How to Calculate the Effectiveness of Energy Efficiency Programs

An Online Continuing Education Course for Engineers

Course Number: R-4023

Credit: 4 Hours / 4 PDH / 4 CPD

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Introduction

The United States is the second-largest energy consumer in the world (China is the largest), consuming almost 4,000,000,000 kWh annually. Average residential consumption is about 11,000 kWh per year. U.S. energy consumption is divided into three primary categories: residential, commercial, and industrial. Residential is the largest share at 37% of annual energy consumption, followed closely by commercial (36%), and industrial at 26%. See Figure 1.

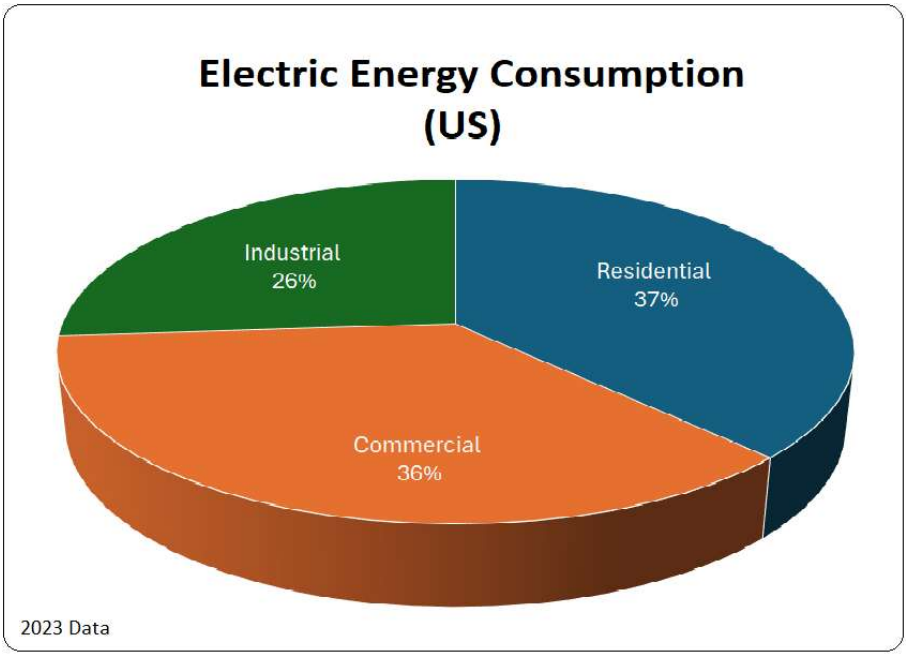

Figure 1

Improving energy efficiency in residential, commercial, and industrial sectors is one of the most cost-effective ways to address high energy prices and global climate change. Mining this efficiency can help reduce a significant portion of the expected growth in U.S. consumption of electricity and natural gas in the coming decades, yielding many billions of dollars in saved energy bills and avoiding significant emissions of greenhouse gases and other air pollutants.

Background on Cost-Effectiveness Tests

The question of how to define the cost-effectiveness of energy efficiency investments is a critical issue to address when advancing energy efficiency as a key resource in meeting future energy needs. How

cost-effectiveness is defined substantially affects how much of the United States' efficiency potential will be accessed and whether consumers will benefit from the lower energy costs and environmental impacts that would result. The decisions on how to define cost effectiveness or which tests to use are largely made by state utility commissions and utilities, along with input from consumers and other stakeholders.

Cost-effectiveness in its simplest form is a measure of whether an investment's benefits exceed its costs. Key differences among the cost-effectiveness tests include the following:

- **The stakeholder perspective of the test.** Is it from the perspective of an energy efficiency program participant, the organization offering the energy efficiency program, a non-participating ratepayer, or society in general? Each of these perspectives represents a valid viewpoint and has a role in assessing energy efficiency programs.

- **The key elements included in the costs and the benefits.** Do they reflect avoided energy use, incentives for energy efficiency, avoided need for new generation, and new transmission and distribution?

- **The baseline against which the costs and benefits are measured.** What costs and benefits would have been realized absent investment in energy efficiency?

This course examines the five standard cost-effectiveness tests that are used to assess the cost-effectiveness of energy efficiency, the perspectives each test represents, and how states are currently using the tests. It also discusses how the tests can be used to provide a more comprehensive picture of the cost-effectiveness of energy efficiency as a resource. Use of a single cost-effectiveness test as a primary cost-effectiveness test may lead to an efficiency portfolio that does not balance the benefits and costs between stakeholder perspectives. Overall, using all five cost-effectiveness tests provides a more comprehensive picture than using any one test alone. The five commonly used cost-effectiveness tests are listed below:

1. Participant cost test (PCT).
2. Program administrator cost test (PACT).
3. Ratepayer impact measure test (RIM).
4. Total resource cost test (TRC).
5. Societal cost test (SCT).

These cost-effectiveness tests are used differently in different states. Some states require all the tests, some require no specific tests, and others designate a primary test.

This course explains how to analyze the cost-effectiveness of energy efficiency programs, reviews the issues and approaches involved in considering and adopting cost-effectiveness tests for energy

efficiency, including discussing each perspective represented by the five standard cost-effectiveness tests and clarifying key terms. There are several tools to help understand the value of cost-efficiency programs. This course describes these tools and how they can be used to determine the relative value of energy-efficient programs.

