Retrofit Depot

Managing Deep Energy Retrofits

RetroFit
AN RMI INITIATIVE

Rocky Mountain Institute®

Available for download at www.RetroFitDepot.org

Introducing the Retrofit Depot: Deep Energy Retrofit Guides

*Several commercial building energy retrofit guides already exist, but none address **deep** energy retrofits.*

Rocky Mountain Institute wants the owners, occupants, service providers, and retrofit practitioners[1] of our nation's commercial buildings to be aware of the opportunity in deep energy retrofits. We want them to know the value. We want them to have a solid understanding of the process. We also want to arm them with design recommendations that will help make their deep energy retrofits most effective.

Such is the aim of the RetroFit Depot website. It is an unbiased source of information about deep energy retrofits for commercial buildings. On the website people are able to gain a high level understanding of the value of deep retrofits and the required process to achieve them. For those who would like to learn more, we have created a set of three guides.

Since you are now reading the Guide to Managing Deep Energy Retrofits, you are likely motivated to realize the value of deep energy retrofits as described on the RetroFit Depot website and the Building the Case guide. This guide will help you understand the key action items for a deep energy retrofit.

You may be the building owner, or perhaps you are the energy efficiency or sustainability champion at your organization, or maybe you are a service provider preparing a pitch to your client.

Regardless of who you are, you are ready to get started.

1	**BUILDING THE CASE**	Provides comprehensive guidance on framing and quantifying the value of deep energy retrofits.
2	**MANAGING DEEP ENERGY RETROFITS**	Lists the key components of the deep energy retrofit process that limit or eliminate cost premiums, enable risk management, and create maximum value
3	**IDENTIFYING DESIGN OPPORTUNITIES**	Provides the retrofit practitioner with instructions for identifying opportunities to reduce energy consumption by end-use.

[1]We use "owners" and "occupants" to refer to those individuals making the decision to invest in deep energy savings for their building space. They include owner-investors, owner-occupants, and tenants of buildings. We use "service providers" to refer to those individuals that help business professionals retrofit their building space. These professionals include portfolio, asset, property, and facility managers, as well as other service providers such as brokers, appraisers, lawyers, and sustainability/LEED consultants. We use "retrofit practitioners" to refer to those individuals that help owners renovate and upgrade. These professionals include architects, engineers, and contractors, as well as professionals at energy service companies (ESCOs).

Table of Contents

Acknowledgements

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Deep Energy Retrofit Overview

Buildings use 42 percent of the nation's energy—much of which is wasted through inefficient design and operation. While some savings opportunities are obvious and easily attainable, retrofit teams can often achieve much deeper savings cost effectively.

By aggressively adopting efficiency solutions, we can transform our buildings from energy hogs to more comfortable, liveable and workable spaces that can help usher in an efficient and renewable energy era.

Introducing Deep Energy Retrofits for Commercial Buildings

We define *deep energy retrofits* as a whole-building analysis and construction process that achieves much larger energy cost savings—sometimes over 50% reduction—than those of conventional, simple retrofits and fundamentally enhances the building value. Deep energy retrofits create deep energy savings but not necessarily all at once—measures can be implemented over several years.

Of the few who are doing energy retrofits, many would take a "light" approach by switching out the lighting and adding new motors to the heating and cooling system. The decision making for this light approach is driven by the capital cost and return on investment for each measure—hence big measures like new windows are typically not even considered because they are perceived as too risky. This "light" approach leaves significant opportunity for energy savings on the table.

A more thoughtful and strategic approach could increase returns and energy savings dramatically. A deep energy retrofit considers all the major capital needed in the building over the next several years (the "business-as-usual" scenario). Then, it evaluates the potential to meet all business-as-usual objectives in addition to capturing other benefits such as managing utility costs, attracting and retaining desired employees and tenants, improved reputation and leadership, and complying with present and future sustainability reporting requirements.

Buildings are composed of multiple systems and whole-building analysis recognizes how one kind of efficiency gain can affect other building systems and attributes. By simply recognizing how systems are interrelated, design teams can cause small improvements to cascade into substantially larger benefits. As such, deep retrofits improve the economics of efficiency measures, as well as incur myriad other benefits to building owners, occupants, and society as a whole.

Why Deep Energy Retrofits?

Deep energy retrofits provide attractive financial and business opportunities for building owners, tenants, engineers, and architects alike. Since the 2008 economic collapse, real estate owners have increasingly been looking for ways to cut costs, retain tenants, increase market performance, and gain competitive advantage. Deep energy retrofits can achieve these objectives by turning business-as-usual upgrades—normally unavoidable cost-sinks—into profitable investments.

