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Life-Cycle Cost Analysis Framework for Water Efficiency Measures

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List of Acronyms

BLCC	Building Life Cycle Cost
FEMP	Federal Energy Management Program
hr	hour(s)
kgal	kilogallon(s)
kWh	kilowatt-hour(s)
LCC	life-cycle cost
LCCA	life-cycle cost analysis
NIST	National Institute of Standards and Technology
NPV	net present value
O&M	operations and maintenance
PV	present value
SIR	savings-to-investment ratio

Executive Summary

Life-Cycle Cost Analysis Framework for Water Efficiency Measures (hereafter referred to as “this report”) provides a technical framework for federal agencies to conduct a life-cycle cost analysis (LCCA) for water efficiency projects in accordance with 42 U.S.C. § 8253. This report leverages insights from the 2023 report, PNNL-34006, Water and Wastewater Annual Price Escalation Rates for Selected Cities Across the United States: 2023 Edition (Unger et al. 2023).

The primary objective of this report is to provide a framework to assist federal agencies with evaluating the full economic impact of water efficiency projects by assessing both initial investments and long-term operational benefits. This report is intended for federal agency personnel responsible for evaluating and implementing water efficiency projects. An LCCA can provide a comprehensive view of all costs associated with a water efficiency project, including initial investment, ongoing operations and maintenance (O&M), and eventual disposal or replacement, ensuring the most cost-effective solution is selected.

The LCCA methodology outlined in this report enables users to compare base case scenarios with potential alternatives using a standardized present value approach. It incorporates key cost components such as energy, water and wastewater, installation, O&M, and equipment replacement. Additionally, the framework introduces relevant evaluation metrics, such as the net savings and the savings-to-investment ratio, to ensure that water efficiency measures are economically justified over the lifespan of the project.

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1 Introduction

Life-Cycle Cost Analysis Framework for Water Efficiency Measures (hereafter referred to as “this report”) is intended to provide a technical overview of a life-cycle cost analysis (LCCA) for water conservation and water efficiency projects completed by federal agencies. As codified in 42 U.S.C. § 8253, federal agencies are required to implement water efficiency measures and conduct an LCCA for said water efficiency project(s). The LCCA guideline will help agencies assess the costs and benefits of implementing water efficiency projects through a description of metrics, equations, and examples.

In this report, water efficiency refers to the reduction of water consumption through monitoring, improving operations and maintenance (O&M), and installing efficient equipment, thereby reducing cost and protecting source water. Water efficiency is an enabler for resilience and can lead to significant cost savings, not only commodity savings, but also in O&M. By implementing water efficiency measures, especially for critical functions, federal agencies can conserve water and use it more effectively, ultimately helping to ensure a reliable supply for future uses. An LCCA can assist federal agencies in determining which water efficiency measures may be best for them and provides a comprehensive evaluation that goes beyond initial costs.

In the context of this framework, an LCCA is defined as a mathematical method that can be used to assess and compare the total costs and benefits of water efficiency projects and project alternatives over the course of their useful life. Throughout the guideline, federal agencies/workers responsible for conducting an LCCA for water efficiency projects are referred to as “LCCA users.”

The information provided in this report is aligned with the Federal Energy Management Program (FEMP) life-cycle cost (LCC) methodology, as conveyed in National Institute of Standards and Technology (NIST) Handbook 135 (Kneifel and Webb 2022). This report is intended to provide relatively high-level guidelines, acting as a complement to, rather than substitute for, that resource.

1.1 LCC Equation

The typical components of an LCC for water efficiency measures are shown in Eq. 1-1:

$$\begin{aligned} \text{LCC} = & \text{Installed Cost} + \text{PV of Energy Costs} & (1-1) \\ & + \text{PV of Water Costs} \\ & + \text{PV of Wastewater Costs} + \text{PV of O\&M Costs} \\ & + \text{PV of Replacement Costs} \\ & - \text{PV of Residual Value} \end{aligned}$$

The components of the LCC equation are converted into their present values (PVs) to enable an accurate comparison of costs, both for a given measure and across measures. As seen in Eq. 1-1, an LCC calculation may require installed costs, as well

as costs for energy, water, wastewater, annual maintenance, and eventual equipment replacement. As relevant, it may also include any residual value (or disposal cost) of equipment at the end of the analysis period.

