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Standard Practice for Measuring Net Benefits and Net Savings for Investments in Buildings and Building Systems[1]

This standard is issued under the fixed designation E1074; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε1 NOTE—Adjunct title and stock number in 2.2 were updated editorially in April 2020.

INTRODUCTION

The net benefits (NB) and net savings (NS) methods are part of a family of economic evaluation methods that provide measures of economic performance of an investment over some period of time. Included in this family of evaluation methods are life-cycle cost analysis, benefit-to-cost and savings-to-investment ratios, internal rates of return, and payback analysis.

The NB method calculates the difference between discounted benefits and discounted costs as a measure of the cost effectiveness of a project. The NS method calculates the difference between life-cycle costs as a measure of the cost-effectiveness of a project. The NB and NS methods are sometimes called the net present value method. The NB and NS methods are used to decide if a project is cost effective (net benefits greater than zero, or net savings greater than zero), or which size, or design, competing for a given purpose is most cost effective (the one with the greatest net benefits, or the one with the greatest net savings).

1. Scope

1.1 This practice covers a recommended procedure for calculating and interpreting the net benefits (NB) and net savings (NS) methods in the evaluation of building designs and systems.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E631 Terminology of Building Constructions

E833 Terminology of Building Economics

E917 Practice for Measuring Life-Cycle Costs of Buildings and Building Systems

E964 Practice for Measuring Benefit-to-Cost and Savings-to-Investment Ratios for Buildings and Building Systems

E1057 Practice for Measuring Internal Rate of Return and Adjusted Internal Rate of Return for Investments in Buildings and Building Systems

E1121 Practice for Measuring Payback for Investments in Buildings and Building Systems

E1185 Guide for Selecting Economic Methods for Evaluating Investments in Buildings and Building Systems

E1369 Guide for Selecting Techniques for Treating Uncertainty and Risk in the Economic Evaluation of Buildings and Building Systems

E1765 Practice for Applying Analytical Hierarchy Process (AHP) to Multiattribute Decision Analysis of Investments Related to Projects, Products, and Processes

E1946 Practice for Measuring Cost Risk of Buildings and

[1] This practice is under the jurisdiction of ASTM Committee E06 on Performance of Buildings and is the direct responsibility of Subcommittee E06.81 on Building Economics.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

Building Systems and Other Constructed Projects
E2204 Guide for Summarizing the Economic Impacts of Building-Related Projects

2.2 *ASTM Adjunct:*[3]

Discount Factor Tables - Adjunct to E917 Practice for Measuring Life-Cycle Costs of Buildings and Building Systems - Includes Excel and PDF Files

3. Terminology

3.1 *Definitions*—For definitions of general terms related to building construction used in this practice, refer to Terminology E631; and for general terms related to building economics, refer to Terminology E833.

4. Summary of Practice

4.1 This practice is organized as follows:

4.1.1 *Section 2, Referenced Documents*—Lists ASTM standards referenced in this practice.

4.1.2 *Section 3, Definitions*—Addresses definitions of terms used in this practice.

4.1.3 *Section 4, Summary of Practice*—Outlines the contents of the practice.

4.1.4 *Section 5, Significance and Use*—Explains the application of the practice and how and when it should be used.

4.1.5 *Section 6, Procedures*—Summarizes the steps in making NB (NS) analysis.

4.1.6 *Section 7, Compute NB (NS)*—Describes calculation procedures for NB (NS).

4.1.7 *Section 8, Anaylsis of NB (NS) Results and the Decision*—Discusses the decision criterion and the treatment of uncertainty, risk, and unqualified effects.

4.1.8 *Section 9, Applications*—Explains circumstances under which the NB (NS) method is appropriate.

4.1.9 *Section 10, Report*—Identifies information that should be included in a report of a NB (NS) analysis.

5. Significance and Use

5.1 The NB (NS) method provides a measure of the economic performance of an investment, taking into account all relevant monetary values associated with that investment over the investor's study period. The NB (NS) measure can be expressed in either present value or equivalent annual value terms, taking into account the time value of money.

