# Business Case for Proactive Rooftop Unit (RTU) Replacement

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# Executive Summary

Rooftop air conditioning systems or rooftop units (RTUs) are common, cooling nearly 60% of the U.S. commercial building floor area and consuming 4.3 Quads of energy annually. RTUs that are more than 15 years old can waste substantial amounts of energy and money; however, facility managers often wait until an RTU no longer provides adequate space conditioning, requires frequent maintenance, or fails completely before replacing it. In many instances, replacing inefficient and underperforming RTUs proactively with more energy-efficient units can be a smart business move, especially when compared with replacement-on-failure or even with a like-for-like replacement at the end of an RTU's useful service life.[1]

Developing and delivering a cost-effective proactive replacement strategy for RTUs is challenging because it involves many complex factors. To successfully optimize energy and cost performance, the strategy must include evaluation of a range of economic and non-economic factors.

This document introduces the key elements to consider in making the business case for a proactive high-efficiency RTU replacement strategy for facility maintenance staff and building engineers who are responsible for energy management of commercial buildings. This business case analysis is one step in an overall RTU evaluation and replacement methodology as outlined in Figure ES1.[2] Finding the optimal balance of performance, nonenergy features, and total cost of ownership is an iterative process. This document provides guidance on key activities to include in the business case analysis step.

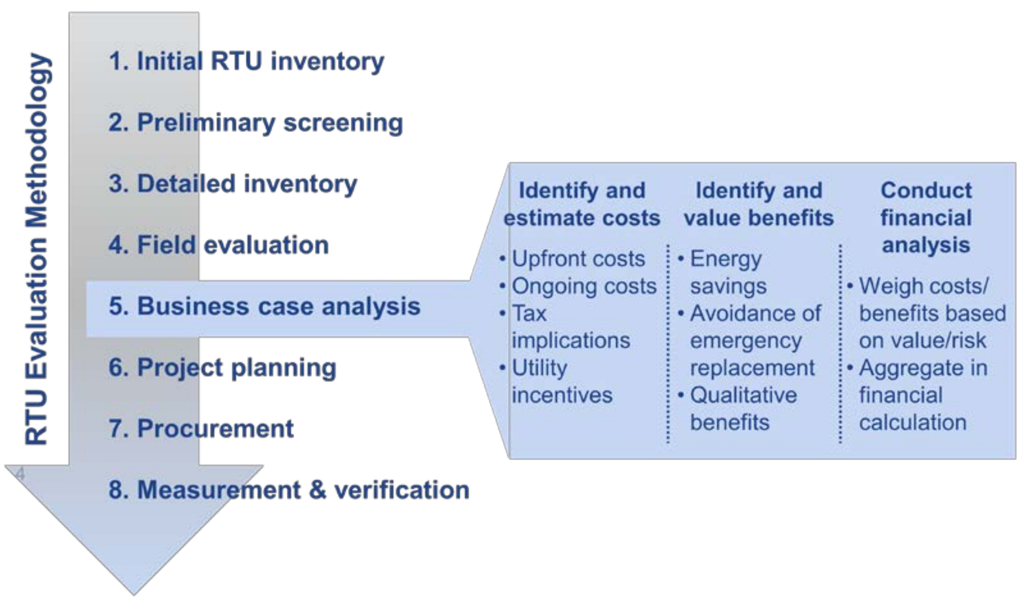


**Figure ES1. Streamlined RTU evaluation methodology**

The business case analysis shown in Figure ES1 can be broken down further into the following 3 activities:

## 1) Identify and Estimate Costs of Proactive Replacement

After the facility manager has identified a list of top candidate RTUs for replacement or retrofit with advanced controls, the associated costs should be identified and evaluated. Additionally, the facility manager should conduct an engineering analysis to identify opportunities for downsizing, eliminating equipment, and optimizing the design. The following list should be modified for each project.

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[1] The end of useful service life (EUSL) is defined as when the RTU no longer satisfies the space-conditioning needs, likelihood of failure is high, and/or maintenance costs become increasingly high. The EUSL is typically 15 years or more but may be less in highly corrosive environments.

[2] See the Advanced RTU Campaign for more resources, www.advancedrtu.org; and download the decision tree for RTU replacements and retrofits at https://buildingdata.energy.gov/cbrd/resource/1332.

a. Prepare a specification with performance and feature requirements, request quotes from multiple vendors, and compare for the highest quality bid. (Include required control and physical upgrades such as curb adapters, ducting, roof reinforcements, etc.).
b. Review utility incentives and tax rebates for new equipment.
c. Assess the tax depreciation write-offs of retired assets.
d. Determine the recovery cost or value of old equipment and refrigerant.
e. Evaluate costs and positive or negative impacts on operations and maintenance.
f. Consider financing options (e.g. property-assessed clean energy [PACE], on-bill financing, leasing, energy savings performance contracts [ESPC], Managed Energy Services Agreement [MESA]).

## 2) Identify and Value the Benefits of Proactive Replacement

A well-designed high-efficiency system will produce benefits beyond energy savings. Determining and assigning value to all the benefits, including non-energy benefits, can make the difference between a successful project and one that never gets off the ground. Keep the following suggestions in mind when evaluating benefits of proactive replacement:

a. Estimate the energy savings of candidate replacement RTUs compared with existing RTUs. Performance of the existing RTUs should be degraded depending on the condition.
b. Evaluate cost avoided from a planned replacement compared to costs associated with emergency replacements (loss of service during critical business operations, high service fees from the installing contractor, lost opportunities for system optimization, etc.).
c. Include cost savings of replacing multiple RTUs on a roof at one time compared to separate replacements of individual RTUs.
d. Include the value of eliminating R-22 refrigerant from your inventory.
e. Consider the qualitative benefits such as improved indoor temperature and relative humidity control, reduced noise, and reduced maintenance.
f. Consider the business value of demonstrating high performance and sustainable practices.

## 3) Conduct Financial Analysis to Weigh Costs and Benefits

A variety of financial metrics can be used to find the right balance between the costs and benefits of proactive RTU replacements. The final answer will likely require some iteration to the costs and benefits summarized in Figure ES2. Fortunately, there are tools available to help in this process, such as the RTU Comparison Calculator. Consider these financial return metrics to support decision-making:

- Payback period
- Return on investment (ROI)
- Net present value (NPV)
- Internal rate of return (IRR).

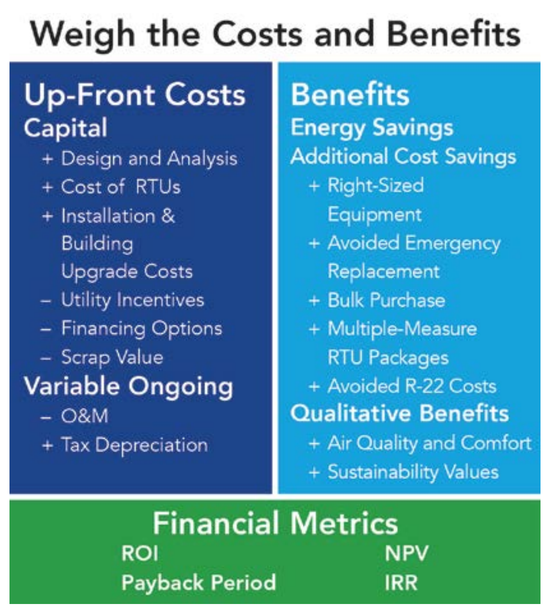


**Figure ES2. RTU business case evaluation**

To fully evaluate the opportunity for proactive RTU replacement, decision-makers must understand each issue affecting the costs and cash flows. Fully understanding and making informed decisions about these issues may require discussions with building engineers, vendors, and service providers. The Advanced RTU Campaign supports this analysis by providing resources designed to help building managers make informed decisions about RTU replacement.

