Guide to Resource Planning with Energy Efficiency

A RESOURCE OF THE NATIONAL ACTION PLAN FOR ENERGY EFFICIENCY

NOVEMBER 2007

About This Document

This *Guide to Resource Planning with Energy Efficiency* is provided to assist gas and electric utilities, utility regulators, and others in the implementation of the recommendations of the National Action Plan for Energy Efficiency (Action Plan) and the pursuit of its longer-term goals.

This Guide describes the key issues, best practices, and main process steps for integrating energy efficiency into resource planning.

The intended audience for this Guide is any stakeholder interested in learning more about how to promote energy efficiency resource decisions. Utility resource planners who are early in the process of integrating energy efficiency into resource planning may turn to the Guide to address their questions about how to proceed. Those overseeing utilities, such as public utility commissions and city councils, can use the Guide to help ask the right questions and understand the key issues when reviewing utility resource planning decisions.

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The *Guide to Resource Planning with Energy Efficiency* is a product of the National Action Plan for Energy Efficiency Leadership Group and does not reflect the views, policies, or otherwise of the federal government. The role of the U.S. Department of Energy and the U.S. Environmental Protection Agency is limited to facilitation of the Action Plan.

This document was final as of December 2007 and incorporates minor modifications to the original release.

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List of Abbreviations and Acronyms

A

ACEEE American Council for an Energy-Efficient Economy

AEE Association of Energy Engineers

AEO (Department of Energy's Energy Information Agency) Annual Energy Outlook

AP2 Air Pollution Prevention (forum)

ASHRAE American Society of Heating, Refrigerating, and Air Conditioning

B

BPA Bonneville Power Administration

Btu British thermal unit

C

CEE Consortium for Energy Efficiency

CRF capital recovery factor

CFL compact fluorescent light bulb

CH4 methane

CO2 carbon dioxide

CO2eq carbon dioxide equivalent

CONE cost of new entrant

CPUC California Public Utilities Commission

CT combustion turbine

D

DEEM Database of Energy Efficiency Measures (EPRI)

DEER Database of Energy Efficiency Resources (California)

DOE U.S. Department of Energy

DRG Demand Resources Group

DSM demand-side management

ECMB Energy Conservation Management Board

E

EE energy efficiency

eGRID Emissions & Generation Resource Integrate Database (EPA)

EIA Energy Information Administration (DOE)

EM&V evaluation, measurement, and verification

EPA U.S. Environmental Protection Agency

EPRI Electric Research Power Institute

ERCOT Electric Reliability Council of Texas, Inc.

ESCO energy service company

EVO efficiency valuation organization

F

FCA forward capacity auction

FCM forward capacity market

FEMP Federal Energy Management Program

FERC Federal Energy Regulatory Commission

G

GHG greenhouse gas

GWh gigawatt hour

H

HVAC heating, ventilation, and air conditioning

I

ICAP installed capacity

ICE IntercontinentalExchange

ICR installed capacity requirement

List of Abbreviations and Acronyms (continued)

IEA	International Energy Agency
IECC	International Energy Conservation Code
IEPEC	International Energy Program Evaluation Conference
IGCC	integrated gasification combined cycle
IPMVP	International Performance Measurement and Verification Protocol
IRP	integrated resource planning
ISO	independent system operator
ISO-NE	Independent System Operator—New England

K

kW	kilowatt
kWh	kilowatt hour

L

LBNL	Lawrence Berkeley National Laboratory
LEED	Leadership in Energy and Environmental Design
LNG	liquefied natural gas
LOLP	loss of load probability
LSE	load serving entity

M

M&E	monitoring and evaluation
MCF	thousand cubic feet (of natural gas)
MMBtu	million British thermal units
MW	megawatt
MWh	megawatt hour
MVA	megavolt ampere

N

N2O	nitrous oxide
NARUC	National Association of Regulatory Utility Commissioners
NEEP	Northeast Energy Efficiency Partnerships, Inc.
NEMS	National Energy Modeling System
NO_X	nitrogen oxide
NTGR	net-to-gross ratio
NYMEX	New York Mercantile Exchange
NY ISO	New York Independent System Operator
NYSERDA	New York State Energy Research and Development Authority