5.2 The NB (NS) method is used to decide if a given project is cost effective and which size or design for a given purpose is most cost effective when no budget constraint exists.

5.3 The NB (NS) method can also be used to determine the most cost effective combination of projects for a limited budget; that is, the combination of projects having the greatest aggregate NB (NS) and fitting within the budget constraint.

5.4 Use the NB method when the focus is on the benefits rather than project costs.

5.5 Use the NS method when the focus in on project savings (that is, reductions in project costs).

6. Procedures

6.1 The recommended steps for applying the NB (NS) method to an investment decision are summarized as follows:

6.1.1 Make sure that the NB (NS) method is the appropriate economic measure (see Guide E1185);

6.1.2 Identify objectives, alternatives, and constraints;

6.1.3 Establish assumptions;

6.1.4 Compile data;

6.1.5 Convert cash flows to a common time basis (discounting);

6.1.6 Compute NB (NS)[4] and compare alternatives; and

6.1.7 Make final decision, based on NB (NS) results as well as consideration of risk and uncertainty, unquantifiable effects, and funding constraints (if any).

6.2 Since the steps mentioned in 6.1.2 – 6.1.5 are treated in detail in Practice E917 and briefly in Practices E964 and E1121, they are not discussed in this practice. In calculating NB (NS), these four steps should be followed exactly as described in Practice E917. The remainder of this practice focuses on the computation, analysis, and application of the NB (NS) measure. A comprehensive example of the NB method applied to a building economics problem is provided in Appendix X1. A comprehensive example of the NS method applied to a building economics problem is provided in Appendix X2.

7. NB (NS) Computation

7.1 Computation of NB for any given project requires the estimation, in dollar terms, of differences between benefits, and differences between costs, for that project relative to a mutually exclusive alternative. Computation of NS for any given project requires the estimation, in dollar terms, of the difference between life-cycle costs for the project relative to a mutually exclusive alternative. The mutually exclusive alternative may be a similar design/system of a different scale, a dissimilar design/system for the same purpose, or the do nothing case. Denote the alternative under consideration as A_j and the mutually exclusive alternative to be used for purposes of comparison as A_k. Alternative A_k is typically the do nothing case or the project with the lowest first cost, which may or may not be the same project. But the analyst can choose any of the mutually exclusive alternatives as the base case against which to compare alternatives. Benefits can include (but are not limited to) revenue, productivity, functionality, durability, resale value, and tax advantages. Costs can include (but are not limited to) initial investment, operation and maintenance (including energy consumption), repair and replacements, and tax liabilities.

7.2 Eq 1 is used to compute the present value of net benefits ($PVNB_{j:k}$) for the proposed project relative to its mutually exclusive alternative.

$$PVNB_{j:k} = \sum_{t=0}^{N} \left(B_t - \bar{C}_t\right)/(1+i)^t \quad (1)$$

[3] Available from ASTM International Headquarters. Order Adjunct No. ADJE091717-EA. Original adjunct produced in 1984. Adjunct last revised in 2003.

[4] The NIST Building Life-Cycle Cost (BLCC) Computer Program helps users calculate measures of worth for buildings and building components that are consistent with ASTM standards. The program is downloadable from http://www.eere.energy.gov/femp/information/download_blcc.html.

where:

B_t = dollar value of benefits in period t for the building or system being evaluated, A_j, less the counterpart benefits in period t for the mutually exclusive alternative against which it is being compared, A_k,

$\bar{C}_t$ = dollar costs, including investment costs, in period t for the building or system being evaluated, A_j, less the counterpart costs in period t for the mutually exclusive alternative against which it is being compared, A_k,

N = number of discounting time periods in the study period, and

i = the discount rate per time period.

7.3 Use Eq 2 to convert the present value of net benefits to annual value terms, where N is the number of years in the study period and i is the discount rate.

$$AVNB_{j:k} = PVNB_{j:k} \cdot [(i(1+i)^N)/((1+i)^N - 1)] \quad (2)$$

where $AVNB_{j:k}$ = annual value of net benefits.