The economic downturn also gives engineers, architects, and contractors time to course-adjust their business strategy so when the market comes back, they are ahead of the competition. There is no time like the present for building professionals to retool, to rethink, and to retrain.

At the same time, deep retrofits benefit society as a whole through the generation of new jobs, reduction in carbon emissions, and energy security.

Now, more than ever, the U.S. building stock is due for business-as-usual upgrades. According to the Energy Information Administration, one in three U.S. commercial buildings are failing and in need of major renovations, offering a unique window of opportunity for owners to not only get their buildings back to working order, but also to make them significantly more efficient and valuable. Study after study reaffirms the large efficiency opportunity that currently exists in the U.S., predicting that ~30% of commercial building energy use could be cost-effectively cut by 2030 (McKinsey 2009, NAS 2010). More recently, Amory Lovins and Rocky Mountain Institute predicted building energy savings of 38–69% to generate $1.4 trillion in positive net present value by 2050 (Lovins & RMI 2011).

The time to take advantage of this opportunity is now, which is why we have provided the following guide to help retrofit teams cost-effectively achieve the deepest savings possible.

OPPORTUNITIES FROM DEEP ENERGY RETROFITS*	
OWNERS	Reduce costs; improve public relations, sales, and employee health/productivity
INVESTORS	Increase market performance for a better yield
LANDLORDS	Attract and retain desired tenants; increase rent and decrease vacancy
TENANTS	Benefit from space that is more comfortable, satisfying, and productive for lower occupancy costs
SERVICE PROVIDERS	Differentiate in a crowded building market, gain access to larger projects and larger client base, and deliver more value
SOCIETY	Improve economy with more jobs, reduce carbon emissions, and create energy security

* Read more in the Building the Case Guide

How to Use this Guide

The Managing Retrofits Guide provides a comprehensive overview of deep energy retrofits for commercial buildings and a framework for implementing them, with detailed process guidance for design/retrofit teams. Building owners, managers, and retrofit practitioners should use this guide to plan and implement a deep energy retrofit for their building. The Guide should be used in conjunction with the Building the Case Guide and Identifying Design Opportunities Guide also provided on www.RetroFitDepot.org.

The guide is a "desk reference" that is divided into several sections to make it easier to find topics of interest. All the practices and approaches described in this document are techniques used by leading real estate owners, managers, and retrofit practitioners.

The optimal way to use this guide is to read it and circulate among other building stakeholders. After gaining a solid foundation of understanding, set up a meeting of stakeholders and begin the process. If you need more guidance on your commercial building deep energy retrofit project, you may contact Rocky Mountain Institute's Built Environment Team at bet@rmi.org.

At the end of each section in the deep energy retrofit framework are Key Action Items, highlighted in green boxes as shown to the right. These boxes summarize the main recommendations that your organization can follow. Share these items with your senior decision makers and, as applicable, get them involved with the deep energy retrofit project. You will also find Deep Energy Retrofit Highlights in blue boxes that identify the unique aspects of a deep energy retrofit.

Design and Analyze

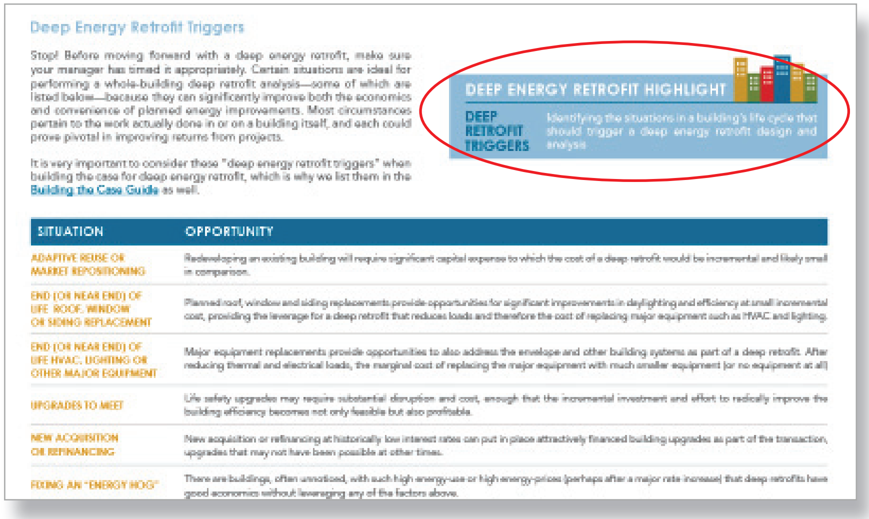
CREATE THE BASELINE SCENARIO

An owner needs a reference point to be able to evaluate an efficiency scenario. Such a baseline can be a less aggressive investment in efficiency or it can be a business-as-usual scenario without any investment in efficiency. A business-as-usual scenario does have costs, though many retrofit project teams fail to acknowledge that capital investment is required to maintain basic building functionality or to achieve other non-efficiency-related goals.

