2025b) assume that each grid is decarbonizing by 95% over the 25 years following project inception (see Figure 3.1 of Chapter 3). While this is not precisely true of any specific grid, it is directionally correct universally and helps project teams base their decisions on the big picture rather than being distracted by the competing predictions buffeting them from other sources.

2.2.2 Energy Efficiency and Demand Reduction

In addition to the shift to electrification, continued emphasis on energy efficiency will be essential to driving down the cost of decarbonization. Electric heat pumps are roughly three times as efficient as fossil-fuel alternatives, but these more complex machines can be significantly more expensive. Incorporating efficiency strategies such as demand reduction, load shifting, envelope improvements, and rightsizing systems can be key to creating decarbonization plans that are more financially feasible by reducing the size (capacity) and associated cost of new equipment. These efficiency measures are also often "no regrets" measures, meaning the annual savings will accrue regardless of when the broader electrification work happens. Finally, implementing efficiency in the near term can reduce carbon emissions from grid-delivered electricity in the near term, since very few grids are carbon-free now or will be soon.

From a system perspective, the reduction of peak loads (demand reduction) is even more important than efficiency. Efficiency reduces overall or average energy use but may not significantly reduce peak demand. Because the grids must be sized to cover the highest system peaks of the year, higher peaks mean that larger, more expensive clean grids will be required, ultimately raising the cost of electricity. The highest peaks of each electrical grid occur when temperatures are the hottest and the coldest, because that is when all buildings require heating and cooling at the same time. These thermally driven peaks will only increase as buildings electrify, introducing new winter peaks, and as climate change accelerates, driving higher summer peaks. The most effective way to lower these peaks is to improve the thermal performance of buildings, largely by improving envelopes through better insulation and sealing leaks and by recovering the energy of ventilation. Buildings that implement such measures will also benefit from reduced capital equipment costs and peak energy costs.

2.2.3 Generating or Purchasing of Carbon-Free Power

The primary responsibility of the building sector is to set itself up for the cleaner grids of the future through electrification, efficiency, and peak demand reduction. However, buildings and large building portfolios can also help accelerate grid decarbonization by installing on-site renewables and/or purchasing carbon-free power, especially power that is new and incremental to any existing mandate. The latter encourages the development of new, large-scale clean power. On-site renewables have additional benefits, such as reducing building energy costs and increasing building resiliency by providing on-site power if the grid fails. They can also reduce strain on the grid; however, note that in places like California that have excess on-site renewable capacity during certain times, on-site renewables should be augmented with energy storage.

2.3 How Strategic Decarbonization Plans Differ from Energy Audits

Energy audits were standardized for three different levels of assessment in ANSI/ASHRAE/ACCA Standard 211-2018 (ASHRAE 2018).[6] For the past 50 years, these energy audits have been the analytic tool the industry has used to help buildings reduce their energy consumption costs, and they have worked well for that purpose. But a traditional audit is not the right tool for long-term decarbonization planning, nor is a full audit a prerequisite step in the development of a strategic decarbonization plan (SDP). However, because of the considerable overlaps between energy audits and the preplanning phase for an SDP, the information from an energy audit can be productively used in the development of an SDP. The principal distinctions between a typical ASHRAE Level 2 energy audit (ASHRAE 2023) and strategic decarbonization planning are shown in Table 2.1.

Decarbonization assessments were initially named in 2023 in the Informative Appendix H of ASHRAE/ACCA Standard 211-2018 (RA2023) (ASHRAE 2023). ASHRAE Standing Standards Project Committee (SSPC) 211 is in the process of more clearly standardizing the definition of a decarbonization assessment, and the next edition of Standard 211 will detail the required analytical exercises to support decarbonization planning and allow projects or building owners to confidently contract for these services.

The information developed for energy audits, decarbonization assessments, and SDPs overlaps considerably, which means that an energy expert will be familiar with gathering much of the information required in the preplanning phase of strategic decarbonization planning. Although the distinctions between these three processes may be confusing, standardization will happen for decarbonization as it has for other processes over time.

While this guide's authors and sponsoring organizations are endeavoring to standardize strategic decarbonization planning and the foundational building blocks of the process, the multifaceted, multi-stakeholder nature of the process means much future work is required of professional organizations and standards-developing organizations. In particular, the future work of SSPC 211 may identify different levels of decarbonization assessments that will define the level of rigor and breadth of scope for engineers contributing to SDP, similar to what they have done for Level 1, Level 2, Level 3 energy audits. Less rigorous but still useful efforts can also aid decarbonization planning, but increasingly qualified expertise should be solicited at the appropriate time in the process as options are formed and decisions are made.

6. ASHRAE/ACCA Standard 211, *Standard for Commercial Building Energy Audits*, was first published in 2018, defining three levels of energy audits following the publication of an ASHRAE book titled *Procedures for Commercial Building Energy Audits* in 2004 and its second edition in 2011. The 2018 edition of Standard 211 was reaffirmed in 2023, when a new appendix was added, Informative Appendix H: Building Decarbonization Assessment.

Table 2.1 Differences Between Energy Audits and Strategic Decarbonization Planning

Paradigm Shift	Energy Audits	Strategic Decarbonization Planning
From energy to carbon	Energy audits by definition have solved for energy use reduction. Audits have not focused on carbon reductions; audits often do not calculate or consider carbon emissions.	Strategic decarbonization planning focuses on reducing carbon. While energy efficiency typically is an integral part of an SDP, it is not the only focus. Nor is it the only strategy that can be utilized; fuel switching, electrification, renewables, and peak load reductions can also reduce carbon emissions.
From modest improvements to deep reductions	Audits have sought opportunities where there is a relatively quick return on investment to the building owner. The relatively short payback requirements of building owners can limit the types of measures that auditors study. The energy measure payback does not capture BAU costs.	Decarbonization often starts with a deep carbon reduction target as the goal. With a deep carbon reduction target, broader thinking about major changes to building systems over a long time horizon open new opportunities.
Change from predictably positive cost-energy equations	Energy audits are typically limited by their scope, and the impact of their outcomes can be limited by financial considerations for payback or cost-effectiveness. Energy audits can almost always deliver a package of measures that will pay for themselves quickly enough to meet an owner's time horizon, generating positive cash flow thereafter.	The goal of an SDP is achieving deep carbon reductions, with the financial lens being the least possible cost. Deep carbon reductions are often expensive and may not pay for themselves or produce cost savings. The goal of the strategic decarbonization planning process is to be strategic and reduce costs to a minimum.
Dimension of time	Audits have traditionally focused on near-term opportunities, with financial payback from energy cost savings within 3 to 10 years to owners.	A longer time horizon drives a more comprehensive look at opportunities out 10 to 20 years (or more) and a long-term strategic view about how to capitalize on those opportunities. A longer time horizon can anticipate trigger events that enable implementation of measures that may not be feasible in the near term.
Engineering expertise vs multidisciplinary expertise	Energy audits can be conducted solely by engineers in consultation with building operators.	The development of an SDP is similar to a design exercise, which requires a multidisciplinary team, including financial experts, architects, and other technical and real-estate experts.

3

Strategic Decarbonization Planning Process

This chapter outlines the ideal strategic decarbonization planning process for a commercial real-estate company, including perspectives, participants, and milestones. Real-world strategic decarbonization planning processes may be constrained, but project teams should work to mitigate shortcomings in the process and develop strategic decarbonization plans (SDPs) that get implemented despite the challenges. For other types of building ownership the process may be simplified, but participants should be careful to avoid missing crucial progressions. Engineers and technical professionals should take care to understand how their recommendations will feed into the broader planning process and optimize accordingly.

Strategic decarbonization planning can be broken into two phases: a preplanning phase, where the relevant background information is collected, and a planning phase, where options are analyzed and discussed and the SDP and capital plan are developed. Since this SDP will span years, even decades, it also needs to be reviewed regularly and amended as needed in an ongoing maintenance and adjustment phase.

3.1 Preplanning Phase

Strategic decarbonization planning is a complex, bottom-up process that requires the assembly of a multidisciplinary team and a considerable amount of structured information before an educated planning process can begin. The necessary information collected during this phase is compiled in the Workbook (USGBC 2025b), which will serve as the central repository of all information for the SDP. At the end of this phase, the team will develop rough conceptual plans to be discussed in the brainstorming meeting (a charrette) that kicks off the planning phase.

The data-collection steps of the preplanning phase are listed in Table 3.1 and described in greater detail in the following subsections.

3.1.1 Assemble a Project Team

Creating a good SDP requires a project team with a wide variety of perspectives, similar in breadth to a team created for a major renovation. Decarbonizing can be like a major renovation in slow motion—one that happens over 15 or 20 years. Like a major renovation, decarbonization can have significant impacts on many aspects of a building: the capital budget, annual expenses, architecture, aesthetics, desirability, structure, code compliance, operations, leasing, and more.