7.4 Use Eq 3 to compute the present value of net savings ($PVNS_{j:k}$) for the proposed project, A_j, relative to its mutually exclusive alternative, A_k. The terms appearing in Eq 3 are based on the life-cycle cost (LCC) method, Practice E917. Subtract from project costs in the year in which they occur any pure benefits (for example, increased rental income due to improvements) in the LCC calculation.

$$PVNS_{j:k} = LCC_k - LCC_j \quad (3)$$

where:

LCC_j = the life-cycle costs of the alternative under consideration, A_j, and

LCC_k = the life-cycle costs of the mutually exclusive alternative, A_k.

7.5 Use Eq 4 to convert the present value of net savings to annual value terms, where N is the number of years in the study period and i is the discount rate.

$$AVNS_{j:k} = PVNS_{j:k} \cdot [(i(1+i)^N)/((1+i)^N - 1)] \quad (4)$$

where:

$AVNS_{j:k}$ = annual value of net savings.

7.6 For a given problem and data set, solutions in either present value or annual value terms will be time equivalent values (although different in actual dollar values) and will result in the same investment or design decisions, provided annual values are calculated using Eq 2 for net benefits and Eq 4 for net savings.

7.7 A simple application of Eq 1 is presented in Table 1 for an initial investment of $10 000 that yields an uneven yearly cash flow over four years. (Implicitly, the mutually exclusive alternative is the *do nothing* case.) Assuming a discount rate of 15 %, the discounted cash flows yield a PVNB of $1823. (Note that the sum of net cash flows, $7000, is a much larger value, since it fails to account for the eroding value of money over time.) The larger the PVNB for a given project, the more economically attractive it will be, other things being equal.

7.8 To find the AVNB that is time equivalent to $1823, use Eq 2. The equivalent AVNB is $639.

8. Analysis of NB (NS) Results and the Decision

8.1 Use the results of the NB (NS) computation to rank order alternatives from highest to lowest NB (NS). The alternative with the highest NB (NS) is the most cost effective.

8.2 In the final investment decision, take into account not only the numerical values of NB (NS), but also uncertainty of investment alternatives relative to the risk attitudes of the investor, the availability of funding and other cash-flow constraints, any unquantified effects attributable to the alternatives, and the possibility of noneconomic objectives. (These topics are discussed in Section 10 of Practice E917.)

8.2.1 Decision-makers typically experience uncertainty about the correct values to use in establishing basic assumptions and in estimating future costs. Guide E1369 recommends techniques for treating uncertainty in parameter values in an economic evaluation. It also recommends techniques for evaluating the risk that a project will have a less favorable economic outcome than what is desired or expected. Practice E1946 establishes a procedure for measuring cost risk for buildings and building systems, using the Monte Carlo simulation technique as described in Guide E1369. Practice E917 provides direction on how to apply Monte Carlo simulation when performing economic evaluations of alternatives designed to mitigate the effects of natural and man-made hazards that occur infrequently but have significant consequences. Practice E917 contains a comprehensive example on the application of Monte Carlo simulation in evaluating the merits of alternative risk mitigation strategies for a prototypical data center.

8.2.2 Describe any significant effects that remain unquantified. Explain how these effects impact the recommended alternative. Refer to Practice E1765 for guidance on how to present unquantified effects along with the computed values of NB (NS) or any other measures of economic performance.

TABLE 1 Calculation of Net Benefits

Year, t	Benefits, B_t, dollars	Costs, $\bar{C}_t$, dollars	Net Cash Flow $B_t - \bar{C}_t$, dollars	SPV Factor[A] for $i = 15$ %	PVNB, dollars
0	0	10 000	−10 000	1.000	−10 000
1	4 000	3 000	+1 000	0.8696	+870
2	11 500	4 500	+7 000	0.7561	+5 293
3	10 000	4 000	+6 000	0.6575	+3 945
4	8 000	5 000	+3 000	0.5718	+1 715
Total	33 500	26 500	+7 000		+1 823

[A] To find the PVNB of the net cash flow for each discounting period, the single present value (SPV) discount factor is multiplied times the net cash flow. For an explanation of discounting factors and how to use them, see Discount Factor Tables.