When developing a baseline scenario, a deep retrofit team should coordinate with a project's facility manager and should refer to building reports, such as a facility condition assessment report, to identify realistic capital and operating/utility expenses. These expenses should be projected five, ten, or more years into the future and accounted for in the life cycle cost analysis. Will windows need to be replaced in ten years? Will lighting need to be updated to comply with future regulations? Such predicted expenditures should be quantified in the baseline case.

SUMMARY OF KEY ACTION ITEMS

- Evaluate the existing building or speak with the facility manager to determine business-as-usual capital and maintenance requirements
- Schedule a process for evaluating the building for efficiency opportunities and informing stakeholders
- Identify specific efficiency opportunities using the Identify Design Opportunities Guide and other Tools & Resources
- Create and evaluate retrofit scenarios that help you tell a compelling retrofit story to decision makers and/or other stakeholders



Deep Energy Retrofit Triggers

Stop! Before moving forward with a deep energy retrofit, make sure your manager has timed it appropriately. Certain situations are ideal for performing a whole-building deep retrofit analysis—some of which are listed below—because they can significantly improve both the economics and convenience of planned energy improvements. Most circumstances pertain to the work actually done in or on a building itself, and each could prove pivotal in improving returns from projects.

It is very important to consider these "deep energy retrofit triggers" when building the case for deep energy retrofit, which is why we list them in the Building the Case Guide as well.

DEEP ENERGY RETROFIT HIGHLIGHT

DEEP RETROFIT TRIGGERS — Identifying the situations in a building's life cycle that should trigger a deep energy retrofit design and analysis

SITUATION	OPPORTUNITY
ADAPTIVE REUSE OR MARKET REPOSITIONING	Redeveloping an existing building will require significant capital expense to which the cost of a deep retrofit would be incremental and likely small in comparison.
END (OR NEAR END) OF LIFE ROOF, WINDOW OR SIDING REPLACEMENT	Planned roof, window and siding replacements provide opportunities for significant improvements in daylighting and efficiency at small incremental cost, providing the leverage for a deep retrofit that reduces loads and therefore the cost of replacing major equipment such as HVAC and lighting.
END (OR NEAR END) OF LIFE HVAC, LIGHTING OR OTHER MAJOR EQUIPMENT	Major equipment replacements provide opportunities to also address the envelope and other building systems as part of a deep retrofit. After reducing thermal and electrical loads, the marginal cost of replacing the major equipment with much smaller equipment (or no equipment at all)
UPGRADES TO MEET	Life safety upgrades may require substantial disruption and cost, enough that the incremental investment and effort to radically improve the building efficiency becomes not only feasible but also profitable.
NEW ACQUISITION OR REFINANCING	New acquisition or refinancing at historically low interest rates can put in place attractively financed building upgrades as part of the transaction, upgrades that may not have been possible at other times.
FIXING AN "ENERGY HOG"	There are buildings, often unnoticed, with such high energy-use or high energy-prices (perhaps after a major rate increase) that deep retrofits have good economics without leveraging any of the factors above.

Key Action Items for Deep Energy Retrofits

To fully achieve the benefits of deep energy retrofits, those implementing a deep energy retrofit should piggyback efficiency improvements on already planned capital improvements and breaks in occupancy, take advantage of advanced energy modeling and life cycle cost analysis methods, verify savings and continuously improve energy performance, and use the other practices outlined in this section.

Key Aspects of a Deep Energy Retrofit Process are:

Deep Retrofit Triggers

Identifying the situations in a building's life cycle that should trigger a deep energy retrofit design and analysis

Technical Potential

Finding the energy use that would result from implementing all of the most cutting-edge efficiency measures possible and minimizing constraints to achieving it

Modeling

Determining energy and life cycle cost savings using advanced methods and tools

Right-Timing & Right-Sizing

Timing efficiency improvements with already planned capital improvements and breaks in occupancy; accurately sizing (not over sizing) mechanical and electrical equipment

Measurement & Verification

Ensuring achievement of savings while illuminating opportunities for continuous improvement

The following sections do not provide an exhaustive list of action items for any energy retrofit; rather, they highlight the items that are important for a deep energy retrofit. Deep energy retrofits may require more soft costs than standard retrofits, however the return can more than offset the difference.