Table 3.1 Overview of Preplanning Phase Steps and Deliverables

Preplanning Phase Step	Preplanning Phase Deliverable
Assemble a project team, including at a minimum the following: team leader, owner or owner's representative, engineering/energy expert, experts on the building's operations, financial expert and/or asset manager, architectural/code expert, building envelope expert, and cost estimator	Team list; enter name, company, and expertise for each team member into the Workbook
Compile a building profile inclusive of the following: • **Basic building and energy data**, including building name, primary occupancy, size, address, one year of energy use data for each type of energy, and most recent carbon coefficient for the grid • **Inventory of equipment and system information**, including the end of useful life for major equipment • **Trigger events and timeline**, including replacement of major equipment or façade elements, refinancing, sunsetting of incentives, asset repositioning, institutional deadlines, etc. • **System end-use analysis**, including a breakdown of energy use by type and system, ideally informed by a peak-day hourly heating and cooling load profile analysis; also determine the percentage of each type of energy	Data entered into the Workbook
Create a business-as-usual (BAU) carbon projection; a basic BAU carbon projection will be generated by the Workbook, and projects subject to building performance standards (BPS) must also generate a BAU carbon projection based on regulated emissions factors with an overlay of project-specific BPS caps and fee projections	BAU carbon projection generated by the Workbook If subject to BPS, a BPS-based BAU carbon projection
Create a BAU financial projection, including estimated costs of energy from each source, costs to replace major equipment and envelope components in kind, and any carbon or energy fees related to BPS, along with any special opportunities	Data entered into the Workbook
Compile historical analyses and reports, including retrocommissioning reports, audits, other energy-related analyses, property condition assessments, etc.	Historical analyses and reports
Compile case studies of SDPs, including those that have been developed for similar buildings, if possible	Minimum of two case studies
Develop conceptual decarbonization plans, including a rough-estimate carbon impact analysis, with at least one plan that achieves an estimated reduction of on-site combustion emissions >90%	Minimum of two conceptional decarbonization plans; enter narrative and ballpark carbon projection for each conceptual plan into the Workbook

To comprehensively address these issues and identify key factors that could either simplify or complicate the decarbonization process, entities with the following expertise/roles need to be part of the project team:

- **Project manager/team leader.** An individual tasked with assembling the team, ensuring that the work proceeds properly, and acquiring additional expertise or information as required. This person could be a generalist and could be one of the participants listed below but should have reasonable experience leading complex architectural/engineering projects.

- **Building owner or owner's representative.** An individual who understands and represents the owner's perspective vis-à-vis their long-term vision and plans for the building; the business case; the environmental, social, and governance (ESG) reporting requirements; the sustainability goals, etc. The owner's representative should ideally remain engaged throughout the entire strategic decarbonization planning and implementation process (unlike for energy audits). This role is critically important, as the person must be able to convey complex engineering concepts in business terms that resonate with the owner and other decision-makers. While being able to communicate financial implications and strategic benefits to stakeholders, the owner's representative should also have sufficient technical understanding to engage meaningfully with engineers. This function is especially crucial given the complexity of decarbonization planning compared to traditional energy audits.
- **Engineering/energy expert.** An individual who understands existing buildings and how their energy systems can be improved. It may be advantageous to also have on the team those with expertise in designing new, all-electric mechanical and supporting electrical systems. Often energy auditors are skilled at improving old systems, but planning for decarbonization may be more akin to new system design than improving existing systems.
- **Experts on the building's energy operations (facility manager, building operator, and/or operating engineer).** Individuals familiar with the operations of the building and the capital planning process.
- **Financial expert/asset manager.** An individual with oversight of asset financial performance and capital expenditure (CapEx) planning.
- **Architectural/code expert.** Individuals who understand the design implications of new mechanical and envelope systems, including the impact on aesthetics, room layouts, and code compliance.
- **Building envelope expert.** An individual with expertise in retrofitting building envelopes for improved thermal performance, including reduced air leakage and thermal bridging, improved fenestration, adding interior or exterior insulation to walls, moisture and thermal comfort control, etc.
- **Cost estimator.** An individual who can provide estimated costs for the decarbonization plan options, the SDP, and the five-year capital plan. Note that rule-of-thumb estimates will not be adequate, as project-specific aspects could be significant. This capacity is of particular importance when new mechanical systems are designed with significant heat recovery and efficiency improvements, since per-square-foot estimating cost benchmarks may not be appropriate for HVAC systems of reduced size.

The following additional people may be valuable on a strategic decarbonization planning project team, as well:

- **Property manager.** An individual with an understanding of the building occupants' needs and level of satisfaction.
- **Leasing agent.** An individual with insight into future occupant demands and the positioning of the asset related to competitors.
- **Structural expert.** An individual with expertise in structural engineering. Recommended if the project entails building envelope modifications or locating and supporting heavy new mechanical or electrical equipment.
- **Incentive expert.** An individual with experience identifying and securing financial incentives. This expertise can be especially helpful for strategic decarbonization planning, as the

options can be challenging to navigate and change frequently. These could include incentives or tax rebates at the local, state, and/or national level as well as utility incentives.

3.1.2 Compile a Building Profile

Creating an SDP requires the team to have access to a fair amount of basic information about the building and its energy systems. The information includes much of the background information collected during an energy audit plus other information that can help project teams better understand their drivers of carbon emissions and the future events in the life of the building that will have impacts on the timing and costs of decarbonization. The overlap between the building profile information collected for an energy audit and during the preplanning phase of strategic decarbonization planning is summarized in Table 3.2.

The basic building information to be collected in the preplanning phase includes the following:

- **Basic building data** such as the building's size, age, location, and occupancy type.
- **Basic energy and carbon data**, including annual energy use for each type of energy; a breakdown of energy use by system, including type of energy used; and carbon emissions.
- **Equipment and energy system information**, including an inventory of energy-using equipment and the end of useful life and cost to replace each piece of major equipment.

Table 3.2 Information Collected in Building Energy Audits and Strategic Decarbonization Planning

Information Category	Information Line Item	Energy Audit	Preplanning Phase of Strategic Decarbonization Planning
Building data	Building data	Y	Y
Energy and carbon data	Energy use data	Y	Y
	Breakdown of energy use by system	Y	Y
	Carbon emissions data	N	Y
	BAU carbon projection	N	Y
Energy equipment and trigger events	Inventory of energy-using equipment	Y	Y
	Trigger events	N	Y
	End of useful life for major equipment	Y	Y
	Cost to replace major equipment	Y	Y
Energy conservation measures (ECMs)	List of ECMs and paybacks	Y	N
	Carbon impact of ECMs	N	N
BAU financial projection, reports, case studies, and conceptual decarbonization plans	BAU financial projection	N	Y
	Historical analyses and reports	Y	Y
	SDP case studies	N	Y
	Conceptual decarbonization plans	N	Y

- **Trigger events and timeline**, including lease turnover, refinancing, repositioning of the asset, regulatory deadlines, and sunsetting of incentives, in addition to replacement of major equipment. Some examples of trigger events and how they can impact decarbonization planning include the following:
  - **Refinancing.** A time when money becomes available for capital investment generally, and potentially for decarbonization projects, or when basic property needs assessments will be performed.
  - **Asset repositioning.** An occasion to make significant upgrades to how a building functions, which could dovetail well with decarbonization, while higher rents could offset costs.
  - **Equipment's end of useful life.** An opportunity to execute decarbonization projects associated with major mechanical equipment or facade components, such as windows and fenestration elements.
  - **Tenant turnover.** An opportunity during which invasive decarbonization measures can be implemented within a tenant space and/or when energy upgrades can be financed as part of a tenant improvement allocation.
  - **Financial incentive availability.** Tax credits, utility rebates, or other incentive programs that may prompt more immediate action while funds are available.
  - **Institutional decarbonization commitments.** Institutional deadlines that decarbonization plans must meet, pursuant to commitments.
  - **Compliance deadlines for energy/carbon regulations.** Dates at which energy or carbon fees will be imposed or expected to increase.

3.1.2.1 Important Note on Historical Energy Audits

While this guide notes the overlap between information collected in energy audits and during the preplanning phase of strategic decarbonization planning, it is important not to assume that historical energy audits have been fully implemented or that their recommendations remain valid. In practice, many buildings have incomplete implementation histories of audit recommendations. Project teams should verify which recommended energy conservation measures (ECMs) from previous audits were actually implemented, which were not, and whether those not implemented remain viable. Additionally, teams should confirm whether previously implemented ECMs are still functioning as intended. This verification step is essential before building upon existing information for decarbonization planning purposes. Even well-documented buildings often have gaps between recommended and implemented measures that must be addressed as part of the preplanning process.

3.1.3 Create a BAU Carbon Projection

A simple BAU carbon projection can be generated by the Workbook (USGBC 2025b) from the building's current annual energy data and information about its location (and local grid). The BAU carbon projection generated by the Workbook is a default BAU carbon projection that all properties can use. It assumes that the carbon coefficients for all grids are based on the most recently published national or regional coefficients—such as those included in the Emissions & Generation Resource Integrated Database (eGRID) subregional coefficients from the United States Environmental Protection Agency (EPA 2025b) (see the sidebar The Other Side of the Meter)—and will decline by 95% over the next 25 years. If projects have more specific information about their grid that they want to use in a projection (or specific information about a district energy system), they can tailor their BAU projection calculations accordingly.

Pacelines within the BAU carbon projection represent the declining emissions trajectory that a project should meet in order to comply with institutional goals, jurisdictional requirements, science-

THE OTHER SIDE OF THE METER

Carbon Projections, Forecasts, and Decision-Making on the "Other" Side of the Meter

For the building side of the meter, developing a plan to cost-effectively replace fossil-fuel equipment with electric alternatives at the end of the current equipment's useful life, or sooner, is the main task. As a result, it is helpful to understand a bit about the factors that will determine total emissions on the other side of the meter—the utility side—although that rarely impacts building decarbonization planning for an individual building.