Equation 1-1 can be used to calculate LCCs for multiple competing water measures and the base case, or current situation (i.e., default equipment for new construction or equipment already in place in existing facilities), providing a basis for comparison.¹

Figure 1 provides a visual foundation for the LCC equation and its supporting inputs to be discussed in Section 2.

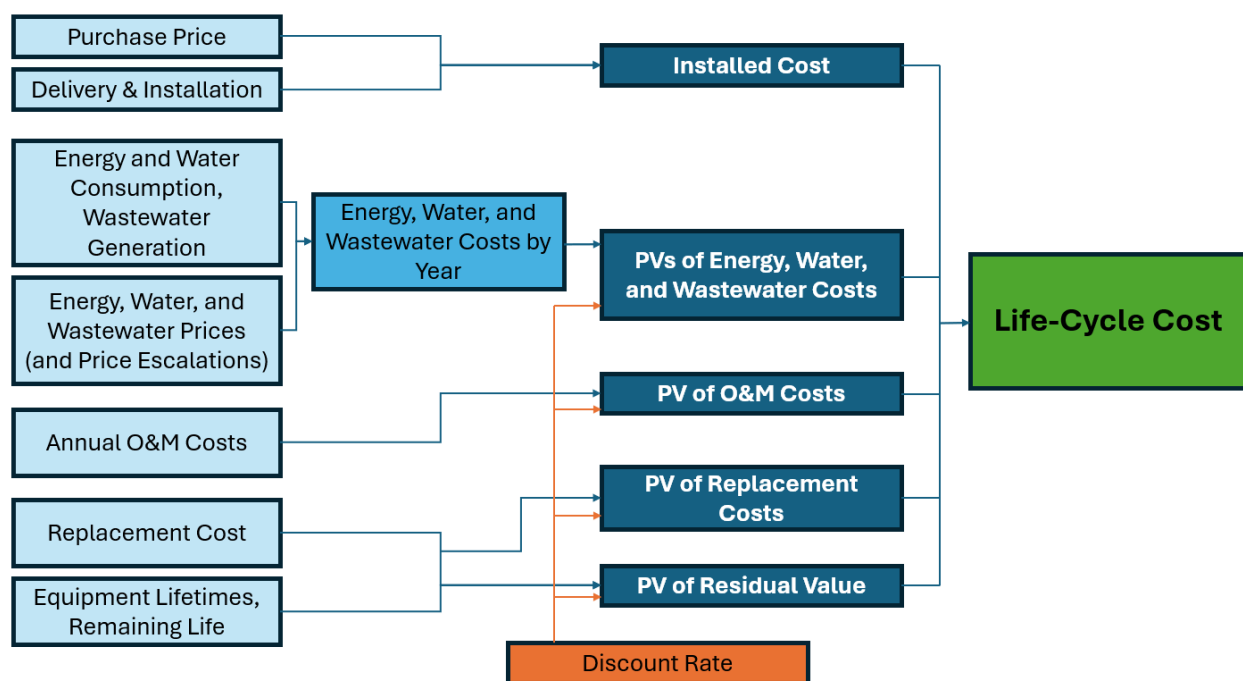


Figure 1. Relationships between LCC components and inputs

¹ The LCCA methodology is equally useful for comparing options for new and existing facilities. For new facilities, the base case may be the default or typical choice. In existing facilities, the base case refers to existing equipment under consideration for replacement with alternatives offering greater efficiency and/or other characteristics. This report often uses “retrofit case” as a generic term to refer to alternatives competing against the base case.