Deep Energy Retrofit Triggers

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TRIGGER	OPPORTUNITY
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END (OR NEAR END) OF LIFE HVAC, LIGHTING OR OTHER MAJOR EQUIPMENT REPLACEMENT	Major equipment replacements provide opportunities to also address the envelope and other building systems as part of a deep retrofit. After reducing thermal and electrical loads, the marginal cost of replacing the major equipment with much smaller equipment (or no equipment at all) can be negative.
UPGRADES TO MEET CODE	Life safety upgrades may require substantial disruption and cost, enough that the incremental investment and effort to radically improve the building efficiency becomes not only feasible but also profitable.
NEW ACQUISITION OR REFINANCING	New acquisition or refinancing at historically low interest rates can put in place attractively financed building upgrades as part of the transaction, upgrades that may not have been possible at other times.
FIXING AN "ENERGY HOG"	There are buildings, often unnoticed, with such high energy-use or high energy-prices (perhaps after a major rate increase) that deep retrofits have good economics without leveraging any of the factors above.
MAJOR OCCUPANCY CHANGE	A company or tenant moving a significant number of people or product into a building or major turnover in square footage presents a prime opportunity for a deep retrofit, for two reasons. First, a deep retrofit can generate layouts that improve energy and space efficiency, and can create more leasable space through downsizing mechanical equipment. Second, ownership can leverage tenant investment in the fit-out.
ENERGY MANAGEMENT PLANNING	As part of an ongoing energy management plan for a group of buildings, the owner may desire a set of replicable efficiency measures. These measures can be developed from the deep retrofit of an archetypical building.

Get Started

To realize a truly deep energy retrofit, it is important to begin by creating a set of project requirements, carefully selecting a team, using Integrated Project Delivery principles, and writing a contract that aligns the team around a shared vision for the project.

OWNER PROJECT REQUIREMENTS

Owner Project Requirements (OPR) is a set of criteria defined by an owner before a design team is even brought on board. It can be a useful and powerful tool if the owner actively helps draft it. Unfortunately, OPRs are frequently written by design teams, with little input from owners, well into the design process and then only to fulfill a LEED credit or other requirement.

The Whole Building Design Guide, a valuable green building design resource, offers guidance on creating an OPR. In addition to the extensive list of topics outlined in the guide, an OPR for a deep energy retrofit may include:

- Owner's mission and vision for the project
- Drivers and motivation for change
- Financing constraints and targeted incentives
- Project energy goals
- Indoor air quality requirements
- Potential allies or partners
- Methods/tools to be used, such as energy and life cycle cost analysis for integrative design (see Tools & Resources)
- Measurement & Verification

SUMMARY OF KEY ACTION ITEMS

- [ ] **Set up a meeting with key building stakeholders to discuss project vision and objectives**
- [ ] **Specifically define what skills and experience you are looking for in a team and issue a Request for Qualifications**
- [ ] **Create a contract that correctly incentivizes the team to achieve the project vision**

REQUEST FOR QUALIFICATIONS

An OPR should be incorporated into a Request for Qualifications (RFQ), a document that should carefully articulate the deep retrofit approach as defined in this guide. A team should be eager to do intensive and iterative design work that supports the owner's mission and vision. The team members should have a "can do" attitude and be experienced with sustainable design.

INTEGRATED PROJECT DELIVERY

Integrated Project Delivery (IPD) is a process that includes all stakeholders in optimizing project design and implementation through synergistic collaboration; it is an ideal method for tackling deep retrofits. IPD is typically used for new construction, but it has been successfully applied to a tenant fit-out; its key principles and elements are universally applicable to all building types and projects that involve major building changes. Those key items are:

- Early involvement of key participants
- Shared risk and reward
- Multiparty contract
- Collaborative decision-making and control
- Liability waivers among key participants
- Jointly developed and validated goals
- Analysis and integration of multiple building systems

For more on Integrated Project Delivery, see AIA (2007) and Cohen (2010). For a case study on how IPD was used for a high performance tenant fit-out, see Bendewald et al (2010).

CONTRACT

Whether working with an ESCO or a more traditional design-build team, an owner should use a project contract as an opportunity to explicitly outline incentives to maximize efficiency gains. A design-build team should be rewarded for the energy and resources that it helps save, not the money that it helps spend. Performance contracting should not be limited to Energy Saving Performance Contracts (ESPCs).

A key part of making a deep retrofit economical is right sizing the mechanical and other equipment. In a contract, an owner should consider including an indemnification clause for the mechanical and electrical engineers to specify equipment that is just the right size (not larger). The common line is, "No engineer is ever sued for designing a system that is too big." We need to allow these professionals to right size the mechanical and electrical systems, without fear of recrimination.