Building professionals engaged in decarbonization planning can easily find themselves lost in the details of grid decarbonization, electricity generation, and a variety of complexities that exist on the utility side of the meter. While concerns about the carbon emissions associated with electricity are valid given that most planners do not want to increase emissions in the short or long term, the bottom line for reducing carbon emissions from the building sector is that the electric grid must decarbonize, and buildings must shift away from on-site combustion, as rapidly as possible.

USGBC, through LEED and the Workbook, is relying on the following simplified concepts:

- **What are my carbon emissions today?**
  Understanding a building's historic and current emissions resulting from electricity use is not easy; different utilities function across regional grids with a variety of generation resources. In the United States, the EPA provides resources to help interested parties understand the carbon emissions of their electric use, typically by averaging retrospectively on an annual basis. For example, the EPA's eGRID data (2025b) are used by ENERGY STAR® Portfolio Manager® (EPA 2024a) and the Workbook (USGBC 2025b) and serve as a great resource to start—but note that this emissions intensity is just that: a starting point. As of 2025, eGRID data from 2023 are the most current available for use. Additional resources available from the EPA include a Portfolio Manager Technical Reference that provides information on calculating greenhouse gas emissions (EPA 2024b) and the Power Profiler, which is a tool that can help calculate building emissions (EPA 2025c).
- **What will my carbon emissions be in the future?**
  Moving forward, electricity grids will be served by cleaner energy generation, but the rate of change is uncertain and will vary across grids and geographies, and forecasting is notoriously difficult. Future emissions intensity will be determined by the new generation of energy resources in the development pipeline today, to be followed by another generation of projects with new technologies and strategies driven by current and future policy and market demand. There is no consensus emissions intensity forecast to cite, and many forecasts that consider only currently known projects effectively forecast failure of state carbon goals and should not be used for decarbonization planning.

  The best forecasts provide a suite of scenarios, like the Cambium forecasts from National Renewable Energy Laboratory (NREL) in the United States that provide energy futures data for long-range planning (NREL 2024a). In the context of long-term decarbonization planning for a building, the most appropriate is the "95% decarbonization by 2050" scenario, which does not project failure of carbon policy and utility regulation. The marginal rate forecasts are the most appropriate to consider, as adding or removing load from the grid adds or removes the emissions from the last kilowatt hour (marginal) and not the average kilowatt hour. For international locations, information is limited, but progressively some is emerging (Goldsworthy and Aryai 2023).

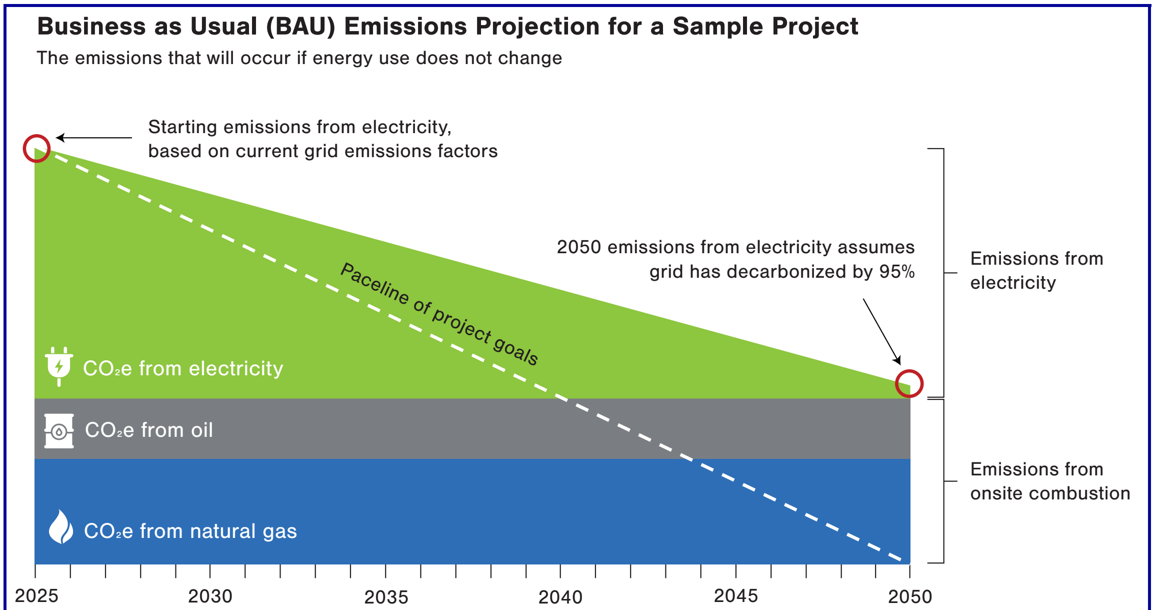


Figure 3.1 BAU carbon projection visualization. (Image credit: USGBC; reprinted with permission)

based targets, or other targets. A paceline acts like a North Star for a building, helping it to navigate and track the rate of progress toward its carbon destination. Ideally, projects should aim to keep their carbon emissions below their paceline, but this can be challenging. The default BAU carbon projection generated by the Workbook includes a paceline (shown in Figure 3.1 as a dashed line) that is a straight-line carbon reduction to zero between the base year and 25 years out.

There are three major implications from the BAU carbon projection as defined in the Workbook:

- Emissions from grid electricity generally are not zero, especially in the near term.
- Emissions from grid electricity will decline to almost zero over the next 25 years.
- Emissions from the on-site combustion of fuel will not change unless retrofits to the building are made.

3.1.3.1 Incorporating Pacelines

While this guide focuses on bottom-up, building-level strategic decarbonization planning, informed by a building's systems and equipment, there are also top-down initiatives that provide buildings with emissions budgets based on science-based targets or other sector, region, or fund-specific goals. These top-down goals or caps are typically represented as lines or curves (pacelines) that can be laid over the BAU carbon projection. Whereas the Workbook includes a simplified paceline that goes to zero linearly over 25 years (see Figure 3.1), the Carbon Risk Real Estate Monitor (CRREM)[7] is a commonly referenced set of pacelines that has been developed for various types of buildings based on science-based targets. Such pacelines can be useful for determining whether a project's bottom-up SDP timeline (based on system reconfiguration and equipment replacement) should be accelerated to meet external goals.

7. See Carbon Risk Real Estate Monitor (CRREM n.d.).

A critical paceline that should be laid over the BAU carbon projection is one representing building-specific carbon caps from carbon-based building performance standards (BPS), if the building is subject to them, as shown in Figure 3.2. BPS are local ordinances that set declining caps on a building's emissions that are typically enforced by fees or fines if the building exceeds its annual caps. Project teams should calculate the annual fees the project would incur in the BAU scenario. Establishing this BPS paceline is required for projects pursuing the LEED v5 Operations and Maintenance (O+M) Energy and Atmosphere (EA) Credit Decarbonization and Efficiency Plans (USGBC 2025a). Project teams should take care to update the BAU carbon projection to use the electrical grid coefficients and other particulars as prescribed in the local regulations, not the 95% reduction of the default BAU carbon projection. If the local regulations have not prescribed the electrical grid coefficients in the out-years, project teams should make their best guesses. The BPS data can be collected in the Workbook (USGBC 2025b) and can be used to calculate any possible BPS fees in the BAU financial projection.

3.1.4 Create a BAU Financial Projection

A rough BAU financial projection should be considered alongside the BAU carbon projection, since it is important to understand the true cost of inaction. Although the Workbook will not support financial analysis or discounted cash flow (DCF) analysis because of the breadth of different cost analysis methods and metrics, users can use it to collect the like-for-like replacement costs and end-of-life estimates for existing equipment as well as fines or fees associated with building performance requirements. Project stakeholders can use this raw data to develop more complex financial analyses, as appropriate.

Even without discounting, the nominal future costs associated with BAU operations and emissions will guide discussions with the team and highlight opportunities. Successful SDPs have been based on understanding and avoiding or mitigating future costs of envelope safety regulatory compliance or known repairs, creating new roof amenities, and improving occupant comfort or access to additional space or amenities. Each of these opportunities were identified by impending future costs that became opportunities for the SDP.

The BAU financial projection should include workable estimates of the following costs over the next 25 years, including the estimated year of each expense:

- Cost to replace major equipment and envelope components at the end of useful life, based on the inventory of major energy-using equipment
- Anticipated fees or fines, if any, from noncompliance with BPS
- Annual cost of energy from each energy source, including escalation if discounting future cash flows (note that these variables may shift over time and should be considered for sensitivity and scenario analyses, as discussed in Chapter 5)
- Annual maintenance costs, especially if they may increase or decrease over time
- Other costs, such as lost revenue due to the building being perceived as having lower income potential because it has not taken steps to reduce its emissions

3.1.5 Compile Historical Analyses and Reports

Often, a building is not starting from square one in considering its energy use and/or carbon emissions. It may have undergone a recent audit and/or retrocommissioning or a property condition analysis that can shed light on the condition of the building's energy systems. The planning team should collect all such reports and summarize the information that is most relevant to decarbonization planning. Note that if a building has undergone a recent energy audit, the audit report could potentially provide much of the basic building, energy, and equipment information required in the preplanning phase of strategic decarbonization planning—provided of course that the audit is not outdated and reflects the current building operations.

3.1.6 Compile Case Studies of Strategic Decarbonization Plans

It is likely that some project team members have not had experience developing SDPs, so they may not know how to engage in this new type of planning process. Exposing the team to several good SDPs or decarbonization case studies could help get them up to speed on everything from BAU calculations to the types of strategies they might consider and how trigger events and non-financial issues can impact the schedule and financial viability of emissions reduction measures (ERMs). The example plans and case studies should be distributed to the team prior to the kickoff charrette to give team members a chance to study them.

