



Environment, Energy, and Economic Development

A RAND INFRASTRUCTURE, SAFETY, AND ENVIRONMENT PROGRAM

THE ARTS
CHILD POLICY
CIVIL JUSTICE
EDUCATION
ENERGY AND ENVIRONMENT
HEALTH AND HEALTH CARE
INTERNATIONAL AFFAIRS
NATIONAL SECURITY
POPULATION AND AGING
PUBLIC SAFETY
SCIENCE AND TECHNOLOGY
SUBSTANCE ABUSE
TERRORISM AND
HOMELAND SECURITY
TRANSPORTATION AND
INFRASTRUCTURE
WORKFORCE AND WORKPLACE

This PDF document was made available from www.rand.org as a public service of the RAND Corporation.

[Jump down to document](#) ▼

The RAND Corporation is a nonprofit research organization providing objective analysis and effective solutions that address the challenges facing the public and private sectors around the world.

Support RAND

[Browse Books & Publications](#)

[Make a charitable contribution](#)

For More Information

Visit RAND at www.rand.org

Explore [RAND Environment, Energy, and
Economic Development Program](#)

View [document details](#)

Limited Electronic Distribution Rights

This document and trademark(s) contained herein are protected by law as indicated in a notice appearing later in this work. This electronic representation of RAND intellectual property is provided for non-commercial use only. Unauthorized posting of RAND PDFs to a non-RAND Web site is prohibited. RAND PDFs are protected under copyright law. Permission is required from RAND to reproduce, or reuse in another form, any of our research documents for commercial use. For information on reprint and linking permissions, please see [RAND Permissions](#).

This product is part of the RAND Corporation technical report series. Reports may include research findings on a specific topic that is limited in scope; present discussions of the methodology employed in research; provide literature reviews, survey instruments, modeling exercises, guidelines for practitioners and research professionals, and supporting documentation; or deliver preliminary findings. All RAND reports undergo rigorous peer review to ensure that they meet high standards for research quality and objectivity.

TECHNICAL
R E P O R T



Evaluating the Benefits and Costs of Increased Water-Use Efficiency in Commercial Buildings

David G. Groves, Jordan Fischbach, Scot Hickey

Sponsored by the Jane and Marc Nathanson Family Foundation



Environment, Energy, and Economic Development

A RAND INFRASTRUCTURE, SAFETY, AND ENVIRONMENT PROGRAM

This research was sponsored by the Jane and Marc Nathanson Family Foundation and conducted under the auspices of the Environment, Energy, and Economic Development Program (EEED) within RAND Infrastructure, Safety, and Environment (ISE).

The RAND Corporation is a nonprofit research organization providing objective analysis and effective solutions that address the challenges facing the public and private sectors around the world. RAND's publications do not necessarily reflect the opinions of its research clients and sponsors.

RAND® is a registered trademark.

© Copyright 2007 RAND Corporation

All rights reserved. No part of this book may be reproduced in any form by any electronic or mechanical means (including photocopying, recording, or information storage and retrieval) without permission in writing from RAND.

Published 2007 by the RAND Corporation
1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
1200 South Hayes Street, Arlington, VA 22202-5050
4570 Fifth Avenue, Suite 600, Pittsburgh, PA 15213-2665
RAND URL: <http://www.rand.org>
To order RAND documents or to obtain additional information, contact
Distribution Services: Telephone: (310) 451-7002;
Fax: (310) 451-6915; Email: order@rand.org

Summary

Water is a critical input to commercial buildings, yet the amount of water required to meet the uses in a typical commercial building is highly variable. Water use depends on the technology employed in water-using devices, system maintenance, and intensity of building use. The cost of water used in commercial buildings can be substantial, and commercial building owners and managers face increasing operation costs in regions where water is scarce and the costs of energy used to heat water are on the rise.

Commercial building owners have many options for improving the water-use efficiency of their buildings. They can increase efficiency by replacing or retrofitting water-using devices before scheduled remodels. They can also purchase more efficient models when updating restrooms and other water-using systems. Not all efficiency investments will make financial sense to a building owner. A key decision facing owners is whether and how much to invest in new technologies, retrofits, or repairs to improve water efficiency.