2 LCCA Components and Evaluation Metrics for Water Efficiency Measures

Section 2 describes the typical aspects, components, and evaluation metrics of LCCA that users will consider when conducting an analysis of water efficiency measures. Additionally, several necessary supporting elements or aspects of LCCA are discussed. Where applicable, specific equations are provided and explained.

2.1 Foundational Aspects

This section outlines the foundational aspects of LCCA required for understanding and defining the context before delving into the components and metrics of LCCA. Establishing a solid grasp of these aspects ensures a comprehensive approach to evaluating the full economic impact of projects, facilitating informed decision-making in water efficiency initiatives.

2.1.1 Equipment Lifetimes and Remaining Life

Perhaps, not surprisingly, the expected equipment lifetimes and expected remaining life of any existing equipment are important inputs to an LCCA. Lifetimes determine the timing of any replacement costs, influence residual values, and can play a role in determining appropriate analysis periods.

Although it's generally not overly challenging to find estimates of lifetimes for new equipment, or at least classes of equipment, it can be more difficult to estimate the remaining life of existing equipment. Records of past installations may not be readily available, and in some cases, equipment may have been continually patched and kept running long beyond their expected lifetimes. These situations require some rough estimation and assumptions, in consultation with site staff. Estimating the remaining life to be half of the expected lifetime can be reasonable, absent no additional information. But in some cases, equipment may obviously be near the end of its life, making it more appropriate to use a reduced value.

2.1.2 Analysis Period

The analysis period is the amount of time, generally measured in years, over which the costs of a given efficiency measure and its alternatives (including the base case) are evaluated. As long as residual values are considered, the choice of analysis period length is not usually critical. However, it is crucial that the same analysis period is used to analyze a given set of mutually exclusive or competing alternatives. Thus, if several showerheads were being compared to an existing showerhead, all those items should be evaluated under the same analysis period. However, this does not imply that all other measures (e.g., faucets, irrigation) for a site must use that same analysis period.

Given the described flexibility regarding analysis period choice, an LCCA can sometimes be simplified by careful analysis period selections. Examples of analysis period selections that can be both reasonable and simplifying include the following:

- remaining life (time until failure) of existing (base case) equipment
- life of measure (retrofit) equipment.

The former option avoids the need to account for the replacement of equipment in the base case, simplifying data collection. The latter avoids the need to account for the replacement costs of the retrofit equipment. This second option may be less useful if there are multiple alternative measures with different lives. It is also entirely reasonable to use a common analysis period (e.g., 15 years) for every measure evaluated at a site.

2.1.3 Real vs. Nominal Analysis

LCCA can be undertaken in either real or nominal terms. Real analysis refers to analyzing price or cost data that are net of inflation. Thus, if a piece of equipment is expected to only increase in cost by the rate of general inflation from year to year, the cost used in the analysis may be held constant when undertaking a real analysis.

In contrast, a nominal analysis entails analyzing cost and price data that includes inflation. Nominal analysis can be somewhat complex when developing data, as it requires incorporating changes in both real prices and general inflation into the price and cost data. Whichever path is chosen, it's important to be consistent (i.e., never use both real and nominal data).

2.1.4 Discount Rates

Discount rates are values that allow LCCA users to calculate the PV of an asset's future costs. An LCCA looks at an asset over the course of the analysis period. Discount rates allow LCCA users to convert the costs and cash flows incurred throughout the analysis period to their PV.

Discount rates may be either real (i.e., net of inflation) or nominal. If performing real analysis, a real discount rate should be used, and a nominal discount rate is needed for nominal analysis.

LCCA, for federal water efficiency projects, should use the annually revised FEMP-provided discount rates.¹

2.1.5 Initial Prices for Water, Wastewater, and Energy

To perform an LCCA of equipment that consumes water or energy, or generates wastewater, it is vital to know the prices associated with that consumption or generation. It is the *marginal* price, or the price of the incremental units avoided, consumed, or generated that is relevant in an LCCA. In contrast, an average price may include fixed costs or service fees that are unaffected by any changes in use and may provide an inaccurate measure of the impact of efficiency measures.