The team should collect examples of successful SDPs for buildings that have energy systems and envelopes similar to the building they are working on. However, the team should also include SDPs for buildings that differ if those plans introduce novel strategies that could be applied to this building. This can free project teams to intellectually let go of the building's current configuration and imagine a different future.

Some example plans have been compiled as part of New York State Energy Research and Development Authority (NYSERDA) activities to support strategic decarbonization planning and are included in the Case Studies and Examples section of this guide's appendix.

3.1.7 Develop Conceptual Decarbonization Plans

The last step of preplanning entails the development of at least two conceptual decarbonization plans to help kick off discussion in the decarbonization charrette that launches the planning phase. These conceptual plans should identify different ways of achieving substantial decarbonization. The plans should list the main ERMs entailed, the order in which these measures should be pursued if relevant, and a back-of-the-envelope estimates of their impacts on energy, carbon, and costs.

Each plan should include a summary visualization of its impact on carbon, such as a waterfall chart, which will enable the project team to understand the overall carbon strategy at a glance. These conceptual decarbonization plans should enable the team to start imagining how the building could achieve substantial decarbonization and should facilitate more in-depth discussion.

3.2 Planning Phase

The planning phase includes a structured process to help project teams proceed from general concepts to decarbonization plan options and, finally, to a well-considered SDP with thoroughly analyzed carbon and financial impacts. The process is similar to a standard architectural design process where a team starts with a few basic design schemes, develops the schemes to an increasing level of detail sufficient to allow them to be compared with a fair understanding of the consequences, and finally develops a chosen scheme to a high enough level of detail that the building owner and project team can adopt it and commit to pursuing the first five years of it.

The steps of the planning phase are listed in Table 3.3 and described in greater detail in the following subsections.

3.2.1 Conduct a Decarbonization Charrette

To start the planning phase, the team leader should schedule a decarbonization charrette for the full project team. The charrette should occur after completion of all the preparatory work from the preplanning phase. The team leader should distribute all materials to the full project team with sufficient time for review in advance of the charrette.

Table 3.3 Overview of Planning Phase Steps and Deliverables

Planning Phase Step	Planning Phase Deliverable
Conduct a decarbonization charrette, which should include as many team members as possible; in it, present materials compiled in the preplanning phase and discuss the conceptual decarbonization plans, the issues that make those plans unfeasible, how to overcome their obstacles, possible changes to the plans, and any other ideas	Meeting minutes detailing decisions about the conceptual decarbonization plans to be developed further
Develop and investigate multiple decarbonization plan options by building on the charrette discussion; one option must reduce on-site combustion emissions by >90% within 20 to 25 years, and each option must include a narrative and a list of ERMs, with the timeline and projected impact of each measure on energy and carbon emissions as well as the realistic architectural, structural, and code costs	At least two decarbonization plan options; enter narrative and data into a unique sheet of the Workbook
Create the strategic decarbonization plan by determining which decarbonization plan option to pursue—an option from the previous step, an amendment of an option, or a new option; the SDP must include a narrative and a list of s, with the timeline and projected impact of each measure on energy and carbon emissions as well as realistic architectural, structural, and code costs	A narrative of the SDP; enter narrative and all the data about the SDP into the Workbook
Create a five-year capital plan of the SDP's ERMs to be pursued in the next five years, developed sufficiently for accurate carbon assessments and budgeting and including the timeline, cost, and projected impact of each measure on energy and carbon emissions, a description of how the plan will be financed, and an outline or Gantt chart of the steps to be taken to implement the plan	Refined analysis of the ERMs to be pursued during the first five years; describe the financing and include the outline or Gantt chart

Effective charrettes require an investment of time—usually at least half a day. The purpose is to ensure that all members of the cross-disciplinary team are up to speed on the variety of issues likely to impact the plan and to ensure that all the representatives from essential disciplines are at the table when possible strategies are discussed. This can help to ensure that good ideas from unexpected quarters appear early and problems are not identified late in the process.

The agenda for the charrette should include the following:

- **Introductions and role definitions.**
- **Level setting.** Relevant team members should present the materials collected during the preplanning phase. Time should be allowed for discussion of these materials.
- **Goal setting.** The team should collectively set concrete goals for the decarbonization effort. The ideal end state can reflect various drivers and levels of ambition—is it zero, or meeting a local regulation, or satisfying a larger campus or community goal?
- **Presentation of conceptual decarbonization plans.** A small team, which must include the engineer, should come to the table with a few conceptual decarbonization plans, including a ballpark analysis of each plan's carbon impacts.
- **Facilitated discussion of decarbonization.** Discussion questions like the following should be considered during this discussion:
  - What would be required to get the building to zero or near-zero emissions? What strategies would improve the financial picture? What are the impediments and how can the project overcome them?

    - If not zero or near zero, what other low-carbon goal might be the sweet spot for this building? What alternative strategies and goals can be considered?
    - If getting to near-zero emissions does not seem feasible, what changes in technology, regulations, incentives, positioning of the asset, etc., might make it feasible?

  The discussion should include architectural, structural, life-safety, quality-of-life, operational, and resiliency impacts in addition to engineering and financial considerations; goals could also include reduction of peak thermal and electrical loads and conversion to refrigerants with lower global warming potential (GWP) where possible.
- **Outline of the decarbonization plan options.** The project team should work together to assemble two or more packages of ERMs that collectively approach a low-carbon future for the building. Breakout groups at the beginning of this exercise might help ensure a variety of approaches. The team should discuss the decarbonization plan options and work together to refine them.
- **Decision on the decarbonization plan options to be developed further.** The project team should decide on two or more decarbonization plan options to develop further, at least one of which should deliver operations that are near zero carbon in 20 to 25 years.

3.2.2 Develop and Investigate Multiple Decarbonization Plan Options

The purpose of this step of the planning phase is to enable the project team to compare and contrast the impacts of different decarbonization plan options to avoid getting locked into a single option too early. Ideally, the decarbonization plan options should differ in basic approach rather than being variations on a single theme, such as one with a complete set of strategies and another with a few strategies excluded.

An appropriate subset of the project team (including the engineer, architect, etc.) should develop each of the decarbonization plan options sufficiently to enable the full team to make the big fork-in-the-road planning decisions with a clear understanding of the financial consequences. This requires more than just a list of the engineering interventions planned. What will be the architectural implications of the new engineering systems in each option? Will rooms have to be built or allocated for new equipment? Will the structure need to be reinforced to carry the new equipment? Will walls need to be insulated to reduce the sizes and costs of the new systems? To understand the ramifications and visualize these issues, some rudimentary schematic sketches may need to be generated. During this step, the full project team should meet regularly to provide input to the design team. Deliverables for each decarbonization plan option include the following:

- **Outline of the decarbonization plan option.** This should include feasibility analysis and engineering analysis, followed by engineering and architectural design in sufficient detail to capture the main engineering and architectural costs that will be incurred.
- **Timeline in relation to trigger events.**
- **Carbon projections for 25 years.** These projections should show when ERMs will occur, their cumulative impact on carbon emissions, and their relationship to any BPS or other commitments. The Workbook will generate the visualizations of carbon projections of the decarbonization plan options minus the overlay of any unique pacelines, such as the dotted step-down BPS caps, as shown in Figure 3.2. Such unique pacelines must be generated by the project team.
- **Cost estimation of implementing the decarbonization plan option.**
- **Financial analysis of the plan compared to the BAU financial projection.** This should include up-front costs, cost of energy, fees, fines, projected increased rents, etc. The financial team should analyze each decarbonization plan option against different future scenarios, including escalation, fuel costs, and regulatory environment.

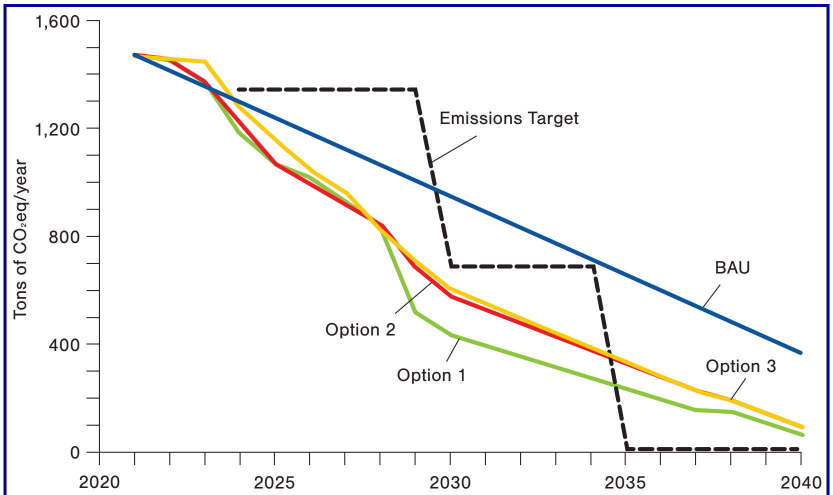


Figure 3.2 Visualization of the carbon projections of decarbonization plan options, with overlay of BPS emissions targets.

The Workbook contains separate sheets to allow project teams to record each option and visualize its impacts.

Once the decarbonization plan options have been designed and analyzed as outlined here, the full project team should meet to review the designs and their impacts on all relevant outcomes, such as carbon, finances, and market positioning. This meeting should be approached with an open mind as an opportunity to provide constructive criticism and to identify whether opportunities or problems were missed in the design of the decarbonization plan options.