# 1. Introduction—Business Considerations for Proactive RTU Replacement

Rooftop air conditioning units (RTUs) are very common, cooling nearly 60% of the U.S. commercial building floor area while consuming 4.3 Quads of energy annually. By replacing older RTUs with high-efficiency units and retrofitting the remaining eligible RTUs with advanced controls, buildings can reduce annual cooling and ventilating energy consumption 20-50% and energy costs by $900 to $3,700 per RTU. This equates to a national savings potential of $6.7 Billion dollars and 670 trillion Btu annually. Better Buildings Alliance members recognize the value of efficient RTU practices and have identified them as a priority with the development and launch of the Advanced RTU Campaign.

Despite the substantial savings opportunities, RTUs are often ignored, and a common practice is to run them past their economically useful life but still within their operational life. Although RTUs can provide 15–20+ years of service, the performance of RTUs can decrease significantly by the end of life, especially when compared with new high-efficiency RTUs. Proactively replacing older RTUs with high-efficiency RTUs can be a very effective energy-saving strategy under the right conditions. Building owners and facility managers need to consider many factors in determining if proactive RTU replacement makes sense. This document provides information to help identify and evaluate these factors.

The four replacement strategies listed below describe a range of practices from least to most effective. The first two strategies are the easiest and provide the lowest value to building owners. Strategies 3 and 4 are planned proactive RTU replacement approaches that provide highest value to building owners.

1. **Replacement-on-failure with like-for-like RTUs**: This strategy results in high costs, disruption of services, and missed opportunities for energy savings.
2. **Replacement at end of useful service life (EUSL) with like-for-like RTUs**: This strategy has lower costs than emergency replacements but still results in missed opportunities for energy savings. In this case, the building owner may request a replacement unit from a contractor with little or no planning. This replacement is likely to be a standard efficiency unit that will provide minimal energy savings compared to the old but otherwise similar RTU.
3. **Proactive replacement at EUSL or early retirement with right-sized and higher-efficiency RTUs**: This strategy involves assessing RTUs and the building loads to determine proper sizing and consideration of multiple options and efficiency levels. In this scenario, best value is obtained through a competitive bid process, incentives are factored into the process, and replacements are planned to minimize disruption of services and minimize installation costs.
4. **Proactive replacement at EUSL or early retirement with an engineered and optimized design**: This strategy offers the greatest potential to minimize energy use. It includes a complete engineering design analysis that considers all load reductions, optimal ventilation strategies, energy recovery options, and optimal control strategies. This option requires more up-front investment than strategy 3, so it may be best suited for large portfolio owners who can replicate the designs several times to cover the additional up-front costs. However, small portfolio owners can follow best practices and realize benefits of successful strategies implemented by large portfolio owners.

These strategies include three replacement time possibilities: after failure, at the EUSL, and early retirement. EUSL is generally defined in this report as when the RTU no longer provides adequate space conditioning, the likelihood of failure is high, and/or maintenance costs increase over time. The EUSL of an RTU is typically between 15 and 20 years, but may be closer to 10 years in highly corrosive environments. These ages align well with information in the Database for Energy Efficiency Resources from the California Public Utilities Commission, which sets the effective useful life of commercial packaged heating, ventilating, and air conditioning (HVAC) systems at 15 years and the remaining useful life at 5 years.[1] Early retirement of the EUSL is defined as replacement at least 2–3 years prior to the EUSL. This can be effective when there are large energy-savings opportunities (for example, an increase from 11 integrated energy efficiency ratio [IEER] to 20 IEER), major changes to the building loads or functions that have increased or decreased the space conditioning loads, or existing systems that are not meeting thermal comfort requirements. Recent improvements in RTU efficiencies have made early retirement more economically viable because of the large efficiency gains with a new high-efficiency RTU compared to a 15 to 20-year-old RTU with degraded performance.

The business case analysis in the RTU Evaluation Methodology[2] diagram in Figure 1 outlines three main activities for proactive RTU replacement strategy: identify and estimate costs, identify and value benefits, and conduct a financial analysis. This report provides more information on these activities to help decision-makers understand each issue affecting the costs, benefits, and cash flows for proactive RTU replacements. The Advanced RTU Campaign provides additional resources designed to help building managers make informed RTU replacement decisions.

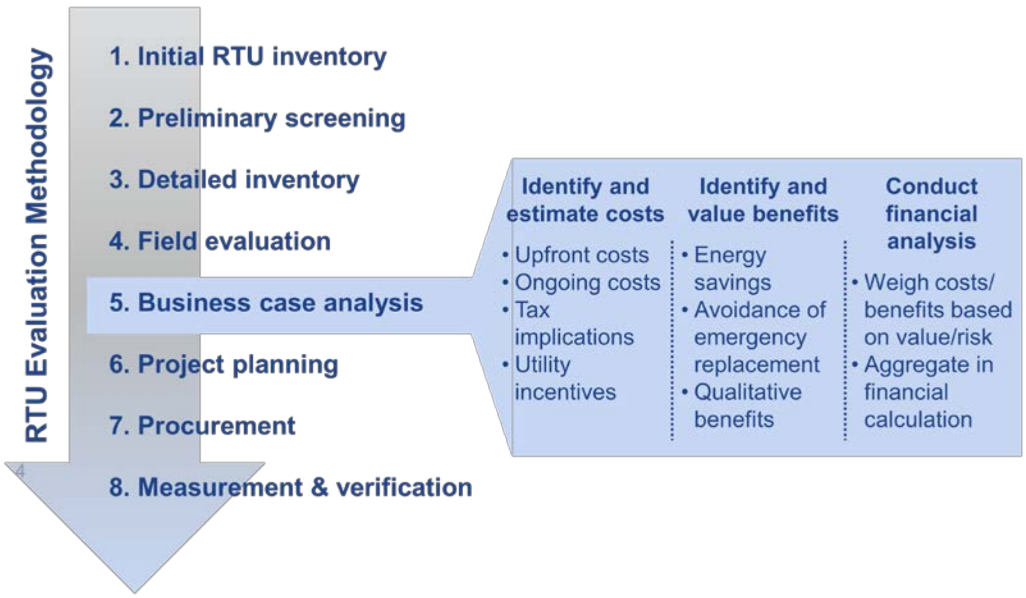


**Figure 1. Streamlined RTU evaluation methodology**

# 2. Identify and Estimate Costs of Proactive Replacement

The cost involved in any RTU replacement activity can be divided into up-front costs and ongoing costs over the life of the new RTU. The building owner can use a proactive replacement strategy to analyze all of the costs and determine the best value options over the life of the project.

## 2.1 Up-Front Costs

### 2.1.1 Design and Analysis

All RTU replacement activities involve some level of design and analysis. The cost for this activity may be included in the total cost of replacement by the local HVAC contractor or it may be an explicit cost for engineering analysis of the building loads and optimal HVAC solutions. An engineered design may lead to a downsizing of the RTUs and improved performance that will reduce other costs as described in Section 3 on identifying and valuing the benefits of proactive replacement. Either way, these costs should be factored into the total cost over the expected life of the RTUs.

### 2.1.2 Price of High-Efficiency RTUs

A key element in making the business case for a proactive RTU replacement is balancing the up-front cost with long-term savings. To secure the best value, building managers should request quotes from several vendors through a formal request for proposals that includes specifications for all the important features desired in the RTUs. For additional information, review the adidas case study[3] for proactive replacement and consider referencing content from the high-efficiency RTU specification[4] documents.