Design and Analyze

CREATE THE BASELINE SCENARIO

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SUMMARY OF KEY ACTION ITEMS

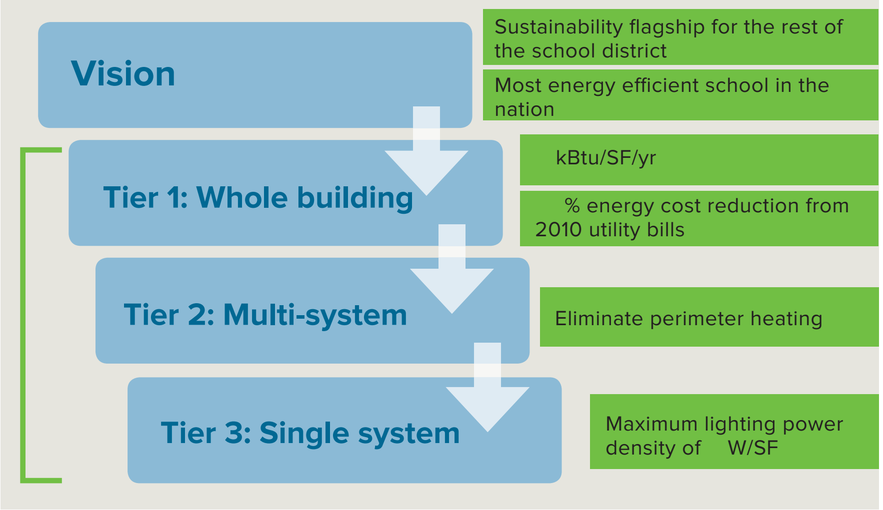
- [ ] **Evaluate the existing building or speak with the facility manager to determine business-as-usual capital and maintenance requirements**
- [ ] **Schedule a process for evaluating the building for efficiency opportunities and informing stakeholders**
- [ ] **Identify specific efficiency opportunities using the** Identify Design Opportunities Guide **and** other Tools & Resources
- [ ] **Create and evaluate retrofit scenarios that help you tell a compelling retrofit story to decision makers and/or other stakeholders**

BENCHMARK AND SET GOALS

Energy benchmarks elucidate how a building compares to others and serve as points of reference within sectors and groups of similar buildings. The most common U.S. energy benchmark used today is the ENERGY STAR rating calculated by ENERGY STAR's Portfolio Manager.

Once a building is benchmarked, one can set clear, shared, and ambitious goals. Goals should be quantifiable and may include a timeframe (e.g. 50 percent of the goal will be met by 2015 and 100 percent by 2020). Goals should rarely be prescriptive (e.g. install solar photovoltaics) as this can lead to a suboptimal building with some green features. Instead, goals should be performance-based, written using metrics such as energy use per square feet, which measures energy use intensity (measured in kBtu per square feet per year). As a project progresses, one should continually revisit the initial project goals to ensure that a project is still on track. Project goals may be organized in tiers, from whole-building goals down to single-system specific ones. (Note that the project vision should have already been specified in the Owner's Project Requirements.)

STRUCTURING GOALS



IDENTIFY OPPORTUNITIES

In the opportunity identification step, a retrofit team should conduct an energy analysis, engage multiple stakeholders, define the technical potential of the building, hold an innovation charrette, and define multiple scenarios.

Conduct an Energy Analysis

The term of art for conducting an energy use analysis as part of a building retrofit is an audit. The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) has defined three types of building energy audits, which vary in rigor and detail. They range from a Level I walk-through survey to a Level III detailed analysis of capital-intensive modifications (also known as an investment grade audit, or IGA). For a deep energy retrofit, complete an investment grade audit because it produces data with a level of confidence necessary for major capital investment decisions.

For detailed instruction on conducting an energy analysis for a deep energy retrofit, see the Identifying Design Opportunities Guide.

Engage Stakeholders

Multiple stakeholders beyond the building owner and service provider can contribute value during a deep energy retrofit project. Tenants, maintenance personnel and facilities operators, customers, utilities, and local governments can all potentially provide input to your efforts.

It is critical to engage tenants because over half of the total energy savings in a tenant-occupied building retrofit can come from retrofitting tenant spaces. There are many potential efficiency measures that require occupant participation. Thus, unique tenant incentives should be created to encourage operational efficiency. It is also worthwhile to explore innovative, "green" leasing options that overcome tenant-owner split incentives. Finally, occupants should be surveyed both before and after the retrofit. This will ensure occupant comfort goals have been met and that occupants are aware of and involved with the retrofit.

Maintenance personnel and facilities operators are key to achieving the operating reduction goals. These parties, whether they are in house staff or an external property management company, should be intimately involved in any building upgrades from the beginning, so they can help form the energy reduction goals, understand them and be more engaged to help achieve them.