3.2.3 Create the Strategic Decarbonization Plan

The project team should determine the basic outline of the preferred decarbonization plan option that the project team will develop into its SDP. This may be one of the decarbonization plan options, an amalgam of several options, or an amended option incorporating some different ERMs. It may take more than one meeting to arrive at a consensus on the outline of the preferred option.

Once the preferred decarbonization plan option is outlined, appropriate members of the project team (such as the engineer or architect) are now in a position to develop the SDP. This step of the planning phase entails a more thorough design development in terms of engineering and architectural design and financial analysis. By the end of this step, the building owner should be able to understand, to a high degree of confidence, the impacts of the SDP in terms of modifications to the building and their costs and benefits.

The SDP should include all the deliverables from the decarbonization plan options (i.e., the outline, timeline, etc.), plus the following:

- More robust financial analyses, including sensitivity analysis across different scenarios
- Rough proposals for the funding of the SDP over the first 5 years and over the subsequent years
- An analysis of what would need to change for a near-zero plan to become feasible if the SDP does not approach near zero emissions by 2050

Prior to finalizing the SDP, the full team should review it, and the owner or owner's representative should sign off on it.

3.2.4 Create the Five-Year Capital Plan

One challenge with long-term plans is that they tend to sit on a shelf. The five-year capital plan for an SDP is meant to ensure that does not happen and that the building makes progress on the SDP that has been outlined. This is where the rubber meets the road.

The five-year capital plan should include all the ERMs from the SDP slated for the first five years. More fundamentally, it is meant to be real—it is what the building ownership is committing to pursue, and it is what building management knows how to finance and implement. Because the five-year capital plan is just the initial rollout of the SDP, project teams should not expect the project to necessarily be cash positive, as the initial rollout may represent a down payment on future savings, as shown in Figure 5.2 of Chapter 5.

The ideal five-year capital plan should include the following:

- Design of all ERMs in sufficient detail to determine detailed cost estimates and clear timelines
  - Any issues not related to the decarbonization work that could impact the cost or schedule or that should be coordinated, such as lease turnover or other capital projects
- Financial assessments
  - If relevant, sources of financing and anticipated cost of capital with sensitivity analysis
  - Estimated dates financing is to be secured
  - Potential tax benefits and incentives
  - Impacts on operational costs (energy and maintenance costs) and carbon fees or fines, if any
- Summary of capital plan
  - ERMs
  - Implementation plan/Gantt chart including estimated dates for work to begin and end for each measure and trigger events, if any
  - Implementation-ready cost estimate for each ERM and total cost of five-year plan
  - Estimated annual impact on fuel and electrical use and carbon reductions from each ERM and in total
  - Visualization of carbon emissions and energy consumption during the five-year period, to be generated by the Workbook

3.3 Ongoing Maintenance and Adjustment of the Strategic Decarbonization Plan

Strategic decarbonization planning can be a significant effort and expense given the breadth of real-estate and engineering expertise that must be assembled. The outcome of this process should be immediately useful and as durable as possible; in fact, durability should be viewed as a measure of success.

However, durability should not be assumed. The building owner and engineer should review progress against the SDP annually, with a deeper dive at least every five years when new multiyear capital plans are being developed (though this could range from three to seven years, depending on the capital planning cycle). It is important that the SDP stay in sync with capital planning cycles. At those intervals, a small team including the owner and the team developing the multiyear capital plan (and ideally including key members of the initial strategic decarbonization planning project team so that they can educate any new team members) should review the progress on the SDP to see if the plan is on track, to assess why if it is not, and to determine whether the SDP needs minor revisions or major amendments. At a minimum, the team should expect to make minor revisions to the SDP to bring the plan's assumptions up to date, such as updating cost estimates, accelerating timelines for measures or installations, or reconfiguring phasing with changes to leasing or ownership. Such small-scale recalibration should be possible with minimal effort if the original SDP is robust.

However, if circumstances have changed in ways that will make achieving the measures in the SDP significantly more difficult, such as major cost escalations, or in ways that will make it easier to achieve the decarbonization goals, such as new products or new industry insights on decarbonization plan options, it may be necessary to reassemble the whole strategic decarbonization planning team to make amendments to, or even rethink, the SDP.

SDPs that stopped short of achieving near-zero carbon emissions because of poor economics or other issues constitute a group of SDPs that could change significantly over time. For a building with such a plan, it would be best practice to reassemble the project team at the regular capital planning intervals to evaluate whether the plan could cut deeper or go faster. Such reexamination should be productive because it is likely that more options, better equipment, and improved strategies will become available as strategic decarbonization planning becomes more widespread. For this reason, SDPs that may fall short of zero should not be discouraged, although teams should always be encouraged to try and find a way to go deeper. It is better to get on the road to decarbonization imperfectly than to hold back and wait for perfection.

4

Decarbonization Technical Principles in the New Paradigm

In the context of reengineering and redesign, first principles of decarbonization provide foundational guidance. These include the following:

- **Start with the basics.** Ensure that the building is properly maintained and operating before investing in expensive decarbonization strategies.
- **If possible, address envelope issues first.** A leaky and poorly insulated envelope will result in an electrified system that is overly expensive to build and operate.
- **Stop oversizing equipment.** Existing heating and cooling systems are usually oversized and are not necessarily optimized for current and future needs. Determining actual heating and cooling loads, particularly peak loads, and taking measures to reduce those peak loads (including incorporating thermal storage), will be critical in bringing initial costs down and in delivering efficient systems.
- **Consider lower-grade distribution temperatures.** Maintaining healthy and comfortable conditions in occupied spaces does not require the use of energy-dense fossil fuels; lower-grade heat and lower temperatures are generally sufficient.
- **Move heat, do not create heat.** Using electricity to move heat rather than create it is inherently more efficient; efficiency is the inevitable result of thoughtful electrification.
- **Recover heat from all available sources.** Recoverable heat exists at multiple scales within a building, not only in return or exhaust air; these include within zones, between adjacent zones, and between non-adjacent zones. Air also may not be the ideal collection or transport mechanism.
- **Avoid heat rejection where possible.** Heat rejection during the winter heating season is inherently wasteful if the building's heating demands are not already satisfied.
- **Understand that simultaneous heating and cooling can be both a waste and an opportunity.** Although simultaneous heating and cooling is generally wasteful, recovered heat can sometimes replace heat from a utility and can essentially be free. Therefore, heat from purchased utilities should be a prime target for optimization.
- **Avoid using electric resistance heating.** Electric resistance has high operating costs and low efficiency relative to heat pump alternatives (for more information, see the sidebar Electric Resistance Heating).

There are also some common pitfalls to be avoided when decarbonizing buildings. Poor decarbonization plans can lead to negative impacts on both building operating costs and the electric

ELECTRIC RESISTANCE HEATING

Heat pumps are three to four times more efficient than electric resistance at providing heat, so if possible electric resistance heating should be avoided in favor of heat pumps to decrease energy waste. However, it is not always a simple decision between heat pumps and electric resistance, since the technologies are often combined. Because air-source heat pumps become less efficient at low temperatures, many heat pump products switch to electric resistance at low temperatures. If a high percentage of buildings adopt such hybrid technologies, it could lead to dramatic peaks in demand at low temperatures because the systems are the least efficient precisely when the most heat is required. Moreover, it may not be clear that a heat pump product is switching to electric resistance at low temperatures because of the confusing names used for the various heating modes. Engineers should be aware of these issues when specifying new heat pumps.

Rather than using a hybrid heat pump/electric resistance product, design teams may want to consider a different hybrid solution, where air-source heat pumps are used at normal temperatures and existing furnaces or boilers are switched on when it is really cold and heat pumps become very inefficient. Yes, the use of a furnace or a boiler means on-site combustion, but it won't amount to that much carbon because it is used for very few hours of the year and it protects the grid from being overwhelmed.

grid. Some of the potential pitfalls that planners should consider are discussed in the following subsections.

4.1 Beyond OpEx-Only Optimization—Do Not Focus on Paybacks

In energy audits, the cost savings of efficiency improvements or envelope upgrades are often compared to their up-front cost for financial justification. If a measure "pays back" its costs within a prespecified number of years it is considered more viable. In the context of long-term capital planning for decarbonization, however, considering only the payback period may undervalue the benefits of a measure or group of measures. For example, envelope sealing and new secondary windows or an exterior window film may not be cost-justified based on operating expense (OpEx) reductions alone, but they may enable the reduction of the capital expenditure (CapEx) of heating or cooling equipment during a plant redesign. Decarbonization plans should always strive to reduce the size of the heating and cooling plant capacity or otherwise eliminate oversizing to improve the overall economics of the plan.

4.2 Looking Beyond the Constraints of Today

In the real world, some improvements or measures will not be possible, and the building ownership may communicate that clearly during the decarbonization planning process. While proposed plans must respect such constraints, things will change over the decade or more during which the building may be decarbonized. As a result, even if a system or structure is categorized as off limits during the planning process, it is crucial that technical professionals advise their clients of the role such a system or structure could play in the long-term decarbonization plan. Defining the opportunity or previewing the conditions under which these constraints should be revisited is advisable. A common example is building envelope assemblies, which are often "untouchable" for a variety of reasons. However, if envelope improvements would materially change the decarbonization plan for the building (meaning that significant cost savings could be achieved in the future if the system were improved), then the building owner or management should be made aware that improvement to the envelope represents a significant opportunity should the constraints be reduced. Another example is the availability of heat pump technology to meet certain design criteria, such as hot-water temperatures or space constraints. Decarbonization planners should take care to frame the future opportunities for decision-makers in the context of the constraints of today.