¹ Available in (Kneifel 2024) and (Kneifel and Lavappa 2024).

In some cases, there may be multiple relevant prices for a given resource. For example, some utilities may use seasonal pricing for water. In that case, it would be important to analyze changes in water consumption by season to capture that variation in pricing and costs.

2.1.6 Price Escalations

While energy, water, and wastewater prices at the beginning of an analysis period are important, they are insufficient to properly perform an LCCA. These prices are likely to change over the analysis period, and accounting for such changes enables a more accurate assessment of the costs of water efficiency measures and their alternatives. These price changes over time are referred to as “price escalations” or “price escalation rates.” If performing a real analysis, then price escalations should be net of general inflation, while price escalations should include general inflation when performing a nominal analysis.

2.1.6.1 Energy Price Escalations

In addition to discount rates, real energy price escalation indices (for a variety of energy types) are provided in the annually revised report (Kneifel and Lavappa 2024) and spreadsheet (Kneifel 2024).

The data provided may be used in a couple of ways. First, the year-by-year indices can be used to create vectors of real prices for each energy type relevant to a site’s analysis. Alternatively, the documents also provide “modified uniform present value factors,” which are discount factors incorporating both real energy price escalations and real discount rates. These factors may be multiplied by initial annual energy expenditures to obtain a PV of energy costs over a desired timeframe.

2.1.6.2 Water and Wastewater Price Escalations

Water and wastewater price escalations are equally important to consider, but they can be more challenging to obtain than those for energy. The report *Water and Wastewater Annual Price Escalation Rates for Selected Cities Across the United States: 2023 Edition* (Unger et al. 2023) describes several options for deriving water and wastewater prices escalations.¹

“Modified uniform present value factors,” as mentioned in Section 2.1.6.1, can be derived for water and wastewater prices using the approach provided (labeled “UPV* Calculation Method”) in (Kneifel and Lavappa 2024).

As noted in Section 2.1.3, it’s important to be consistent with real and nominal data. If performing a real analysis, water and wastewater price escalations should be converted into real terms as well.

¹ See Section 5.0 of (Unger et al. 2023) for LCC-related water and wastewater price escalation guidance.

2.2 Installed Costs

LCCA users should understand that installed cost includes the equipment cost and everything necessary to obtain it and initially make it operational. These additional items include delivery of and installation labor for the item(s). Essentially, the installed costs capture the entire initial cost of the water efficiency project.

Note that installed costs are often not relevant when calculating an LCC for the base case, unless the analysis is examining options for a new building. If retrofitting an existing facility, then installed costs are generally only relevant for the LCCs of the proposed retrofit measures. In that case, the installed costs for the base case are “sunk” costs, as they occurred prior to the beginning of the analysis period and are not reversible.

Example: An agency purchased eight \$200 high efficiency toilets. Sales tax is 8.5%, and the toilets were ordered locally, with free delivery. The toilets were installed by a plumber who charges \$130/hr, and it took them two eight-hour workdays to install all the toilets. The installed cost is \$3,816:

1. 8 toilets × \$200 = \$1,600
2. Adding sales tax: $1,600 \times (1 + 0.085) = \$1,736$
3. Adding installation labor: $(16 \times \$130) + \$1,736 = \$3,816$