Course Outline

Chapter one of this course discusses the five standard cost-effectiveness tests and their application in four utility best practice programs.

Chapter two briefly describes the interpretation of each test and presents a calculation of each cost-effectiveness test using an example residential program.

Chapter three presents the key factors and issues in the determination of an energy efficiency program's cost-effectiveness.

Chapter four gives guidelines and examples for regulators to consider when choosing which cost-effectiveness tests to emphasize and summarizes of the use of the cost-effectiveness tests in each state.

Chapter five describes the calculation of each cost-effectiveness test in detail, as well as the key considerations when reviewing and using cost-effectiveness tests and the pros and cons of each test in relation to increased efficiency investment.

Chapter 1: Cost Effectiveness Tests

This chapter provides a brief overview of the cost-effectiveness tests used to evaluate energy efficiency measures and programs. All the cost-effectiveness tests use the same fundamental approach in comparing costs and benefits. However, each test is designed to address different questions regarding the cost-effectiveness of energy efficiency programs.

Each of the tests described in this chapter provides different kinds of information about the impacts of energy efficiency programs from different vantage points in the energy system. On its own, each test provides a single stakeholder perspective. Together, multiple tests provide a comprehensive approach for asking: Is the program effective overall? Is it balanced? Are some costs or incentives too high or too low? What is the effect on rates? What adjustments are needed to improve the alignment? Each test contributes one of the aspects necessary to understanding these questions and answering them.

The basic structure of each cost-effectiveness test involves a calculation of the total benefits and the total costs in dollar terms from a certain vantage point to determine whether the overall benefits exceed the costs. A test is positive if the benefit-to-cost ratio is greater than one, and negative if it is less than one. Results are reported either in *net present value* (NPV) dollars (numerical difference) or as a ratio (i.e., benefits/costs). In its most simplistic form, the basic approach for calculating and representing cost-effectiveness tests is in the following mathematical form:

$$\textbf{Net Benefits} = \textbf{NPV}\sum(\textbf{Benefits}) - \textbf{NPV}\sum(\textbf{Costs})$$

$$\textbf{Benefit/Cost Ratio} = \frac{\textbf{NPV}\sum(\textbf{Benefits})}{\textbf{NPV}\sum(\textbf{Costs})}$$

Where,
Net Benefits = Difference between the sum of benefits and the sum of costs, in dollars.
Benefit/Cost Ratio = Sum of the benefits divided by the sum of the costs.

Obviously, if the Net Benefits calculation is positive, the project may be viable. If the Benefit/Cost Ratio is greater than one, the project has a positive net benefit. If the ratio is less than one, the project is a net loss. The benefit/cost ratio can also be used as a quick method to evaluate the relative effectiveness of various projects.

The Five Cost-Effectiveness Tests

In its simplest form, energy efficiency cost-effectiveness is measured by comparing the benefits of an investment with the costs. Five key cost-effectiveness tests have been used for over 40 years as the principal approaches for energy efficiency program evaluation. These five cost-effectiveness tests are the participant cost test (PCT), the utility/program administrator cost test (PACT), the ratepayer impact measure test (RIM), the total resource cost test (TRC), and the societal cost test (SCT).

These are some key points to consider when looking at the different tests:

- There is no single best test for evaluating the cost-effectiveness of energy efficiency.
- Each of the cost-effectiveness tests provides different information about the impacts of energy efficiency programs from distinct vantage points in the energy system. Together, multiple tests provide a comprehensive approach.
- Jurisdictions seeking to increase the efficiency of implementation may choose to emphasize the PACT, which compares energy efficiency as a utility investment on a par with other resources.
- The most common primary measurement of energy efficiency cost-effectiveness is the TRC, followed closely by the SCT. A positive TRC result indicates that the program will produce a net reduction in energy costs in the utility service territory over the lifetime of the program. The *distributional tests* (PCT, PACT, and RIM) are then used to indicate how different stakeholders are affected. Historically, reliance on the RIM test has limited energy efficiency investment, as it is the most restrictive of the five cost-effectiveness tests.

Distributional tests are statistical methods used to determine whether a sample data set follows a specific probability distribution.

Table 1 summarizes the five tests in terms of the questions they help answer and the key elements of the comparison.

Table 1 Cost-Effectiveness Tests Used in Energy Efficiency			
Test	**Acronym**	**Key Question Answered**	**Summary Approach**
Participant Cost Test	PCT	Will the partici… benefit over… sure of life?	Comparison of the costs and benefits of t… talling the
Program Adminis… Cost Test			…ram …o supply-side
Ratepayer… Impact Me…			…strator costs …ns to supply-
Total Resou… Cost Test			…ram …ner costs to
Societal Cost Test			…sts of …ce …and

Cost-Effectiv…

To illustrate the us… …different utility programs are analyzed. Each of t… …actual efficiency program analysis. For this course, they are labeled Utility "A… …ity" B," Utility "C," and Utility "D." Each of these was a successful energy efficiency program. The four programs are listed in Table 2 below.

Table 2 Utility Energy Efficiency Programs		
Utility	**Program Name**	**Purpose**
A	Residential Energy Efficiency Incentive Program	Customer incentives for efficient lighting and appliances.
B	Regular Income Portfolio	A variety of programs targeting residential users.