4.3 Failing to Reevaluate the Capacity Needs of a Building Today

In bottom-up plan development, designers must use assumptions about current and future internal loads and occupant requirements. It is well known that many building mechanical systems are oversized, and minimal study of a building's current energy use before commencing the decarbonization planning process can lead to downsizing and rightsizing the building's energy systems. This can shrink the size of the heating plants needed such that electrification may become more feasible when combined with heat recovery, energy efficiency, and envelope improvements. With basic monitoring and light analytics, decarbonization professionals may have the opportunity to correct rather than continue the oversizing mistakes of the engineers that came before them.

5

Making the Business Case for Decarbonization

A narrow decarbonization plan—meaning a plan that solely optimizes carbon emissions outcomes—is unlikely to be perceived as anything but an unwanted cost by building ownership. However, all buildings require periodic investment, recapitalization, or modernization. A broad decarbonization plan is much more likely to uncover multiple value propositions for the building ownership or management and be perceived as a necessary investment. Strategic decarbonization plans (SDPs) should be as broad as possible, reflecting the building ownership's broader goals. When SDPs improve the desirability or usability of buildings or otherwise further modernize them, the buildings can more effectively be positioned as desirable investments and core components of efforts to increase value. Failure to broaden the plan and maximize non-energy or non-carbon benefits represents a missed opportunity.

There are a variety of potential non-energy benefits that comprehensive and well-designed decarbonization plans and projects can yield, including the following:

- Improved indoor environmental quality (IEQ) and occupant satisfaction
- Thermal comfort improvements
- Creation of new amenities (e.g., cooling for residences without air conditioning)
- Improved ventilation
- Reduced envelope maintenance burden and cost, resulting from major building envelope improvements (e.g., exterior overclad insulation)
- Improved resilience and minimized adverse impacts from extreme events

5.1 Financial Concepts

As mentioned previously, the transition from an energy focus to a carbon focus requires a shift in approach. This is also the case for building the financial case for decarbonization. Rather than basing recommendations on the traditional simple payback concept often associated with energy audits, long-term decarbonization planning requires consideration of total value associated with the entire plan and may rely on the time value of money and discounted cash flow (DCF) analysis.

All decarbonization professionals should understand the basic principles of DCF as it relates to real estate. These concepts are inherent to real-estate investing, and building industry professionals should familiarize themselves with how a real-estate pro forma is completed. Many analogous concepts are taught in engineering economics classes and used in life-cycle cost assessment (LCCA), but care should be taken to understand the specific methodology used to evaluate real-estate projects and investments. Building professionals need not be intimidated by new initialisms or analyses, and familiarity with the fundamental concepts is essential.

At the highest level, DCF is a framework that prioritizes near-term benefits over benefits further in the future. The underlying assumption is that the decision-maker will be smarter and richer in the future than they are today, thanks to economic growth and technological improvements. Practically, DCF quantifies this assumption in a discount rate applied to future costs and benefits, which enables summing all future cash flows for the asset (i.e., any income received from owning the asset and any costs associated with ownership) by discounting future cash flows to a common base year, creating a net present value (NPV), or net present cost (NPC), should costs outweigh benefits. (A negative net present value may be more correctly described as a net present cost, but NPV is often used colloquially for both positive and negative totals.)

Useful metrics for strategic decarbonization planning financial analysis include the following:

- **Net present value (NPV)** if positive and **net present cost (NPC)** if negative.
- **Total cost of ownership (TCO)**, which is the present value of costs and benefits of an option or of business as usual over a designated analysis period. TCO can be broken into its component parts—capital costs, operating and maintenance costs, energy costs, regulatory costs, etc.—which is useful for determining the dominant cost drivers.
- **Relative NPV**, which is the difference between an option's TCO and the BAU TCO over the same time horizon.
- **Internal rate of return (IRR)**, which is the discount rate that makes the NPV of a decarbonization plan option (or of business as usual) equal to zero. This metric can help planners contextualize the financial benefits associated with decarbonizing a building over the analysis period, if there are any.

These metrics can be modified or customized to suit the planning process, and their outcomes will vary significantly with the discount rate and analysis period. The financial analysis of a decarbonization plan may include multiple discount rates, time horizons, and multiple NPVs, IRRs, or TCOs. Care should be taken when choosing a single analysis period to avoid missing major expenditures or avoided costs, and capital planning should span at least one full capital cycle that captures the lifetimes of the major investments, as shown in Figure 5.1.

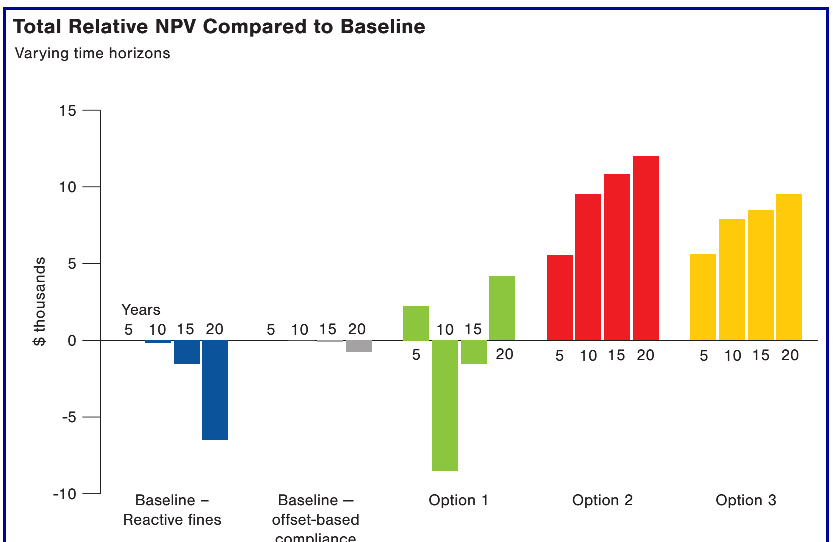


Figure 5.1 Comparing different decarbonization plan options with NPV over different time horizons.

Planners should also be aware of the assumptions about future costs and the rates at which they change over time in the context of DCF analyses. These assumptions represent modifications or special exceptions to the assumptions associated with the discount rate—effectively they are "fixes" to the short-term bias of the discount rate. For example, a utility cost escalation inflates the costs of utilities annually, mitigating the impact of the discount rate and increasing the importance of future utility costs to the outcome of the analysis.

These assumptions may or may not be material to the decision about how and when to decarbonize a building, but the exponential (annual percentage increase) assumptions become more important the longer the analysis period and the lower the discount rate. To explicitly assess these impacts, decarbonization financial analysis should include a sensitivity analysis where these variables are individually changed within the financial model to tabulate the impact on the results. A scenario analysis looks at groups of variables that may move together in a plausible future and is a more advanced method to support decarbonization planning.

It can also be useful to present the results of a DCF analysis comparing expected costs and revenues with the BAU case, as shown in Figure 5.2.

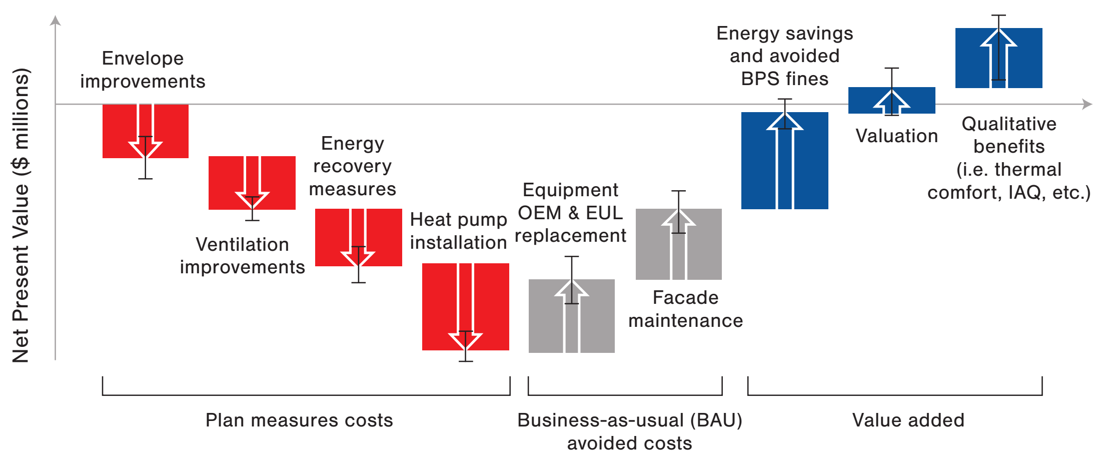
5.2 Lease Impacts on Decarbonization Planning

Different lease types and other leasing considerations can significantly impact decarbonization planning. For example, the lease structure can significantly help or hinder the strategic decarbonization planning process for commercial buildings. Understanding the impacts of the type of building lease is essential for effective planning. Table 5.1 provides information on different lease types, the challenges they can pose to decarbonizing a building, and the opportunities that they can provide.

Beyond the basic lease structure, several other leasing aspects significantly impact decarbonization planning, such as those included in the following list.