This report presents an analytical framework and describes a spreadsheet-based tool to help commercial building owners make reasoned judgments about various water-efficiency investment options. The framework considers the costs that are typically incurred when improving efficiency and seeks to include all tangible financial benefits. Specifically, it considers the avoided water, wastewater, and energy costs realized through increased water efficiency, and it allows the user to specify tiered utility rates that can have a significant impact on investment decisions. As future water savings from efficiency investments cannot always be forecast with certainty, the model includes an innovative scenario-analysis capability to consider variable increases in utility prices (a key uncertainty affecting the financial performance of water efficiency). Although the costs and water savings of efficiency devices may also be uncertain, the framework described here assumes that these characteristics are known with certainty.

The report begins by reviewing the basic financial framework that can be used to value water-use efficiency investments (Chapter Two). The standard financial framework for evaluating investment decisions weighs the present value (PV) of all costs against the PV of all benefits associated with an investment. The report describes the major costs and benefits associated with implementing a generic water efficiency improvement package for a commercial building. It describes the financial metrics that can be used to value water-efficiency investments and proposes a scenario method for considering uncertainty. In Chapter Three, the report describes many efficiency options in commercial restrooms and cooling systems.

Chapter Four describes a spreadsheet-based model called the Building Water Efficiency Analysis Model (BEAM). This model was developed to help building owners evaluate water-use efficiency options for commercial buildings. BEAM considers water use and efficiency improvements in restrooms (including toilets, urinals, sinks, and showers) and building-

cooling systems and is designed to be easily used by building managers, consultants, and efficiency service representatives. Although these efficiency options represent many of the major efficiency opportunities available to commercial business owners, there are others, such as replacing landscaping with low water–using designs, that the software tool does not model.

BEAM analyzes the financial performance of water-use efficiency packages in the following steps. First, the tool prompts the user for information about the building to be analyzed, the specific efficiency packages to be evaluated, and characterizations of resource price scenarios to be considered. Next, the tool uses this information, along with specific assumptions about water use by device type and standard building occupants, to estimate the water and energy use for the base case condition and under each of the different efficiency packages. After calculating water and energy use, BEAM begins the financial analysis. The tool uses a scenario analysis to illustrate the financial performance of the various efficiency packages under the different scenarios of water price, presenting scenario results as tables and graphs. For each scenario, BEAM performs a simple Monte Carlo simulation to evaluate the expected performance of each efficiency option under ranges of water and energy price trends specified for the specific scenario. Note, however, that, because BEAM does not consider uncertainty about device-specific water use or costs, the tool does not fully capture the inherent uncertainty in the benefit and cost calculations. Lastly, BEAM provides results for single combinations of efficiency packages and resource price scenarios and for the entire ensemble of packages and scenarios. A detailed user’s guide is provided in Appendix A.

To demonstrate the capabilities of BEAM, Chapter Five presents a case study of restroom efficiency improvement potential based on the building headquarters of the RAND Corporation. The analysis considers two baseline efficiency conditions—one hypothetical, typical of an older building constructed prior to 1992, and the other consistent with the current building constructed in 2004. The analysis evaluates a wide range of efficiency investments from a simple retrofit of sinks and showers to the installation of the most efficient devices on the market, including non–water-using urinals and high-efficiency toilets. BEAM analyzes the financial performance of these investments under a broad range of scenarios reflecting different trends in water, wastewater, and energy utility prices.

The results for the first baseline efficiency conditions (pre-1992 fixtures) suggest highly favorable investment returns for all efficiency packages. A package that upgrades all devices to the 1992 standard and replacing urinals with non–water-using designs performs particularly well. A \$41,000 investment pays for itself in about 3.6 years and provides a net present value (NPV) ranging from \$91,000 to \$122,000, depending on the scenario of future utility prices. A similar efficiency package that includes replacing existing toilets with the latest (and most expensive) high-efficiency toilets (1.28 gallons per flush) performs less well—it pays for itself in 6.5 years. For the second baseline efficiency case (post-1992 fixtures), only efficiency packages that upgrade urinals to non–water-using models perform well. Specifically, a \$22,000 investment replacing all urinals with non–water-using models yields about \$37,000 in NPV. The analysis shows that the benefit from the non–water-using urinals derives largely from reductions in operation and maintenance costs.