### 2.1.3 Installation Costs

Installation costs include parts, labor, mobilization, equipment, and disposal fees. All of these costs may be higher in the peak cooling season when there is a greater demand for HVAC services. Emergency services often require an additional service charge and do not allow time to compare multiple estimates for the best value. Building managers should also factor in costs associated with the loss of service of the building.

### 2.1.4 Building Upgrade Costs for New RTUs

New equipment (especially equipment from a different manufacturer) may require an adaptor curb, which adds cost, weight, and height. Height may be an issue if screening requirements are present. High-efficiency RTUs may include larger heat exchangers, which can add significant weight to the unit. Due to weight differences, roofing structural reinforcement may be needed. Switching from the current brand of RTU to a different brand may impose a 25% increase in installed cost.[5] Some of the cost increase can be avoided by engineering analysis of system capacity requirements and downsizing of new RTUs.

### 2.1.5 Utility Incentives That Reduce Up-Front Costs

Utilities often offer incentives or rebates for installation of high-efficiency RTUs. Examples include $50/horsepower incentives for a variable-speed-drive retrofit on motors and $150/ton reimbursements for RTU replacements. In addition, many utilities offer custom incentive programs for projects that don't fit into other programs and offer significant energy or demand savings. Explore the RTU Incentives Database[6] on the Advanced RTU Campaign website or the Database of State Incentives for Renewables & Efficiency[7] for specifics on each utility's RTU incentives.

### 2.1.6 Financing Options That Reduce Up-Front Costs

The following financial options can help reduce up-front RTU procurement costs. Building managers should assess their implementation in the overall economic evaluation.

Equipment leasing: Many manufacturers and suppliers have equipment leasing options that allow the building owner to decrease the amount of up-front funding by paying for the unit over time.

Property-assessed clean energy (PACE) financing: PACE and Commercial PACE (C-PACE) programs allow access to loans for energy efficiency and renewable energy projects, which are repaid by charges added to the building's property tax. PACE programs are designed to enable the financing of energy efficiency projects where an owner may sell a property before positive payback on an upgrade is achieved.

Property owners interested in this option should determine if their county or municipality has a PACE program and then research eligibility requirements for participating in the financing program via PACENow.

Energy savings performance contracts (ESPCs) with energy service companies (ESCOs): ESCOs use a suite of financing tools such as an ESPC to reduce the up-front costs of RTU replacements for energy efficiency projects with government agencies and large organizations. These contracts guarantee the building's energy costs will not rise above a specified amount. This arrangement protects the building owner or tenants from rising energy costs, and allows an ESCO to profit by developing measures to reduce consumption.

Managed energy service agreements (MESAs): A MESA is a tool in which a company pays an amount equivalent to its historical energy bill to a service provider. The service provider then invests in equipment to reduce energy usage and is responsible for paying the property's energy bill directly. If the service provider successfully reduces energy bills, it can profit by capturing a portion of the savings. Organizations that are considering RTU replacement as a part of a broader suite of energy efficiency improvements may want to consider an ESPC or MESA as a way to avoid up-front costs. Contact an ESCO or other service provider for more information about these options.

Utility on-bill financing: In this arrangement, the utility offers financing for approved types of energy efficiency projects, and customers repay the financing through an additional charge on their utility bills. Each utility that offers on-bill financing is likely to support different project types and have different eligibility criteria. On-bill financing programs are often coordinated with other incentive and rebate programs.

## 2.2 Variable Ongoing Costs

### 2.2.1 Costs of Adapting Operations and Maintenance to New Equipment

Different RTU models may have different maintenance requirements or present new challenges for completing routine maintenance. New control systems may require additional training. Alternatively, new RTUs may have reduced maintenance requirements or they may come with a service contract that ensures proper operation with minimal ongoing costs.

### 2.2.2 Tax Depreciation Implications

Under current law, depreciation periods for many types of equipment are predefined and often bear little relationship to typical service lives. The Internal Revenue Service uses a straight-line calculation for determining yearly tax depreciation:

$$Yearly\ Depreciation = \frac{Equipment\ Purchase\ Cost - Salvage\ Value}{Life\ in\ Years}$$

Each yearly depreciation can be deducted from the organization's annual taxable income (while the equipment is still in service), and the tax savings (write-offs) are considered a benefit on the accounting books. If an asset is retired before the end of its depreciation period, a portion of the tax deduction associated with the expenses for that asset may be lost, effectively causing the owning organization to lose the tax benefit.

Currently, the depreciation period for RTU equipment is 39 years[8]; however, RTU equipment has a typical service life closer to 15 to 20 years. The 39-year depreciation period acts as a barrier to energy efficiency because many businesses choose to repair equipment when it fails rather than writing off the undepreciated value. This write-off must be considered in the business case for proactive replacement of an RTU. The American Council for an Energy-Efficient Economy published a white paper that further discusses the issue of tax depreciation.

# 3. Identify and Value Benefits of Proactive Replacement

## 3.1 Energy Savings

### 3.1.1 Energy Cost Savings of High-Efficiency RTUs

Energy costs are the largest cost of ownership over the life of an RTU; therefore, it is worthwhile to spend extra time to obtain an accurate estimate of these costs. The RTU Comparison Calculator can be useful for estimating RTU operating costs for individual RTUs based on an average or blended energy charge or with an energy charge and demand charge. High-efficiency RTUs may reduce the peak demand, which should be included if demand charges are a significant part of the utility costs. Estimating the energy cost savings with a blended rate energy charge may overvalue or underestimate the cost savings for high-efficiency units depending on the energy and demand charges.

Older RTUs may be significantly less efficient than new models for two reasons—energy efficiency standards were significantly lower 10–20 years ago and new high-efficiency RTUs have variable or multispeed operation modes that provide significant performance improvement in part-load conditions. Furthermore, RTU performance degrades overtime. A general rule-of-thumb is 1% degradation per year, but it may be lower or higher depending on the environmental conditions, maintenance practices, and unit runtime.

### 3.1.2 Cost Savings of Right-Sized Equipment

Another benefit of proactive RTU replacement is the opportunity to “right-size” the equipment to best fit the energy needs of the building. A proper design analysis can correct previous oversizing and take advantage of load reductions from energy conservation measures that have been implemented, such as efficient lighting improvements. A new HVAC design may result in reduced RTU cooling capacity and potential elimination of some RTUs. Ventilation needs for the space should also be evaluated to determine if ventilation should be modified to meet current needs. Performance-based ventilation methods in ASHRAE Standard 62.1[9] may also reduce capacity requirements. Right-sizing RTUs may reduce capital costs for replacement (based on smaller unit size) and allow RTUs to function most efficiently as specified. The Advanced RTU Campaign offers an RTU Right-Sizing Guidance document to help determine the optimum RTU size for a commercial building.

## 3.2 Avoidance of Unexpected Failure and Emergency Replacement

The costs of an emergency RTU replacement are often much higher than the cost of a planned replacement. In an emergency replacement scenario, installation costs are often very high, there’s no opportunity to shop for the best value, and RTU choices are limited to those in stock. Advanced planning saves money by capitalizing on lower labor and equipment costs, optimal scheduling of lifting equipment, and avoidance of the loss of service. With planned RTU replacements, building engineers can identify and purchase the optimal RTU size and design for the application. Read the Walgreens case study about its successful implementation of a planned RTU replacement program and its partnership with the Advanced RTU Campaign.[10]

## 3.3 Additional Cost-Saving Opportunities

### 3.3.1 Portfolio-Level versus Individual Building-Level Replacements

Organizations can reduce RTU costs through a national purchase agreement for units across their portfolio of buildings. A standardized contract between the building owners and the RTU vendors can provide a simplified system for the RTU replacement process. Furthermore, developing an organization-wide RTU replacement policy can streamline program efficiencies. Portfolio-level programs are most effective in allocating funds to the replacement projects with the most benefit and best savings potential for the organization.