Example business case

Illustration of a discounted cash flow analysis, comparing expected costs and revenues with Business-As-Usual



Net Present Value (NPV) is a financial calculation used to determine the value of an investment or project over a period of time by comparing the present value of its expected future cash inflows with its expected cash outflows. In other words, will the investment generate a positive or negative return after accounting for the time value of money?

Sensitivity bars represent the volatility or uncertainty of the calculation due to input variables.

Figure 5.2 Illustration of SDP DCF analysis.

- **Timing and early engagement** are crucial for engaging tenants about decarbonization plans for the building. The most critical time to engage tenants about such plans is not months or weeks but a full year or more before the end of their lease, as this is when tenants typically begin their renewal evaluation process. Waiting until formal renewal negotiations begin is often too late to incorporate significant system changes into the lease planning.
- **Understanding the distinction between tenant equipment and base building systems** is crucial, as ownership, control, and maintenance responsibilities often vary widely among commercial buildings. A comprehensive decarbonization plan should clearly delineate these boundaries and address how integrated systems will be managed during transitions.
- **Tenant improvement (TI) budgets** represent both a significant opportunity and a potential barrier for decarbonization efforts. For instance, these landlord-provided funds for space customization can be strategically leveraged to implement portions of a decarbonization plan during tenant turnover. However, this requires early education of incoming tenants about the benefits of the systems that align with the building's decarbonization goals. Without such early education, there may be a barrier in that incoming tenants will not be aware of what was done for decarbonization planning and thus the benefits of such planning will not be realized.
- **Green leasing practices** provide a framework for overcoming many traditional lease-related barriers to decarbonization. Unlike conventional adversarial leasing approaches, performance-based green leases create mechanisms for both landlords and tenants to benefit from improvements made for building decarbonization. These lease structures typically include specific provisions for cost- and benefit-sharing, performance expectations, and collaborative decision-making regarding building systems. Incorporating green lease principles early in the decarbonization planning process can significantly enhance the viability of long-term decarbonization strategies.

Table 5.1 Lease Types and Decarbonization Implications

Lease Type	Who Controls/ Pays for Utilities	Decarbonization Challenges	Strategic Opportunities
Gross lease	Landlord controls systems and pays all operating costs	Landlord may hesitate to invest without ability to increase rent	Landlord can directly benefit from energy savings; improvements can support higher rent positioning; improvements can increase building value for future sale
Net lease	Split control; tenants pay portion of operating costs	Classic split incentive; landlord invests but tenant receives utility savings	Lease provisions can allow landlord and tenants to share costs/benefits, link improvements to tenant retention, and enable coordination with other capital improvements
Triple net lease	Tenant controls building systems and pays all costs	Tenant may hesitate to invest in improvements that may outlast lease term	Lease can target immediate improvements, negotiate lease extensions tied to improvements, and enable sharing of capital costs for long-term systems

6

Conclusion

The current climate challenge requires urgent action, and while the building industry does not have all the answers, the facts do reveal that the building sector is a huge part of the problem, and the urgent need for planning is clear. The industry must commence decarbonization planning now, taking early actions where beneficial and readying for the larger changes to be made in the medium and long terms. Planning will prepare the industry to be nimble and effective as new information, intelligence, and technologies evolve. In short, every building needs a plan—especially buildings with somewhat significant on-site combustion.

Alignment around the core concepts of decarbonization plans is imperative, and if these decarbonization plans are strategic decarbonization plans, as defined in this guide, then they are much more likely to be implemented in full or in part. Further standardization is required, but the core concepts and process defined here and in LEED v5 (USGBC 2025a), as implemented in the Workbook (USGBC 2025b), are intended to enable strategic decarbonization planning to scale to meet the challenge. Readers should feel empowered to align with or directly use these concepts, the planning process, and the Workbook as they develop their own processes and procedures to support strategic decarbonization planning. Cities, corporate tenants, investors, and other stakeholders should consider requesting strategic decarbonization plans (SDPs) from their constituents, landlords, clients, or managers. Accelerating demand for SDPs will benefit the industry on all fronts.

Being nimble has not historically been a characteristic of the design, construction, and real-estate sector, but the rapid adoption of green building practices over the past 20 years stands out as a notable exception. The appetite to do more and do better, at least at the top of the market, has been well documented. To harness the green building appetite and pivot to decarbonization, building designers and engineers will need to design differently and develop new skill sets. New knowledge will need to be applied to all projects, not just the high-end ones. The industry will need to investigate new and innovative solutions and then deploy them in both simple and mechanically complex buildings. For this transformation, the building industry needs better tools and resources, and this guide, the Workbook, and LEED v5 are initial contributions to this effort.

This process will certainly evolve in the coming years, and future updates to this guide and other related resources may be required, but success will be charted in declining operational emissions from existing buildings. If every building develops a plan, decarbonization will happen.

Appendix

Tools and Resources

ASHRAE has launched the Center of Excellence for Building Decarbonization (CEBD), developed several technical resources, hosted decarbonization conferences, and added an informative appendix to address decarbonization assessments to ANSI/ASHRAE/ACCA Standard 211.

USGBC, through its new LEED v5 Operations and Maintenance (O+M) Energy and Atmosphere (EA) Credit Decarbonization and Efficiency Plans (USGBC 2025a), has codified the process of plan development and has created USGBC Strategic Decarbonization Workbook (2025b) to help planners organize plan information and provide visualization.

New York State Energy Research and Development Authority (NYSERDA) has been running the Empire Building Challenge (2024) to jump-start decarbonization in New York state, providing a wealth of knowledge about what works and what doesn't, as well as a cache of case studies.

Case Studies and Examples

NYSERDA's Empire Building Challenge (2024) has supported the development and initial implementation of strategic decarbonization plans (SDPs) for a number of tall buildings. Two different buildings, one an office and one an affordable-housing multifamily residence, have completed a full strategic decarbonization planning processes and have deep decarbonization projects currently in implementation. The before and after building system summaries, along with the resulting planned carbon reduction trajectories, are shown in Case Study 1 and Case Study 2. Additional building case studies are presented in the Retrofit Playbook for Large Buildings (Retrofit Playbook 2024).

Case Study 1: Office Building SDP

Key systems in the office building before the SDP was implemented included the following:

- Heating: steam radiators throughout, fed by a gas boiler
- Cooling: water-source direct-expansion units in tenant spaces, tied to a central cooling tower
- Envelope: leaky, single-pane windows

After the SDP was implemented, the key building systems are now the following:

- Heating and cooling: floor-by-floor water-source heat pumps
- Heat recovery: thermal network to share heating and cooling between core and perimeter inside building and with neighbor; thermal storage and energy recovery ventilation
- Envelope: new, tight, double-pane, efficient windows

See Figure A.1 for the office building's SDP and Figure A.2 for the building's emissions trajectory following implementation of the SDP.

Office Building Decarbonization Plan

Key takeaways: Eliminate on-site fossil fuel usage, phased-in implementation based on tenant turnover, lower distribution temperatures, minimize wasted heat, heat sharing

2022	2023	2024	2025	2027	2029
Install ambient loop hydronic spine Convert existing condenser water loop	**Tenant conversion phase 1** Remove steam radiators and water source DX cooling units. Install 4-pipe hydronic, WSHP, fan-coil, radiant options. **Install central ASHP and adiabatic dry cooler**	**Install central DOAS+ERV** Fresh air supply with minimum 85% heat recovery **Thermal network connection to neighbor** New building with geothermal piles	**Install rooftop thermal storage** To supplement central plant **Envelope improvements** Replace windows to improve air infiltration and reduce load	**Tenant conversion phase 2** Phase-in tenant floor work based on tenant turnover lease	**Tenant conversion phase 3**

Figure A.1 Office building SDP. (Adapted with permission from NYSERDA)

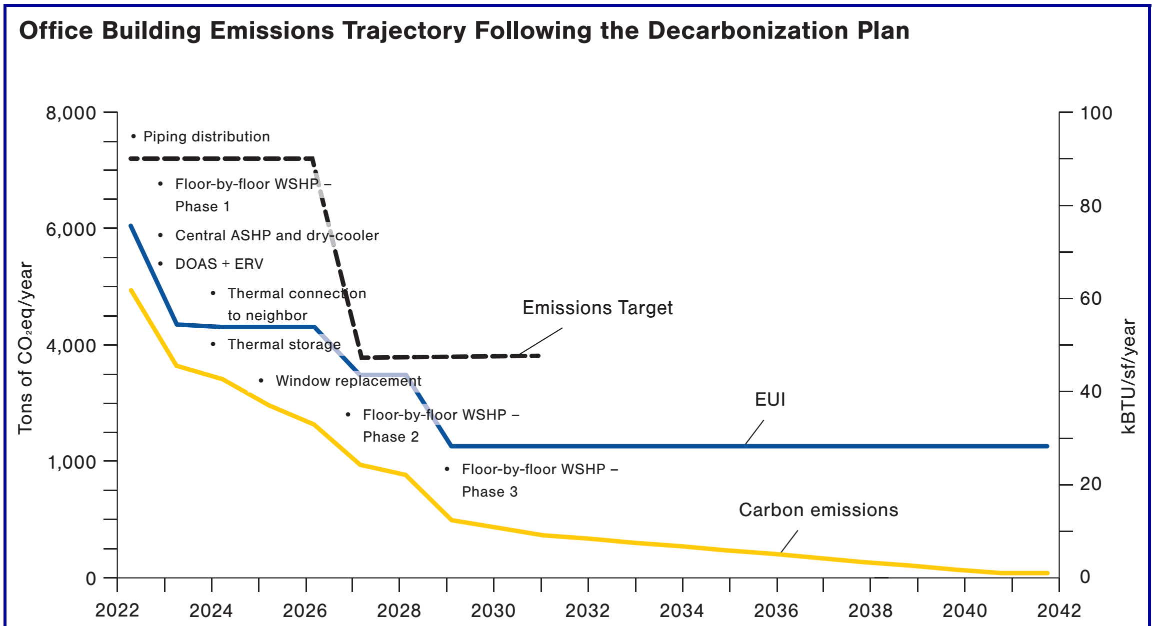


Figure A.2 Office building emissions trajectory following the SDP. (Adapted with permission from NYSERDA)