Utilities should also be made aware of a deep retrofit, especially if one is retrofitting multiple buildings within their service area or jurisdiction. Even if current utility programs don't have incentives or rebates that match the current project, they may be able to develop a custom incentive.

Local government programs may also offer free audit or design assist services, and local government officials can provide valuable assistance in the interpretation of prevailing building codes, regulations, and initiatives that may impact the project.

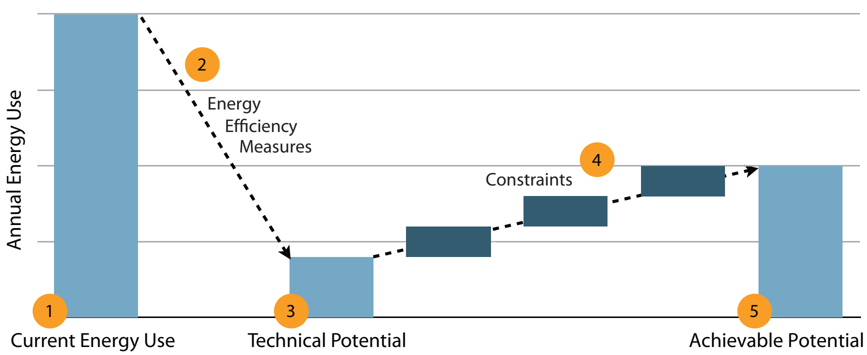
It is important to identify and engage leaders of special interest groups, early and often, to elicit buy-in of potential solutions. It is critical to expose any potential roadblocks early on and for everyone to work together to create a clear pathway.

Define Technical Potential

The *technical potential* of a building is the energy use that would result from implementing all of the most cutting-edge efficiency measures possible, given today's technology, without regard to financial or other restraints. The design team should assess the building's technical potential early on in the design process because efficiency ideas are often limited by preconceptions about cost, schedule, operational disruption, and constructability constraints. Temporarily removing these constraints from the picture, allowing the team to solve problems without any inhibitions, can often lead the team to cost-effective and practicable solutions it otherwise would not have considered.

The technical potential first sets the high bar for what is technically achievable in building performance. As shown below, the team can quantify and document how specific constraints start to push the targeted level of savings away from the technical potential. In order to minimize this effect, the team should then identify what conditions would be necessary to move back toward the technical potential, in order to reach the achievable potential. Such lessons can inform future retrofits of the building at hand as well as other buildings in the owner's portfolio.

Building Energy Use Technical Potential



DEEP ENERGY RETROFIT HIGHLIGHT

TECHNICAL POTENTIAL

Finding the energy use that would result from implementing all of the most cutting-edge efficiency measures possible and minimizing constraints to achieving it

Hold an Innovation Charrette

Many design and strategic challenges can best be solved through an intensive, highly integrative, transdisciplinary innovation workshop, or charrette. A charrette brings together stakeholders and experts at the very outset of the process for small and large group brainstorming, discussion and converging on synergistic solutions. In RMI's experience, this approach yields an ambitious design product, typically conceptual, with some extension into early schematic design.

The innovation charrette during a deep energy retrofit provides an opportunity to engage multiple stakeholders, to introduce them to the idea of the "technical potential," and generally to get the project off to an exciting and effective start.

CREATE SCENARIOS

Once most necessary data is available and innovative ideas are on the table, it is time to analyze which combination of measures can provide the greatest value. To do so, evaluate individual as well as bundled measures, consider the long-term implications of such measures, and tell a compelling story of the process, outcomes, and lessons learned. Present at least one recommended efficiency improvement scenario that maximizes energy efficiency within one or more years. Use life cycle costing metrics such as net present value and internal rate of return to report the expected financial outcomes.

DEEP ENERGY RETROFIT HIGHLIGHT

MODELING Determining energy and life cycle cost savings using advanced methods and tools. Find out how.

Evaluate Bundled Measures

The first step is to transform ideas regarding technical potential into achievable potential options. Once execution of potential measures is better defined, each measure can be individually entered into an energy model to determine its impact on annual energy savings, peak electricity demand, and cooling and heating loads. Estimate the capital costs of the measures as well, taking care to estimate the interactive effects between measures.

Proper financial analysis and digging into cost estimates is just as important as correct technical engineering analysis for a project. Capital cost estimates should always be vetted. Sometimes cost estimators misprice systems or overprice them if they sound overly complicated. Having the design team spend more time helping the cost estimator understand the design and expected equipment (reduced) sizing can help lower cost estimates.

Using the knowledge gained from modeling the energy savings and cost of individual measures, teams should create bundles of measures that form various investment options for the decision-maker. Consider developing bundles of measures that achieve specific client objectives. We recommend identifying a few different bundles, such as those that highlight expected improvement in worker satisfaction and retention, and those that are optimized specifically for other client objectives.