### 3.3.2 Multiple-RTU Replacement versus Single-RTU Replacement

The installation costs associated with replacing RTUs are more heavily based on days of labor than on the number of units being installed. By combining replacements, building managers can efficiently mobilize costs, labor, and lifting equipment into the business case. These economies of scale in installation strengthen the business case for proactive system-wide RTU replacement.

### 3.3.3 Avoidance of R-22 Usage Costs

Hydrochlorofluorocarbon-22 (HCFC-22, also known as R-22) has been the chief refrigerant for RTU systems for many years; however, it is being phased out over the coming years as part of the agreement to end production of HCFCs. The phaseout includes two main tiers: the end of manufacturing of R-22 equipment January 1, 2010 and the termination of production of R-22 after January 1, 2020. Currently, there are two options for phasing out R-22 in RTUs: (1) purchase new RTU equipment that uses a different refrigerant; and (2) retrofit existing RTUs to replace R-22 with a drop-in replacement refrigerant. Because the production of R-22 is slowly decreasing, the price of the refrigerant is projected to increase over time. This is expected to result in higher costs for service, maintenance, and R-22 components for RTU repairs. Learn more at the U.S. Environmental Protection Agency R-22 Phaseout website.[11]

## 3.4 Qualitative Benefits

### 3.4.1 Indoor Environmental Quality and Occupant Comfort

RTUs affect the IEQ values of temperature, relative humidity, noise, and air quality. The indoor environment and comfort level have an impact on overall business success (especially in retail spaces), affecting work efficiency and productivity of occupants. Proactively replacing old, inefficient RTUs can improve the IEQ for tenants, clients, and customers.

### 3.4.2 Organization’s Sustainability Values and Goals

For organizations that value sustainability, the energy savings of an RTU replacement can represent significant progress toward reducing their environmental footprints. Even though proactive replacement of RTUs can often make strong financial sense, recognizing the environmental contribution of energy efficiency leadership can be meaningful for an organization seeking to demonstrate its commitment to sustainability.

Owners can communicate their buildings’ sustainability achievements to tenants, employees, and customers through a green building certification such as Leadership in Energy & Environmental Design™[12] or ENERGY STAR®,[13] or through a corporate social responsibility report. Demonstrating these achievements can enhance the brand value of a company, contribute to public relations efforts, and align with the values of the people who occupy the building. A study by the U.S. Department of Energy showed that green-labeled buildings have higher rental and occupancy rates, increased occupant productivity, and greater market value than conventional buildings.[14]

# 4. Weigh the Costs and Benefits

## 4.1 Financial Metrics to Value Considerations of Proactive RTU Replacement

Once an organization has identified an opportunity for proactive replacement, they may calculate one or more of the financial metrics in Table 1: payback period, ROI, NPV, and IRR. These metrics will help to determine the strength of the case for RTU replacement given the specific characteristics of the organization.

**Table 1. Financial Metrics to Value Considerations of Proactive RTU Replacement**

| Metric | Equation |
|---|---|
| **Payback Period** | $\frac{Up\text{-}front\ Cost\ of\ RTU\ Replacement}{Annual\ Savings}$ |
| **ROI** | $\frac{Lifetime\ Savings - Up\text{-}front\ Cost\ of\ RTU\ Replacement}{Up\text{-}front\ Cost\ of\ RTU\ Replacement} \times 100$ |
| **NPV** | $NPV = \sum_{t=0}^{n} \frac{(Savings - Cost)_t}{(1+d)^t}$ |
| **IRR** | *In the NPV equation, solve for d when NPV = 0* |

The up-front cost of RTU replacement is comprised of the costs (C) and benefits (B) described in Section 2 and can be calculated as:

$$Up\text{-}front\ Cost\ of\ RTU\ Replacment\ = C_{RTU} + C_{RTU\ Installation} - B_{Old\ Unit\ Scrap\ Value} - B_{Utility\ Incentive}$$

The cost benefit or savings of proactively replacing and existing RTU with a high-efficiency RTU can be calculated with the following equations. The annual savings includes the savings on an annual basis and is used for the calculation of the payback period, while the ROI uses the lifetime (or analysis period) savings.

$$Annual\ Savings = \begin{pmatrix} Energy\ Cost\ Savings + O\&M\ Savings - Tax\ Wrte\text{-}off \cdots \\ +Value\ of\ Avoiding\ Unexpected\ Failure + Value\ of\ Other\ Benefits \end{pmatrix}_{annual}$$

$$Lifetime\ Savings = \begin{pmatrix} Energy\ Cost\ Savings + O\&M\ Savings - Tax\ Wrte\text{-}off \cdots \\ +Value\ of\ Avoiding\ Unexpected\ Failure + Value\ of\ Other\ Benefits \end{pmatrix}_{lifetime}$$

### 4.1.1 Simple Payback Period

A payback period is the time required for the benefits of an investment to pay off the initial costs. This metric is generally expressed in years and is calculated by dividing the cost of an investment by the annual value created by the investment. Benefits generated after the payback period represent the net benefits of the investment.

To calculate the payback period of an RTU replacement considering only the energy savings, divide the up-front cost of replacement as defined in Section 4.1 by the sum of the annual energy cost savings, annual O&M savings, and tax write-off losses.

$$Payback\ Period = \frac{Up\text{-}front\ Cost\ of\ RTU\ Replacement}{(Energy\ Cost\ Savings + O\&M\ Savings - Tax\ Write\text{-}off)_{annual}}$$

To calculate the payback period of an RTU replacement considering the value of energy cost savings as well as other benefits, add the estimated annualized value of other benefits to denominator of the calculation.

$$Payback\ Period = \frac{Up\text{-}front\ Cost\ of\ RTU\ Replacement}{\begin{pmatrix} Energy\ Cost\ Savings + O\&M Savings - Tax\ Write\text{-}off \cdots \\ +Value\ of\ Avoiding\ Unexpected\ Failure + Value\ of\ Other\ Benefits \end{pmatrix}_{annual}}$$

### 4.1.2 Return on Investment

ROI represents a percent financial return from an investment and is calculated as the ratio of the net benefit and the investment cost. It does not take into account the time value of money. A positive ROI reflects an investment that increases financial value and a negative ROI represents an investment that does not recover its costs. Overall, the higher the ROI, the greater the monetary benefits of the project. ROI is typically calculated over the lifetime of the investment, but it may be calculated over a smaller analysis period depending on the needs of the project.