P

PACT	program administrator cost test
PCT	participant cost test
PG&E	Pacific Gas and Electric Company
PJM	Pennsylvania New Jersey Maryland Interconnection Inc.
PM	particulate matter
PM10	particulate matter of 10 microns in diameter or smaller
PUC	public utility commission
PUCT	Public Utility Commission of Texas

R

RFP	request for proposals
RIM	ratepayer impact measure

List of Abbreviations and Acronyms (continued)

S

SDG&E San Diego Gas and Electric

SEER Seasonal Energy Efficiency Ratio

SCE Southern California Edison

SCT societal cost test

SF6 sulfur hexafluoride

SPC standard performance contract

T

TOU time-of-use

TRC total resource cost

U

UCAP unforced capacity

UCT utility cost test

UNEP United Nations Environment Programme

W

WACC weighted average cost of capital

WECC Wisconsin Energy Conservation Corporation

WGA Western Governors' Association

Acknowledgements

This Guide to Resource Planning with Energy Efficiency is a key product of the Year Two Work Plan for the National Action Plan for Energy Efficiency. This work plan was developed based on feedback from Action Plan Leadership Group members and Observers during the fall of 2006. The work plan was further refined during the March 2007 Leadership Group meeting in Washington, D.C. A full list of Leadership Group members is provided in Appendix A.

With direction and comment by the Action Plan Leadership Group, the Guide's development was led by Snuller Price, Energy and Environmental Economics, Inc., under contract to the U.S. Environmental Protection Agency (EPA). Chapters 7 and 8 were authored by Chuck Goldman and Nicole Hopper, Lawrence Berkeley National Laboratory, under contract to the U.S. Department of Energy (DOE). Additional preparation was performed by Dr. Jim Williams, Amber Mahone, Jack Moore, and Dr. C.K. Woo, all of Energy and Environmental Economics, Inc.

Rich Sedano of the Regulatory Assistance Project and Alison Silverstein of Alison Silverstein Consulting provided their expertise during review and editing of the Guide.

DOE and EPA facilitate the National Action Plan for Energy Efficiency, including this Guide. Key staff include Larry Mansueti (DOE Office of Electricity Delivery and Energy Reliability); Dan Beckley (DOE Office of Energy Efficiency and Renewable Energy); and Kathleen Hogan, Katrina Pielli, and Stacy Angel (EPA Climate Protection Partnership Division).

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Executive Summary

This Guide to Resource Planning with Energy Efficiency describes the key issues, best practices, and main process steps for integrating energy efficiency into electricity resource planning. The Guide is provided to assist in the implementation of the National Action Plan for Energy Efficiency's five policy recommendations for creating a sustainable, aggressive national commitment to energy efficiency.

Improving energy efficiency in our homes, businesses, schools, governments, and industries—which collectively consume more than 70 percent of the natural gas and electricity used in the country—is one of the most constructive, cost-effective ways to address the challenges of high energy prices, energy security and independence, air pollution, and global climate change. Despite these benefits and the success of energy efficiency programs in some regions of the country, energy efficiency remains critically underutilized in the nation's energy portfolio. It is time to take advantage of more than two decades of experience with successful energy efficiency programs, broaden and expand these efforts, and capture the savings that energy efficiency offers. Integrating energy efficiency into resource planning is a key to capturing these benefits.

This Guide details how to use a variety of methods to help ensure that energy efficiency programs provide a resource as dependable and valuable to utilities and their customers as any supply-side resource. The Guide organizes the planning process into ten important steps, each with their own associated technical issues, best practices, and information resources.