2.3 Energy Costs

If a water efficient retrofit results in a change in annual energy consumption, then LCCA users should estimate the potential savings (or increases) in those energy costs. For example, more efficient faucets may result in reduced water heating energy requirements. LCCA users should collect the annual energy consumption (for each affected energy type) of the base case equipment and estimate the anticipated annual energy consumption of the retrofit case equipment. To obtain the initial annual energy costs, multiply the annual energy consumption values by the site’s respective energy prices (e.g., in \$/kWh or \$/therm). The following two equations demonstrate this for the case of electricity:

$$\begin{aligned} \text{Base Case Initial Annual Electricity Cost} \\ &= \text{Base Case Annual Electricity Consumption (kWh)} \\ &\times \text{Initial Electricity Price (\$/kWh)} \end{aligned} \quad (2-2)$$

$$\begin{aligned} \text{Retrofit Case Initial Annual Electricity Cost} \\ &= \text{Retrofit Case Annual Electricity Consumption (kWh)} \\ &\times \text{Initial Electricity Price (\$/kWh)} \end{aligned} \quad (2-3)$$

Applying the appropriate energy price escalations, as described in Section 2.1.6, to such initial annual energy expenditure values enables the derivation of the estimated

base case and retrofit annual energy expenditures over the analysis period. The cost streams can be converted into PVs as follows:

$$PV_{\text{energy costs}} = \sum_{t=1}^N \frac{E_t}{(1+d)^t} \quad (2-4)$$

where E_t = energy expenditure for year t
 d = discount rate
 N = number of years in the analysis period.

Equivalently, a modified uniform PV factor, also described in Section 2.1.6, can be multiplied by the initial base case and retrofit annual energy expenditures (again, by energy type) to derive the PVs of those expenditures.

The difference between the base case and retrofit case PVs represents the impact of the water efficiency measure on the site's energy costs.

2.4 Water and Wastewater Costs

As stated previously, water efficiency refers to the reduction of water consumption through monitoring, improved O&M, and implementing water efficient equipment. In conducting an LCCA, LCCA users should understand their site's water consumption, which is the portion of water use that is not returned to the original source after being withdrawn. Water consumption is typically measured in units of 1,000 gallons (kgal). Users will also need the water and wastewater prices (\$/kgal). Annual water and wastewater costs are calculated by multiplying the volume of water consumed and wastewater generated by their respective prices. The following equations demonstrate this for water, but it is a parallel process for wastewater:

$$\begin{aligned} \text{Base Case Initial Annual Water Cost} & \\ &= \text{Base Case Annual Water Consumption (kgal)} \\ &\times \text{Initial Water Price (\$/kgal)} \end{aligned} \quad (2-5)$$

$$\begin{aligned} \text{Retrofit Case Initial Annual Water Cost} & \\ &= \text{Retrofit Case Annual Water Consumption (kgal)} \\ &\times \text{Initial Water Price (\$/kgal)} \end{aligned} \quad (2-6)$$

Once the annual costs are calculated for the base and retrofit cases, LCCA users will apply water and wastewater price escalations (discussed in Section 2.1.6.2) to derive cost streams for each case for the analysis period. These can be converted into PVs using the following calculation:

$$PV_{\text{water costs}} = \sum_{t=1}^N \frac{W_t}{(1+d)^t} \quad (2-7)$$

where W_t = the water expenditure, or cost, in year t
 d = discount rate
 N = number of years in the analysis period.

Although this specific equation focuses on water costs, an identical calculation can be performed for wastewater costs.

As with the case for energy costs, multiplying an appropriate modified uniform PV factor by the initial base case and retrofit water or wastewater expenditures provides another option to derive the PVs of those expenditures.

2.5 Operations and Maintenance Costs

When conducting an LCCA, it is important to include all affected costs associated with a water efficiency measure and its alternatives. As a result, LCCA users should estimate the annual maintenance, or O&M costs, for both the base and retrofit cases. New equipment sometimes provides reduced O&M expenses, but additional complexity may entail increased O&M costs. It's important to capture these potential changes to provide more accuracy in understanding all measure costs. For each case, these costs can be converted into PVs using the following equation:

$$PV_{O\&M} = \sum_{t=1}^N \frac{M_t}{(1+d)^t} \quad (2-8)$$

where M_t = O&M expenditure in year t
 d = discount rate
 N = number of years in the analysis period.