For RTU replacement at the EUSL, the ROI of high-efficiency RTUs may be calculated as a comparison to replacement with standard efficiency RTUs. To evaluate the value of an early retirement, determine the number of years the new unit would operate compared to the older unit. For example, if a unit is 15 years old and has an expected life of 20 years, upgrading the RTU proactively would yield energy cost savings compared to the existing unit over a five-year period. The savings calculation should also include the tax depreciation losses over the time period. The ROI based on energy-related savings for an early retirement RTU replacement would be calculated as follows:

$$ROI = \frac{(Lifetime\ Savings - Up\text{-}front\ Cost\ of\ RTU\ Replacement)}{Up\text{-}front\ Cost\ of\ RTU\ Replacement} \times 100$$

$$Lifetime\ Savings = (Energy\ Cost\ Savings + O\&M Savings - Tax\ Wrte\text{-}off)_{lifetime}$$

A more complete analysis includes the value of avoiding an unexpected failure and the value of other non-energy benefits. The value of avoiding an unexpected RTU failure may include the additional costs of lost revenue and productivity if the RTU were to be offline for 1–3 days and the added lifetime energy costs from a less than optimal RTU replacement. Managers should also consider the extra costs of unexpected emergency replacement. The impact of these costs can be discounted based on the probability of unit failure. For instance, if an RTU has roughly an A% chance of failure, the costs of lost space conditioning are estimated to be $B, and the extra cost expected for emergency replacement is $C, the value of avoiding this risk would be calculated as ($B + $C) × A%.

Additional non-energy benefits can be included to further support a positive financial case for an early retirement RTU replacement. RTU replacement may lead to benefits such as improved IEQ, occupant comfort, or a demonstration of commitment to sustainability. Although these benefits are less tangible than others, they may still lead to monetary benefits for an organization and can be included in the financial metric calculations. To calculate an ROI incorporating the value of these benefits, add these values to the numerator of the ROI calculation as shown below.

$$ROI = \frac{(Lifetime\ Savings\ - Up\text{-}front\ Cost\ of\ RTU\ Replacement)}{Up\text{-}front\ Cost\ of\ RTU\ Replacement} \times 100$$

$$Lifetime\ Savings = \begin{pmatrix} Energy\ Cost\ Savings + O\&M Savings - Tax\ Wrte\text{-}off \cdots \\ +Value\ of\ Avoiding\ Unexpected\ Failure + Value\ of\ Other\ Benefits \end{pmatrix}_{lifetime}$$

### 4.1.3 Net Present Value

NPV represents the present value of an investment when cash flows over the life of a project are discounted to reflect the time value of money, risk, and the opportunity cost of capital. NPV takes into consideration the timing of costs and benefits by applying a discount rate to future costs or revenues. The discount rate may be an organization's weighted average cost of capital, or it may be the opportunity cost of capital adjusted for the level of perceived risk of a project. Common discount rates fall between 5% and 15%.

A positive NPV represents an investment that returns positive value after the time value of money, the opportunity cost of capital, and the risks have been considered. In general, a positive NPV is interpreted as a sound investment, and a negative NPV represents an investment that does not recover its cost during the time period considered for the economic analysis. A typical analysis period may be 5–7 years due to many unknowns beyond this period.

To calculate a simple NPV, estimate the costs and the benefits or savings that will occur each year over the lifetime of the investment project, and then sum the discounted the value of the costs and savings for each year through the life of the project. For a discount rate d, analysis period n (years) and year t, calculate the NPV as follows:

$$NPV = \sum_{t=0}^{n} \frac{(Savings - Cost)_t}{(1 + d)^t}$$

The costs for t = 0 are the *up-front costs for RTU replacement* as calculated previously. The savings for each year are the annual savings including the appropriate terms depending on the objectives of the project. The NPV can be calculated manually with the equation above; however, a computational tool such as spreadsheet software or a financial calculator with built in NPV functions can simplify this task. Looking at the value of NPV for each year can be very helpful in estimating when the project becomes cash flow positive.

### 4.1.4 Internal Rate of Return

An IRR represents the annualized effective compound rate of return generated by the cash flow of a project. To calculate the IRR of a project, it is necessary to solve for the discount rate that causes the NPV of a project to equal zero. This calculation is difficult to do manually, and it is recommended to use a computational tool such as a spreadsheet that has a feature for calculating NPVs and IRRs to easily solve for this metric.

The IRR represents an effective rate of return generated by a flow of costs and benefits over time; therefore, the higher a project's IRR, the more financially attractive it is. When determining the risk of pursuing a project, a company may want to pursue investments in which the IRR exceeds the firm's cost of capital.

#### 4.1.5 Go/No-Go Decision on Proactive RTU Replacement

RTU replacement projects are complex and deciding on the optimal solution is difficult. However, defining all of the cost and benefits of various options following the methods in this report will help differentiate the options and determine which option provides the highest value. Table 2 provides a summary of interpretations of the financial metrics to help with the decision making process, and the example calculations in the Section 4.2 provide context for the values.

**Table 2: Interpretations for Financial Metrics**

| Financial Metric | Interpretations |
|---|---|
| **Payback Period** | Shorter payback periods are more attractive. Many companies use a 2-5 year payback period for efficiency projects; however, some companies consider longer payback periods for RTU replacements because they are long-term investments. |
| **ROI** | Higher positive ROIs are more attractive. |
| **NPV** | Positive NPV is required to break even, higher is more attractive |
| **IRR** | Higher IRRs are more attractive. The IRR for a successful project is usually greater than the organization's cost of capital. |

If the organization decides to proceed with RTU replacement, it can plan the specific project and procure the equipment. Steps 6 and 7 in the broader RTU Evaluation Methodology provide additional guidance.

### 4.2 Example Proactive RTU Replacement Calculations

In this example, the financial metrics are applied to a hypothetical but reasonable and illustrative case in which an early retirement and replacement with high-efficiency RTUs is shown to be financially attractive. The analysis is completed with just the energy savings and again with energy and non-energy benefits, which shows a significant improvement in the financial metrics. The simplified analysis could be further improved by including a longer analysis period beyond five years. This example follows the early retirement option for RTU replacement strategy #3 from Section 1 — *Proactive replacement at EUSL or early retirement with right-sized and higher-efficiency RTUs*.

#### 4.2.1 The Situation at Superstore

Superstore sells consumer goods in Columbia, Missouri, in a standalone retail building that is cooled by five 12-ton (144,000 Btu/h) RTUs. The building's RTUs are currently 15 years old and have an expected life of 20 years. The building manager is considering replacing the RTUs to save on electricity costs, reduce the risk of an unexpected RTU failure, and improve the air quality in the store, specifically the ventilation and humidity levels.

The current RTUs were installed 15 years ago with the minimum energy efficiency ratio (EER) required by code, which was 8.7. Since then, the performance has degraded such that the effective EER is now 7.3. The building manager is considering new RTUs with an efficiency level recommended by the Advanced RTU Campaign that meets Consortium for Energy Efficiency Tier 2 specifications, which is 12 EER and 13.8 IEER.[15] Upon evaluation, Superstore has determined that its RTUs are oversized. With right-sizing, the appropriate size for the new replacement RTUs is 10-tons (120 kBtu/h) instead of the existing 12-ton size.

Based on quotes from contractors, the manager has determined that the cost to purchase five 10-ton RTUs with a 12 EER will be $8,000/unit and the cost for the multiunit installation will be $20,000. These costs represent significant cost savings for the downsized units ($1,600/unit) and multiunit installation compared to single installations ($5,000/unit). Maintenance costs on the existing units are $500 higher per RTU per year than for the new unit, partially due to the deletion of R-22 O&M efforts. Superstore can sell each of the old RTUs for $200 as scrap for a total of $1,000.

The building manager can use the RTU Comparison Calculator (RTUCC) to estimate the annual energy savings generated by the more efficient RTUs. The calculator will estimate the annual energy and cost savings of the upgrade by using information about building location, temperature set point, the EERs of the new and old units, the price of electricity, building hours of operation, temperature setback, and presence of economizers.. See Appendix B for the specific parameter assumptions input into the RTUCC for this example. For the situation at Superstore, the calculator estimates that the new units will save 74,638 kWh of electricity per year, which equates to $7,688 per year. Because the manager is considering replacing the current RTUs 5 years before they would otherwise be replaced, these energy cost savings will be considered over the next 5 years, leading to a cost savings of $38,439.