It is also possible to focus on the life cycle costs of individual measures to create one bundle that maximizes net present value and another that maximizes energy savings. These bundles will give some bounds to the cost effectiveness of the project.

Creating bundles is an iterative process because energy savings change based on which measures are bundled together, which may also affect capital costs. In creating the bundles, it is also important to consider non-quantifiable benefits and the sources of uncertainty[2].

[2]For a complete discussion of how to consider and present value and uncertainty, see the Building the Case Guide.

Right Time and Right Size

When bundling measures, it is also important to develop an implementation timeline that may be immediate or several years. In doing so, incorporate four main elements into the plan:

1. Alignment with equipment replacement cycles. Better alignment with planned replacements will minimize the retrofit's marginal cost. For example, the efficient air-handling units for the Empire State Building retrofit were installed at the same rate over several years as what was planned for the code-compliant air-handling units. If they are installed at a faster rate, the marginal cost of the units would be higher.
2. Occupant disturbance. Tenant or occupant turnover provides an ideal time to implement measures. Alternatively, work could be completed on nights and weekends, but labor will cost more.
3. Sequence of construction. Implement electrical and thermal load-reducing measures first. This way, you won't have any problems when you install your right-sized (not over-sized) new equipment.
4. Budgeting. It might be necessary to budget for smaller expenditures over several years as opposed to one large sum during one year.

Create Pathway to Very-Low or Net-Zero Energy Use

During or after bundling measures, it is also important to consider the long-term energy goals for a building. While you may decide that upgrading a building's systems with certain technologies is currently too expensive, such measures may be ideal retrofit solutions a decade down the line.

Moreover, a pathway to very-low or even net-zero energy use is not necessarily a scenario that needs to be presented to a decision-maker for consideration for current investment, but it is helpful to the owner to have a high-level plan that illustrates how decisions made today will impact goals set down the road.

DEEP ENERGY RETROFIT HIGHLIGHT

RIGHT-TIMING & RIGHT-SIZING	Timing efficiency improvements with already planned capital improvements and breaks in occupancy; accurately sizing (not over sizing) mechanical and electrical equipment

TELL A COMPELLING STORY

At the conclusion of the analysis stage, it is important to develop a clear and compelling story about the opportunity and the resources required to capture it. Such a narrative will help sustain momentum moving into the execution phase, provide a consistent set of messages to discuss on other projects, and will provide strong marketing material that documents the increased value of—and future opportunities for—the building.

It is quite likely that you will have made numerous discoveries about the building, its operation, the cost of implementation, and options for improvement. As such, this is the point at which an decision-maker will consider the opportunities and risks of moving ahead with the project. Make sure you are well equipped to address risk, or the uncertainty about the project. How confident are you that the building will hit the predicted energy savings? How can you best describe your level of confidence to the owner?

For more on how to discuss risk and create a compelling storyline for a deep energy retrofit, see the Building the Case Guide.

Implement the Measures

The implementation phase realizes the specific efficiency scenario selected by the decision-maker. Careful attention to construction and commissioning during the process will improve the profitability and overall outcome of a deep retrofit project. In addition, Measurement & Verification will ensure savings are achieved and address any issues.

Quality construction and commissioning is key to ensuring that all of the effort expended on a design is executed properly. Too frequently, a lack of coordination between a designer and builder leads to construction delays and additional project costs. By contrast, an inclusive approach that receives input from contractors and commissioning agents early in a design process, and coordinates efforts throughout the construction period, can significantly reduce the likelihood of such issues.

SUMMARY OF KEY ACTION ITEMS

- [ ] **Enable close collaboration between design and construction staff through routine meetings; consider advanced tools for communicating design information**
- [ ] **Secure a commissioning agent for the retrofit project early in the design process to inform the design and ensure it is constructed and operates appropriately**
- [ ] **Enlist the commissioning agent or another service provider to create and implement a Measurement & Verification Plan**

CONSTRUCTION

A retrofit is most successful when designers and builders attempt to coordinate their efforts as if they are a single entity. One coordination strategy is to "co-locate" during design and construction. That is, a representative of the builder works out of the designer's office for a few days during design, and vice versa during the construction phase.

Another strategy is to use building information modeling (BIM) or another type of building model to examine where new building components might spatially conflict (a surprisingly common occurrence) and to produce 3D images of building details that, when provided on the jobsite, help builders visualize what they are constructing. Pre-fabrication of building components (such as ductwork) can also be employed to reduce the chance of onsite construction errors.