Frequently, at least when performing real (as opposed to nominal) LCCA, O&M expenditures are assumed to be constant over an analysis period. In that case, M_t would not vary with t .

2.6 Replacement Costs

LCCA users should consider what replacement costs may accrue during the analysis period in both the base and retrofit cases. These costs cover the replacement of equipment that is expected to fail during the analysis period. As with installed costs, replacement costs should include everything necessary to make the equipment operational, including delivery and installation labor costs.

There is more than one defensible way to mathematically model these replacement costs, with some approaches more complex than others. However, the arguably most intuitive method is to employ explicit streams of replacement costs for a given measure and case (i.e., base or retrofit case), with a given year's cost either being zero or the replacement cost, depending on whether the item is due for replacement.

For example, assume an analysis period of 20 years and that the retrofit case involves installing a piece of equipment with an 8-year life expectancy. That initial installation is

covered by the “installed cost” component of the LCC equation. However, at the end of year 8 and again at the end of year 16, replacements are expected to be required. These replacement costs need to be discounted back to the PV. Equation 2-8 conveys this example:

$$PV_{\text{repl. costs}} = \frac{R}{(1+d)^8} + \frac{R}{(1+d)^{16}} \quad (2-9)$$

where R = replacement cost
 d = discount rate.

Now let's consider the base case. The base case equipment already in place also has an 8-year life expectancy. The actual age is unknown in this case, leading to an assumption that the equipment is halfway through its life span, leaving 4 years of remaining life. Given the chosen analysis period of 20 years, the equipment is expected to need replacement multiple times: at the end of year 4 and at the end of year 12. That second replacement is expected to last through the end of the 20-year analysis period.

Equation 2-8 can be generalized to

$$PV_{\text{repl. costs}} = \sum_{t=1}^N \frac{R_t}{(1+d)^t} \quad (2-10)$$

where $R_t = 0$ in all years other than replacement years. For the retrofit case (or a base case involving new construction) this is equivalent to¹

$$R_t = \begin{cases} \text{repl. equipment cost,} & t \bmod(\text{life expectancy}) = 0 \\ 0, & \text{otherwise} \end{cases} \quad (2-11)$$

For a base case with existing equipment in place, the conditions are

$$R_t = \begin{cases} \text{repl. equipment cost,} & t \bmod(\text{life expectancy}) = \text{initial time to failure} \\ 0, & \text{otherwise} \end{cases} \quad (2-12)$$

While the above example illustrates the incorporation of replacement costs in both the base and retrofit cases, sometimes the analysis may be simplified. Recall the analysis period discussion in Section 2.1.2, which mentioned that it may be advantageous analytically to set the analysis period to the remaining life of the existing equipment, which in this example's case is 4 years. Let's look at the impact of this.

¹ The remainder resulting when dividing t by (life expectancy) is represented by “ $t \bmod(\text{life expectancy})$.” For example, if $t = 4$ and life expectancy = 8, then $t \bmod(\text{life expectancy}) = 4$, given that $4 \div 8 = 0 \text{ R}4$.

For the base case, with the analysis period now set to the remaining life of the existing equipment, there is no need to include a replacement. That conveniently removes the need to estimate a replacement cost for that existing equipment.

For the retrofit case, with the analysis period now at 4 years, there is also no need for a replacement during the analysis period.

2.7 Residual Values

The incorporation of residual values into the analysis is necessary to enable the analysis period flexibility discussed in the previous section. Residual values are the estimated remaining value of an asset at the end of the analysis period. Frequently, equipment remains in place at the end of the analysis period, and the residual value captures the value that it provides by remaining in place, continuing to serve site needs.

There is more than one way to reasonably model such a residual value, but linear proration of the replacement cost over the remaining life is a very understandable and defensible approach. Thus, if a piece of equipment with an 8-year life expectancy had been in place for 4 years at the end of the analysis period, the undiscounted residual value would be 1/2 of the replacement cost. This residual value would need to be discounted back to the beginning of the analysis period, with the following general formula:

$$PV_{\text{residual value}} = \frac{\left(\frac{\text{remaining life}}{\text{life expectancy}} \times \text{replacement cost} \right)}{(1 + d)^{\text{analysis period}}} \quad (2-13)$$

where d is the discount rate.