This example calculates that Superstore saves $70 per year per RTU ($350 per year in total) on taxes due to the depreciation write-offs, and that annual cost must be considered as a loss in the overall financial calculations. Assuming the existing RTU will fail once reaching 20 years of operation, there is a net difference of 5 years of tax write-offs acting as a “cost” to early retirement, totaling $1,750 for all five RTUs as shown in Table 3.

**Table 3. Tax Depreciation Calculation for Annual Write-Off Losses**

| Tax Depreciation Calculation | |
|---|---|
| RTU Book Life | 39 years |
| RTU Failure (on average) | 20 years |
| RTU Proactive Replacement | 15 years |
| Value of Existing RTU at Beginning of Life | $8,000 |
| Value of RTU at End of Life | $200 |
| Yearly RTU Depreciation | $200/year |
| Income Tax | 35% |
| Tax Saved from RTU Depreciation | $70/year |
| | |
| Total Write-Off From Depreciation—at RTU Failure | $1,330 (19 years) |
| Total Write-Off from Depreciation—at RTU Replacement | $1,680 (24 years) |
| Net Difference of Write-Off per RTU | ($350) |
| # RTUs | 5 |
| **Total Write-Off** | **($1,750)** |

The local utility for Superstore has an RTU rebate program, which varies in value by size and efficiency. For a 10-ton, 12 EER unit, the utility rebate is $1,640.[16]

The total up-front cost of the five RTU replacements comprises the following elements:

$$\mathit{Up\text{-}front\ Cost\ of\ RTU\ Replacment} = (\$8{,}000\ \text{RTU} - \$200\ \text{scrap value} - \$1{,}640\ \text{utility rebate}) * 5\ \text{RTUs} + \$20{,}000\ \text{installation} = \$6{,}160\ \text{per RTU} * 5\ \text{RTUs} + \$20{,}000\ \text{installation} = \$50{,}800$$

#### 4.2.2 Calculation of Financial Metrics

With the information above, the manager can calculate an ROI, payback period, NPV, and IRR. For each metric, the manager may calculate the metric once using only energy costs, and again considering the value of other costs such as avoided RTU failure and improved air quality.

**Simple Payback Period** (considering energy-related costs):
To calculate a payback period for RTU replacements based only on energy costs, the up-front cost of RTU replacements is simply divided by the net annual energy and related cost savings.

$$\textbf{\textit{Simple Payback Period}} = \frac{(\$50{,}800\ \textit{up-front cost of RTU replacement})}{(\$7{,}688\ \textit{annual energy savings} + \$2{,}500\ \textit{annual O\&M savings} - \$350\ \textit{annual tax write-off})}$$

$$\textbf{\textit{Simple Payback Period}} = 5.2\ \textit{years}$$

**Simple Payback Period** (considering all costs):
To incorporate the benefits of avoided RTU failure and improved IAQ into a payback period, the values for these benefits must be converted to annual values over the period. To do this, add the value of avoided failure with the value of improved air quality and divide by 5 years. Add these amounts to the annual energy-related savings to arrive at the total annual value for energy savings, avoidance of RTU failure, and IAQ improvements.

$$(\$26{,}250 + \$2{,}000)/5 = \$5{,}650$$

$$\$7{,}688 + \$2{,}500 - \$350 + \$5{,}650 = \$15{,}488$$

$$\textbf{\textit{Simple Payback Period}} = \frac{\$50{,}800\ \textit{up-front cost of RTU replacement}}{\$15{,}488\ \textit{annual energy savings and other benefits}}$$

$$\textbf{\textit{Simple Payback Period}} = 3.3\ \textit{years}$$

**Return on Investment** (considering energy-related costs):
A simple ROI for this early retirement case based on the energy cost savings, O&M savings, and loss of the tax depreciation value can be calculated as follows:

$$\textbf{\textit{ROI}} = \frac{\left((\$38{,}439\ \textit{energy savings} + \$12{,}500\ \textit{O\&M savings} - \$1{,}750\ \textit{tax write-offs}) - \$50{,}800\ \textit{up-front cost}\right)}{\$50{,}800\ \textit{up-front cost}}$$

$$\textbf{\textit{ROI}} = -3.2\%$$

**Return on Investment** (considering all costs):
The simple ROI is slightly negative and may be positive when considering the value of avoiding unexpected replacement and other benefits. To value the benefit of avoiding unexpected failure, calculate the additional costs created by unexpected failure, and then multiply these costs by the probability that the current RTUs will fail over the next 5 years.

In the case of Superstore, the manager knows from experience that emergency RTU replacement costs 50% more than planned replacement, which would constitute an additional $6,500 per RTU and $32,500 for all five units. In addition, if the current RTUs were to fail, the store would have no space conditioning for roughly 2 days. The manager knows that 2 days of lost air conditioning would lead to closing for 2 days, equal to $20,000 in lost profit. The building engineer estimates that the probability of the current RTUs failing in the next 5 years is about 50%. With this information, the building manager can roughly value the benefit of avoiding emergency replacement as follows: 50% * ($32,500 + $20,000) = $26,250 over 5 years.

At Superstore, the age of the RTU has led to poor indoor air quality (IAQ) with overly humid conditions and bad ventilation. Proactive replacement of the RTU should fix these problems. Although valuing the benefits of improved IAQ is a subjective process, it is very important. To value this benefit, the manager at Superstore uses a "willingness to pay" approach and asks, "What is my willingness to pay for an improvement in IAQ for the next 5 years, given how the improvement would affect my store's employees and customers?" With this framework, the manager estimates that the value of IAQ improvements over the next 5 years would be worth $2,000.

Now, an ROI can be calculated that incorporates the non-energy benefits of RTU replacement, as follows:

$$\boldsymbol{ROI} = \frac{\begin{array}{c}((\$38{,}439\ energy\ savings + \$12{,}500\ O\&M\ savings + \$26{,}250\ avoided\ emergency\ replacement \\ +\$2{,}000\ value\ of\ improved\ air\ quality\ - \$1{,}750\ tax\ write\text{-}offs) - \$50{,}800\ up\text{-}front\ cost\ of\ RTU\ replacment)\end{array}}{\$50{,}800\ up\text{-}front\ cost\ of\ RTU\ replacement}$$

$$\boldsymbol{ROI} = 52\%$$

**Net Present Value** (considering energy-related costs):
To calculate the NPV of early RTU upgrades, it is necessary to calculate the annual net cash flow over the time period considered as shown in Table 4.