Case Study 2: Affordable-Housing SDP

Key systems in the affordable-housing building before the SDP was implemented included the following:

- Heating, cooling, and domestic hot water: fed by campus steam and steam absorption chiller
- Heating and cooling: hydronic distribution with fan-coil units in each apartment
- Envelope: leaky envelope and old windows

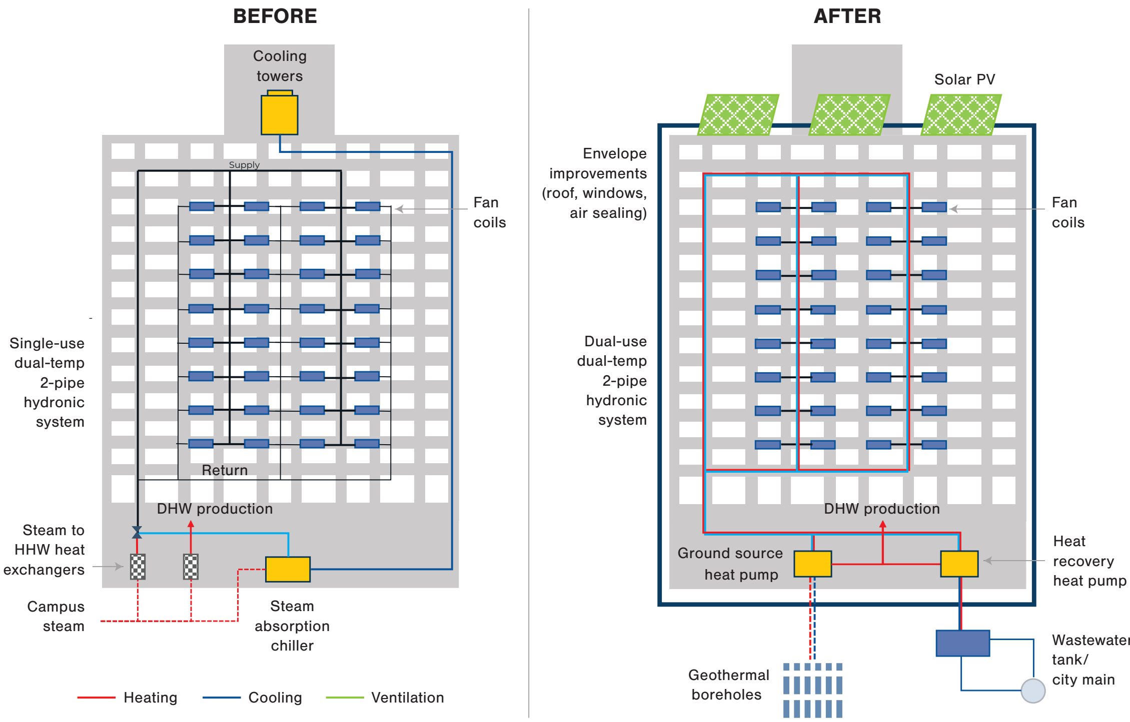
After the SDP was implemented, the key building systems are now the following:

- Heating, cooling, and domestic hot water: fed by ground-source heat pumps with sewer wastewater heat recovery
- Heating and cooling: new dual-temperature hydronic distribution, with new fan-coils throughout the building
- Envelope: new double-pane, efficient windows, roof insulation, and air sealing
- Renewables: solar photovoltaics and appliance electrification

See Figure A.3 for the affordable-housing building's SDP and Figure A.4 for the building's emissions trajectory following implementation of the SDP.

Affordable Housing Decarbonization Plan

Key takeaways: Affordable housing recapitalization, tenant total cost reduction, failing distribution infrastructures, eliminate fossil fuel usage, improve comfort, resilient system



2024

Retrofit dual-temp hydronic system
Existing distribution system and terminal units beyond EUL. Install new dual-use dual-temp 2-pipe hydronic piping, with new FCUs in apartments.

Wastewater Energy Transfer (WET) system
Install sewage tank and use water source heat pumps to produce heating, cooling and DHW

Ventilation system maintenance

2026

Envelope improvements
Insulate roofs, replace windows and air seal walls

Submetering and controls upgrades

Geothermal system
Drill geothermal boreholes on property land and install ground source heat pumps to produce heating, cooling and DHW

2028

Solar PV
Take advantage of rooftop space to install solar PV system for clean electricity generation

2030+

Laundry and cooking appliance electrification

Figure A.3 Affordable housing SDP. (Adapted with permission from NYSERDA)

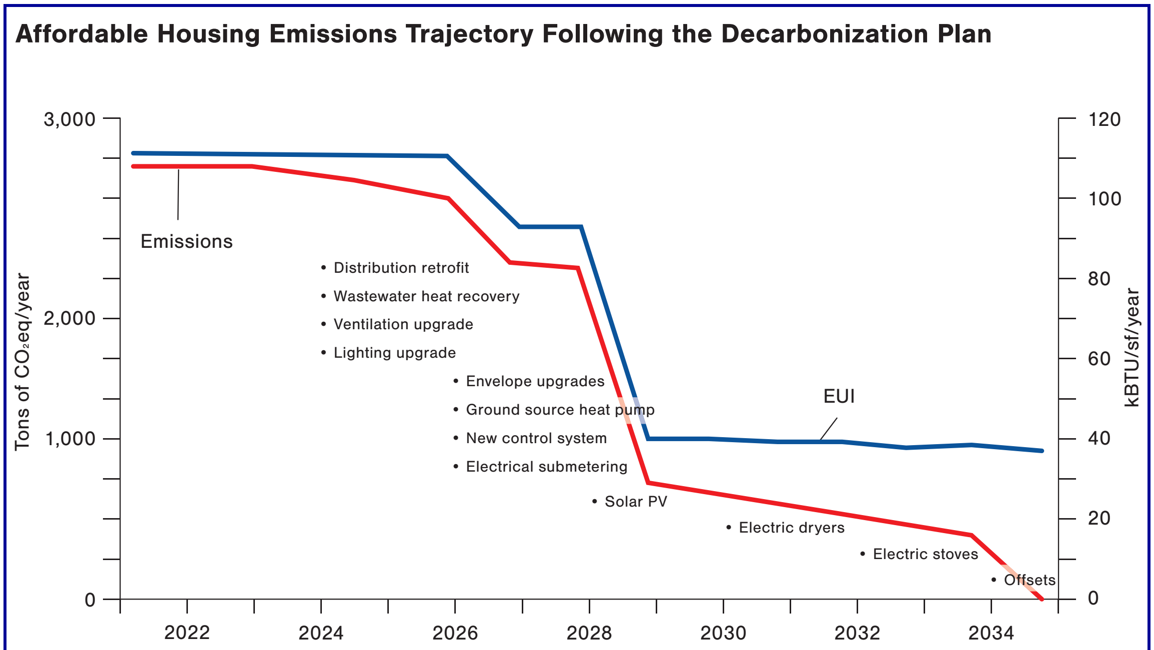


Figure A.4 Affordable housing emissions trajectory following the SDP. (Adapted with permission from NYSERDA)

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Understanding, Creating, and Implementing Strategic Decarbonization Plans

This guide helps project teams establish strategic decarbonization plans for deep reductions in operational carbon emissions in existing buildings and aids engineers and building professionals in hastening the transformation of the real-estate market toward a decarbonized state.

Decarbonization planning should focus on the core operations of a building itself, with the goal of making the building capable of operating on clean electricity most of the time. Strategic decarbonization is an approach that champions integrating budgeting and execution of decarbonization strategies into the typical planning and business cadence of a real-estate asset. This combination of technical and real-estate insight enables decision-makers to achieve more significant decarbonization with less capital by executing strategies in tandem with interventions already identified in capital expenditure planning.

The value of a strategic decarbonization plan is not limited to projects that intend to reach full decarbonization in the near future. While the ultimate goal is getting to zero emissions by 2050, some buildings may not be able to immediately pursue these strategies; but even for these buildings, strategic decarbonization planning will prove immensely valuable. Things change over time and the future is impossible to predict; much of the value of a decarbonization planning exercise is the understanding of what a building should and should not do to decarbonize, what barriers make specific strategies impossible to implement now, and what factors might change in the coming years to make them possible.

This guide was developed as a collaboration among ASHRAE, U.S. Green Building Council (USGBC), and New York State Energy Research and Development Authority (NYSERDA), which all recognize the need to drive the building sector toward carbon neutrality by mid-century and that decarbonizing the energy consumption of existing buildings will be key to this transition. This guide is just one of three integrated tools developed by these organizations—the others are the USGBC Strategic Decarbonization Workbook and the Leadership in Energy and Environmental Design® (LEED®) v5 Operations and Maintenance (O+M) Energy and Atmosphere (EA) Credit Decarbonization and Efficiency Plans, which are both discussed in this guide.

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