COMMISSIONING

Commissioning a building is another critical element of the deep retrofit process. When implemented properly, commissioning is an intensive quality assurance process in which a third-party commissioning agent provides oversight not only during construction, but also during the design phase and then later through occupancy and operations to ensure the project meets defined objectives and criteria.

A commissioning agent may help define objectives and criteria, provide periodical design reviews, offer insight into constructability or control strategies, and/or develop operations manuals and training procedures. During construction, an agent will ensure that systems and equipment are installed and operating according to design through on-site inspections and tests. After construction, the agent may also facilitate an onsite owner-architect-contractor building walk-through immediately after construction in order for the owner or facility manager to get a visual understanding of the systems in place. Finally, the agent may ensure that operators are trained.

The benefits of commissioning can be extended indefinitely by incorporating a regular commissioning program into a facility's ongoing energy management plan.

MEASUREMENT & VERIFICATION

Once constructed and commissioned, the deep energy retrofit will begin saving energy. Now is the time to implement Measurement & Verification (M&V) to ensure the building will continue to save what was anticipated, and possibly more.

Equipment defects that emerge after passing the initial commissioning test, and uninformed occupants or ill-trained facilities staff can undo the best building design. M&V is a formalized process for diagnosing and addressing these issues. As an added benefit, measured building energy use data can be used to confirm (and sometimes correct) utility billing and can then be communicated to occupants in the form of a wall display or energy bill as part of an energy management plan providing feedback to further reduce energy use. Also, ongoing M&V provides opportunities to continually improve equipment performance through better control strategies.

DEEP ENERGY RETROFIT HIGHLIGHT

MEASUREMENT & VERIFICATION

Ensuring achievement of savings while illuminating opportunities for continuous improvement

Owners should begin the M&V process during the opportunity identification phase of a retrofit to guarantee that the design team appropriately specifies metering equipment and develops an M&V plan. An M&V plan outlines the objectives, responsible parties, metering points, data-handling methods, baselines, performance adjustment parameters, savings calculation options, and other procedures associated with the process. As such, M&V should only occur once the project has already been constructed, commissioned, occupied, and reached a state of steady operation. The process should also be carried out according to industry-accepted standards defined by the Efficiency Valuation Organization (2009).

Once operation is stable for at least a year, the M&V team will determine energy savings on a system level through calibrated spreadsheet analysis or on a building level through calibrated whole-building simulation analysis. The level of detail and rigor followed are outlined in the M&V plan and should be correlated to the risk and value of the savings that are to be quantified. If actual performance lies below the specified range of predicted performance, all stakeholders should understand who is contractually responsible for remediation.

Challenges and Opportunites

A deep energy retrofit results in an efficiency upgrade plan that can extend several years into the future and across other facilities with similar building systems. A main challenge is that energy and maintenance cost savings do not always justify such an investment.

Two approaches can significantly improve the economics of a deep energy retrofit. The first is taking into account the avoided costs of replacements and upgrades that must occur as part of ongoing capital improvements. The second is to consider benefits such as tenant attraction and retention, occupant productivity and performance, and community stature, among many others. A complete list of potential value is provided in the Building the Case Guide.

To fully understand the potential value of the deep energy retrofit on a particular project, retrofit practitioners should collaborate fully with facility managers. Facility managers have a long list of work objectives, which they often do not provide to the energy professional during an energy audit unless requested (often because they do not want to influence the energy professional's recommendations).

At first glance, a facility manager's objectives may seem at odds with efficiency renovations, or in competition for funding. However, a deep energy retrofit that is completed as part of a comprehensive renovation can identify opportunities that achieve both objectives for a single cost. Facility managers must therefore express their full range of objectives and concerns to the energy professional, who can then design solutions that meet the objectives at least cost.

In addition to identifying solutions that meet facility manager objectives, the deep energy retrofit process will reveal ways to piggyback measures onto planned building equipment or component replacements—thereby reducing the cost and inconvenience of standalone efficiency measures.

A well-planned deep retrofit project can identify several piggybacking opportunities that are not necessarily straightforward. Only the deliberate and rigorous process of a deep retrofit can identify these opportunities that make efficiency more cost effective and valuable.

In Conclusion

Performing deep energy retrofits across the U.S. building stock makes sense now, more than ever, because the industry is ready, buildings are ripe, and such renovations are profitable.

With enough commitment and vision, building owners can use this and other RetroFit Depot guides to take advantage of this unique opportunity and reap the many benefits afforded by deep energy retrofits. Businesses can become more competitive, profitable, and resilient by leading the transformation of our building stock that is largely inefficient. This transition will build a stronger economy, a more secure nation, and a healthier environment.

We welcome your feedback. Your experiences and observations are valuable to the continued development of the RetroFit Depot website. The journey is just beginning, and we look forward to hearing from you.

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