**Table 4. Net Present Value (Energy-Related Costs)**

| Year | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| RTU Replacement Cost | ($40,000) | | | | | |
| Installation Cost | ($20,000) | | | | | |
| Utility Rebate | $8,200 | | | | | |
| Scrap Value | $1,000 | | | | | |
| Tax Depreciation Write-Off | | ($350) | ($350) | ($350) | ($350) | ($350) |
| Energy Savings | | $7,688 | $7,688 | $7,688 | $7,688 | $7,688 |
| O&M Savings | | $2,500 | $2,500 | $2,500 | $2,500 | $2,500 |
| **Annual Net Cash Flow** | **($50,800)** | **$9,838** | **$9,838** | **$9,838** | **$9,838** | **$9,838** |

In order to apply the NPV equation, a discount rate is applied to reduce the value of future cash flows in order to reflect the time value of money, risk, and opportunity cost. To use an appropriate discount rate, a manager may use the same rate used in the organization's accounting or forecasting processes. Common discount rates are often between 5% and 15%. At Superstore, a discount rate of 12% is used. To calculate the NPV, the manager may use spreadsheet software or a financial calculator, but it is also possible to calculate manually, as follows:

$$\boldsymbol{NPV} = -50{,}800 + \frac{\$9{,}838}{(1+.12)^1} + \frac{\$9{,}838}{(1+.12)^2} + \frac{\$9{,}838}{(1+.12)^3} + \frac{\$9{,}838}{(1+.12)^4} + \frac{\$9{,}838}{(1+.12)^5} = -\$15{,}337$$

**Net Present Value** (considering all costs):
To incorporate the value of avoided RTU failures, improved air quality, and right-sizing in the NPV calculation, add the annual value of these benefits to the yearly cash flows, and recalculate the NPV using the same discount rate.

**Table 5. Net Present Value (Energy and Other Costs)**

| Year | 0 | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| RTU Replacement Cost | ($40,000) | | | | | |
| Installation Cost | ($20,000) | | | | | |
| Utility Rebate | $8,200 | | | | | |
| Scrap Value | $1,000 | | | | | |
| Tax Depreciation Write-Off | | ($350) | ($350) | ($350) | ($350) | ($350) |
| Energy Savings | | $7,688 | $7,688 | $7,688 | $7,688 | $7,688 |
| O&M Savings | | $2,500 | $2,500 | $2,500 | $2,500 | $2,500 |
| Value of Avoided Failure, Air Quality Improvements | | $5,900 | $5,900 | $5,900 | $5,900 | $5,900 |
| **Annual Net Cash Flow** | **($50,800)** | **$15,488** | **$15,488** | **$15,488** | **$15,488** | **$15,488** |

$$\boldsymbol{NPV} = -50{,}800 + \frac{\$15{,}488}{(1+.12)^1} + \frac{\$15{,}488}{(1+.12)^2} + \frac{\$15{,}488}{(1+.12)^3} + \frac{\$15{,}488}{(1+.12)^4} + \frac{\$15{,}488}{(1+.12)^5} = \$5{,}030$$

**Internal Rate of Return** (considering energy-related costs):
An IRR is calculated by finding the discount rate that sets the NPV equation equal to 0. This rate represents the annual compound rate of return of an investment. While roughly estimating an IRR manually is possible, use a financial calculator or spreadsheet software to easily calculate this metric. Using the cash flows and NPV equations above, IRRs can be calculated as follows:

When NPV = 0, solve for *d.*

$$0 = -\$50{,}800 + \frac{\$9{,}838}{(1+d)^1} + \frac{\$9{,}838}{(1+d)^2} + \frac{\$9{,}838}{(1+d)^3} + \frac{\$9{,}838}{(1+d)^4} + \frac{\$9{,}838}{(1+d)^5}$$

$$\boldsymbol{IRR} = -1\%$$

**Internal Rate of Return** (considering energy and other costs):
To incorporate the value of avoided RTU failure and improved air quality, solve for the IRR when using the cash flow for the NPV equation that incorporates the value of these benefits.

When NPV = 0, solve for *d.*

$$0 = -\$50{,}800 + \frac{\$15{,}488}{(1+d)^1} + \frac{\$15{,}488}{(1+d)^2} + \frac{\$15{,}488}{(1+d)^3} + \frac{\$15{,}488}{(1+d)^4} + \frac{\$15{,}488}{(1+d)^5}$$

$$\boldsymbol{IRR} = 16\%$$

## Superstore Example: Early Retirement of 5 RTUs
## Weigh the Costs and Benefits

### Up-Front Costs

**Capital**

| | |
|---|---|
| + Design and Analysis | |
| + Cost of RTUs | $8,000/unit |
| + Installation & Building Upgrade Costs | $20,000 |
| – Utility Incentives | -$1,640/unit |
| – Financing Options | |
| – Scrap Value | -$200/unit |
| **Total Cost for 5 Units =** | **$50,800** |

**Variable Ongoing**

| | |
|---|---|
| – O&M ($500 * 5 Units)=$2,500/yr * 5 yrs | -$12,500 |
| + Tax Depreciation ($70 * 5 Units) =$350/yr * 5 yrs | $1,750 |

### Benefits

**Energy Savings**

| | |
|---|---|
| + $7,688*5 years = | $38,439 |

Additional Cost Savings

| | |
|---|---|
| + Right-Sized Equipment | (included in price) |
| + Avoided Emergency Replacement | $26,250 |
| + Bulk Purchase | (included in price) |
| + Multiple-Measure RTU Packages | (included in price) |
| + Avoided R-22 Costs | (included in O&M) |

**Qualitative Benefits**

| | |
|---|---|
| + Air Quality and Comfort | $2,000 |
| + Sustainability Values | |

### Financial Metrics

| | | | |
|---|---|---|---|
| ROI Energy and Other Costs | 52% | NPV | $5,030 |
| Payback Period | 3.3 Years | IRR Energy and Other Costs | 16% |

**Figure 2. Superstore summary of early retirement of five RTUs**

## 4.3 Conclusion

After calculating the financial return metrics for a proactive and early retirement RTU replacement, the Superstore manager can decide to replace the building's RTU based on the best available data and strong financial analysis. The financial metrics for Superstore show that replacement based on energy savings alone generated by the investment are not favorable for an RTU upgrade at this time. However, the business case for replacement is quite strong with the additional benefits of avoided RTU failure and improved IAQ as summarized in Figure 2. To understand these financial metrics in the context of Superstore's business, the manager can compare these metrics against similar financial metrics for other capital improvement projects. If the returns for the RTU project are greater than the projected returns for other available projects, the case for RTU replacement will be especially compelling.

The analysis completed for this example was simplified in that the costs were assumed constant over the analysis period and the analysis period was limited to 5 years. It is likely that there will be an increase in energy and maintenance costs over 5 years, which would show an improved financial analysis for proactive replacement. A longer analysis period would show an increased value to the building owner and could include a simple extension of the analysis period or could include RTU replacements at the end of 5 years. In either scenario, the value to the building should increase showing higher values for NPV and IRR.

# Endnotes

[1] Database for Energy Efficient Resources (DEER), California Public Utilities Commission: www.deeresources.com.
[2] Advanced RTU Campaign, RTU Decision Tree: https://buildingdata.energy.gov/cbrd/resource/1332.
[3] adidas RTU case study: https://buildingdata.energy.gov/cbrd/resource/1643.
[4] Advanced RTU Campaign, RTU Procurement Language: http://www.advancedrtu.org/find-a-product.html.
[5] Estimates obtained from DOE Better Buildings Case Competition, 2013: http://www1.eere.energy.gov/buildings/betterbuildings/casecompetition/documents/2013/Everything-Store-case-study.pdf .
[6] Advanced RTU Campaign, RTU Incentives Database: www.advancedrtu.org/financial-resources.html.
[7] DSIRE: www.dsireusa.org.
[8] ACEEE Depreciation White Paper: www.aceee.org/white-paper/depreciation-impacts-on-tax-policy
[9] ASHRAE Standard 62.1-2013 for Ventilation and Indoor Air Quality: https://www.ashrae.org/resources--publications/bookstore/standards-62-1--62-2.
[10] Walgreens Advanced RTU Campaign Case Study: https://buildingdata.energy.gov/cbrd/resource/1929
[11] U.S. EPA R-22 Phaseout Website: www.epa.gov/ozone/title6/phaseout/classtwo.html
[12] USGBC, Leadership in Energy & Environmental Design, www.usgbc.org.
[13] EPA, ENERGY STAR for Buildings, www.energystar.gov.
[14] U.S. Department of Energy, Energy Efficiency & Financial Performance: A Review of Studies in the Market: http://www4.eere.energy.gov/alliance/sites/default/files/uploaded-files/energy-efficiency-and-financial-performance.pdf.
[15] A 10-ton RTU with EER of 12 meets the Advanced RTU Campaign efficiency threshold of CEE Tier 2.
[16] Columbia, Missouri, Utility RTU Rebates Table: www.gocolumbiamo.com/WaterandLight/Business/commercialrebates.php.