While Eq. 2-12 provides an estimate of the residual value for equipment remaining in operation at the end of the analysis period, there are cases where this equation is not appropriate. If, for example, the equipment will be removed at the end of the analysis period, estimating the salvage value would be more appropriate. Such a value may be comparatively low (e.g., the value of scrap metal) and may even be negative if there are disposal costs. It is important to consider site plans when estimating the residual value at the end of an analysis period. If the equipment will not remain in operation at the end of the analysis period, then the following equation may be used to estimate residual value component of the LCC:

$$PV_{\text{residual value}} = \frac{\text{salvage value}}{(1 + d)^{\text{analysis period}}} \quad (2-14)$$

2.8 Evaluation Metrics

Once an LCC is calculated for a water efficiency measure, that alone is not sufficient to enable an informed decision as to whether to proceed. Evaluation metrics enable a

proper comparison of competing measures and their base cases, as well as prioritization of the “winning” measures for potential project funding.

2.8.1 Net Savings

Net savings (sometimes referred to as net present value, or NPV) is the difference in the LCCs of a base case and an alternative:

$$\text{Net Savings} = \text{LCC}_{\text{base}} - \text{LCC}_{\text{alternative}} \quad (2-15)$$

For a measure to be cost-effective, the net savings must be greater than zero. But if there are multiple mutually exclusive measures competing against the same base case (e.g., two different faucets being evaluated as potential replacements for an existing faucet), it is the option (if any) with the minimum LCC (or equivalently, the option that maximizes the net savings) that is the optimal choice. If all measures provide negative net savings, then leaving the base case equipment in place is optimal.

2.8.2 Savings-to-Investment Ratio

Many sites may not have sufficient funding available to implement all of the “winning” measures (as determined via minimizing the LCC, as described in the previous section), at least all at once. As a result, it is important to be able to prioritize these measures to obtain the most value for expenditures of limited budgets. For this purpose, the savings-to-investment ratio (SIR) is the optimal metric. This ratio is defined as follows:

$$\text{SIR} = \frac{\text{PV of operational savings}}{\text{PV of incremental investment costs}} \quad (2-16)$$

An SIR with a value of exactly one corresponds to a net savings of zero. A measure that provides savings greater than the incremental costs yields an SIR greater than one. It is critical to note that the SIR should never be used in place of the net savings to select amongst mutually exclusive alternatives. It is entirely possible for a measure that provides greater net savings to have a lower SIR than a competing measure. Thus, the SIR is not appropriate for picking “winners,” but rather for prioritizing budget allocations amongst those winning measures.

2.8.3 A Note on Simple Payback

It’s important to discuss the arguably most common and intuitive evaluation metric: simple payback. In its most basic form, simple payback is simply the upfront cost of a measure divided by its annual savings. While this is easy to calculate and understand, it involves several drawbacks:

- lack of discounting (not taking account of the time value of money and the timing of costs)
- (possible) failure to include price escalations (e.g., energy, water)
- no accounting for differences in equipment lives

- no accounting for anything beyond the payback period.

It's important to note that payback can be calculated somewhat more robustly by considering energy and water price escalations during the payback period. Additionally, discounted (as opposed to simple) payback takes the time value of money into account. However, in the authors' experience, these added complexities are not commonly employed. Even these more robust forms of payback still are sufficiently flawed and do not align with the minimization of the LCC, and thus may lead to suboptimal choices.

In short, it is important to avoid relying on simple payback as anything other than a very rough screening metric to determine which measures may warrant further investigation via the more robust analysis provided by LCCA.

2.9 Water Efficiency Measures for Consideration

There are many different types of water efficiency strategies to implement for a particular site, which may require unique consideration within an LCCA. The following section provides some examples of common water efficiency measures for which a site may consider conducting an LCCA.