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"Advanced RTU Campaign, RTU Evaluation Methodology," accessed at www.advancedrtu.org/retrofit-or-replace.html.

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"Advanced RTU Campaign, RTU Incentives Database," accessed at www.advancedrtu.org/financial-resources.html.

"Advanced RTU Campaign: RTU Inventory Spreadsheet," accessed at https://buildingdata.energy.gov/cbrd/resource/1331.

"Advanced RTU Campaign: RTU Right-Sizing Guidance," accessed at https://buildingdata.energy.gov/cbrd/resource/1648.

"Advanced RTU Campaign: RTU Procurement Language," accessed at www.advancedrtu.org/find-a-product.html.

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"PACE*Now* Financing Energy Efficiency," accessed at http://pacenow.org.

"Pacific Northwest National Laboratory RTU Comparison Calculator," accessed at www.pnnl.gov/uac.

"U.S. Environmental Protection Agency R-22 Phaseout Website," accessed at www.epa.gov/ozone/title6/phaseout/classtwo.html.

# Appendix A: Rooftop Unit Evaluation Methodology

New technologies for replacements and retrofits of RTUs offer tremendous energy-saving opportunities. To help building managers take advantage of those opportunities, the U.S. Department of Energy's Advanced RTU Campaign has developed a set of resources built around a streamlined RTU Evaluation Methodology.[21] The business case for proactive RTU retirement falls in step 5, Analysis.

| Evaluation Methodology Step | Description | Conducted By | Resources & Links |
|---|---|---|---|
| **1. Initial RTU Inventory** | Gather simple, high-level information on the RTUs (e.g. number, size, age, general condition). | Facility Manager or Building Engineer | RTU Inventory Spreadsheet: https://buildingdata.energy.gov/cbrd/resource/1331 |
| **2. Preliminary Screening** | Organize the RTUs into bins for "retrofit," "replacement," "no action," or "needs further analysis" to quickly identify RTUs for assessment. | Facility Manager or Building Engineer | Decision Tree for RTU Replacements or Retrofits: https://buildingdata.energy.gov/cbrd/resource/1332 |
| **3. Detailed Inventory** | Gather a thorough inventory of the RTUs identified for retrofit, replacement, or those that need further analysis. | Facility Manager or Building Engineer | RTU Inventory Spreadsheet: https://buildingdata.energy.gov/cbrd/resource/1331 |
| **4. Field Evaluation** | Conduct a visual-based field evaluation to help understand the condition (e.g., good, fair, or poor) of individual elements of the RTUs (e.g., compressor, coils, burner section) and identify faults that require more than routine maintenance. | Building Engineer | RTU Field Evaluation Checklist: https://buildingdata.energy.gov/cbrd/resource/1330 |
| **5. Business Case Analysis** | Perform energy and economic analyses to prioritize potential RTU improvements and **make the business case** for taking action. This step may continue throughout the project planning and procurement phases, and often requires several iterations to evaluate possible combinations of manufacturers, efficiency levels, sizes, and RTU configurations. | Finance Team and Building Engineer | RTU Incentives Database: www.advancedrtu.org/financial-resources.html<br>DSIRE: www.dsireusa.org<br>RTU Comparison Calculator: www.pnnl.gov/uac<br>DOE 179D Calculator: http://apps1.eere.energy.gov/buildings/commercial/179d/<br>Advanced RTU Campaign Case Studies: www.advancedrtu.org/case-studies--guidance.html<br>RTU Right-Sizing Guidance Document: https://buildingdata.energy.gov/cbrd/resource/1648 |
| **6. Project Planning** | Develop a plan for completing and financing the RTU replacements and retrofits, which may involve working directly with a manufacturer, an ESCO, a engineering company, or an HVAC contractor. | Finance Team and Building Engineer | Advanced RTU Campaign List of Manufacturers and Service Providers: http://www.advancedrtu.org/supporters.html<br>PACENow Financing Energy Efficiency: http://pacenow.org |
| **7. Procurement** | Prepare procurement specification(s) for replacement or retrofit of RTUs. Incorporate quality installation and quality maintenance requirements in the procurement specification. | Finance Team and Building Engineer | ASHRAE/ACCA Standard 180 for Quality Maintenance & Quality Inspection: www.techstreet.com/products/1832333<br>Sample RTU Procurement Specifications: www.advancedrtu.org/find-a-product.html |
| **8. Measurement and Verification** | Determine the appropriate level of M&V for the project and develop a plan to measure energy and cost savings. | Building Engineer and Facility Manager | *RTU M&V Guidance* Document: https://buildingdata.energy.gov/cbrd/resource/1649 |

# Appendix B: RTU Business Case Example Inputs

The business case example for proactive RTU replacement at Superstore relies on the following parameter inputs with the RTU Comparison Calculator to identify estimated energy savings for the financial calculations. The “cost” of the unit is a net cost/RTU that is a sum of multiple inputs: RTU Cost, Installation Cost, Utility Incentive, and Scrap Value of Old Unit.

| Control Name | Candidate | Standard |
|---|---|---|
| **EER** | 12 | 7.3 |
| **Unit Cost (k$)** | 12.16 | 0 |
| **Annual Maintenance Cost ($/year)** | 500 | 1000 |
| **Specific Candidate Unit** | None | None |
| **Enable Economizer** | On | Off |
| **Power -- EFn (kW)** | 1,356 | 1,356 |
| **Power -- Aux (kW)** | 0 | 0 |
| **Power -- Cnd (kW)** | 8,644 | 15,083 |
| **Condenser Fan (%)** | 9 | 9 |
| **Degradation Factor** | 12 | 25 |
| **Number of Stages** | 2 | 1 |
| **E-Fan and Condenser** | N-Spd: Always ON | 1-Spd: Always ON |
| **S/T Ratio** | 0.72 | 0.72 |
| **Spreadsheet Data** | Off | Off |
| | **Applies to Both Units** | |
| **Lock Load Line** | Off | |
| **Building Type** | Retail-Standalone | |
| **Building Model** | 13.95, 232.60, 0.63 | |
| **State, City** | MO, Columbia | |
| **Schedule** | All week; 6 a.m. to 10 p.m. | |
| **Setpoint Temperature, Setback** | 71, 5 | |
| **Auto Humidity, RH Setpoint** | On, NA | |
| **Total Capacity (kBtuh), Oversizing (%)** | 120, 0 | |
| **Ventilation Rate, Units** | 32,7, % of Fan Cap. | |
| **N for Fan Energy Calcs** | 2.5 | |
| **Electric Utility Rate ($/kWhrs)** | 0.103 | |
| **Demand: Months, Cost ($/kW)** | 0,0 | |
| **Equipment Life** | 15 | |
| **Number of Units** | 5 | |
| **Discounted Costs, Rate** | On, 0.12 | |

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