2.9.1 Water Efficiency Equipment Retrofits

The most common type of water efficient retrofit involves plumbing, specifically through high efficiency toilets, faucet aerators, and showerheads. An example of the installed costs of high efficiency toilets is provided in Section 2.2.

Another example of an equipment retrofit is related to cooling systems and cooling towers. If a site implements a large-scale refrigeration system and uses water for that release of heat, it is possible to improve efficiency based on the type of cooling system. If the site uses once-through cooling, where water is used once and then discharged, the site may switch to a recirculating or closed-loop system, where water can be reused. In the context of an LCCA, this initial installed cost may be high, but the savings associated with using less water may make this LCC effective.

2.9.2 Alternative Water and Water Reuse

Alternative water includes any sources not from freshwater (e.g., harvested rainwater). Using alternative water helps reduce water demand and can be more cost-effective than using potable water. Alternative water can be used in many efficiency upgrades; for example, in toilet and urinal flushing and in some industrial processes like cooling and vehicle wash.

Leveraging alternative water or water reuse can be a cost-effective way to utilize nonpotable water where potable water is currently being used. The cost of this alternative water (as a commodity) may be less than potable water, with lower treatment requirements and reduced demand on the municipal supplier. The cost-effectiveness of this upgrade may depend on the existing infrastructure on-site, and if there is already the ability to convey nonpotable water or if infrastructure upgrades are required. These

are all potential considerations when including an alternative water project within an LCCA.

2.9.3 Irrigation Efficiency Upgrades

Many sites have already upgraded their irrigation systems to improve efficiency and use less potable water. There are several types of irrigation equipment that apply water to the landscape. A site may decide to replace traditional pop-up spray or rotor head systems with a more efficient multistream rotational head or drip irrigation, which reduces evaporation and has lower flow rates overall. Another consideration is the installation of automated controls to ensure that irrigation systems are only watering the landscape when needed. Pairing automated controls with adaptive planting, which uses plants that grow well in their native region with minimal supplemental irrigation needs, improves overall water efficiency. In addition to reductions in overall water costs due to increased efficiency, upgraded sprinkler systems tend to require less O&M, which would be factored into the LCCA. Some sites may also consider using alternative water for irrigation, if not already implemented.

3 Conclusion and Next Steps

The LCCA approach can help federal agencies select cost-effective strategies and technologies to reduce water consumption at their sites while considering the full array of costs associated with potential measures over an analysis period. This approach enables agencies to make optimal choices and prioritize budget allocations while using water more efficiently and effectively.

Not all LCCA users will be comfortable with undertaking an analysis on their own. Fortunately, that is not necessary, as NIST has developed LCCA software: the Building Life Cycle Cost (BLCC) program (NIST 2024). This tool enables LCCA with a relatively shallow learning curve and follows the LCCA methodology outlined in NIST Handbook 135 (Kneifel and Webb 2022) and this report. One limitation is that it is currently available only for Windows PCs, but a web-based version of BLCC is under development and may be available in 2025.

Some LCCA users may prefer to undertake an LCCA on their own via custom spreadsheets. This provides flexibility to handle virtually any unique site or technology-specific analytical issue. It also can provide transparency, as spreadsheets are readily shared and reviewed. But the spreadsheet approach does require substantially greater knowledge of the LCCA methodology and the ability to develop sometimes complex formulas. It also could be more labor-intensive depending on the particular analysis and the user's experience.

There are a myriad of water efficiency measures like equipment retrofits, alternative water and water reuse upgrades, and irrigation system enhancements that prove cost-effective for a federal agency to implement. In conducting an LCCA to make that determination, a user may leverage this report as a first step in understanding the full array of costs associated with water efficiency project improvements or implementation. With an LCCA in hand, a federal site can make the case for future projects and project enhancements that ensure water resilience and reliability long term.

References

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