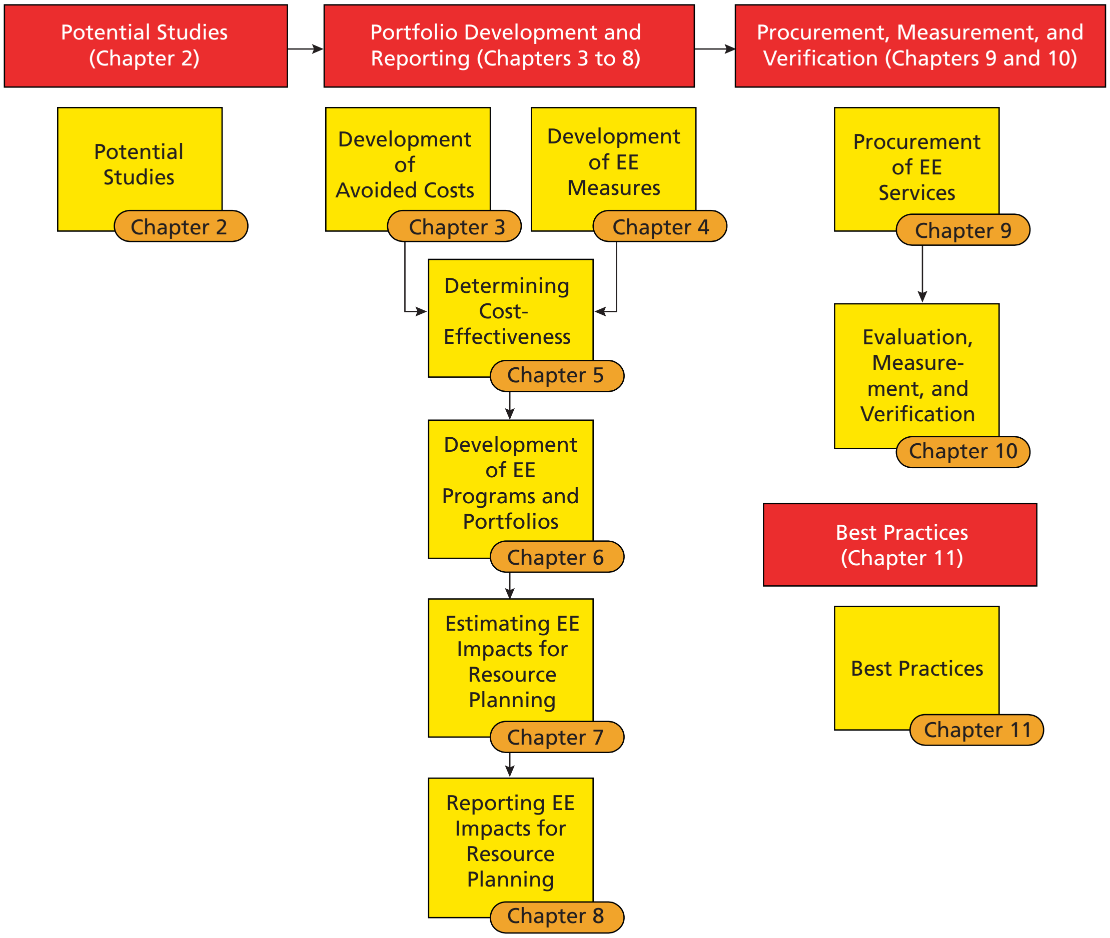
Since multiple approaches exist, the best choice is generally the one that works well with existing practices, the institutional structure in place, the experience of the teams doing the analysis and developing the programs, the time and budget available, and the data available. With this in mind, the steps and techniques described in this Guide should be understood as a starting point for tailoring an approach that best fits conditions and existing planning processes for a given utility or jurisdiction.

Figure ES-1 shows the topics covered in this Guide and their overall relationship in the energy efficiency planning process. The three main sequential topic areas are energy efficiency potential studies; portfolio development and reporting; and procurement, measurement, and verification. After addressing these topics, the Guide discusses emerging techniques and best practices.

The key points from this Guide include:

- Energy efficiency is an important utility resource which should be incorporated into utility resource planning, along with supply-side resources.
- Energy efficiency is a quantifiable resource, and this Guide can help resource planners learn to:
  - Predict the energy efficiency potential within their jurisdiction using a potential study.
  - Calculate the economic benefits of energy savings through an avoided cost methodology.
  - Develop energy efficiency measures and determine their cost-effectiveness.
  - Use the information about energy efficiency measures to develop an energy efficiency program or portfolio.
  - Estimate and report on the impacts of the program for resource planning.
  - Effectively implement an energy efficiency program or portfolio through procurement of energy efficiency resources from contractors, and track program performance with evaluation, measurement, and verification tools.

Figure ES-1. Overall Organization of the Guide to Resource Planning with Energy Efficiency



- Utilities and regulators should aim toward the integration of all of these resource planning functions into a unified whole.

This Guide has been developed to help parties implement the five key policy recommendations of the National Action Plan for Energy Efficiency. (See page 1-2 for a full listing of options to consider under each Action Plan recommendation.) The Action Plan was released in July 2006 as a call to action to bring diverse stakeholders together at the national, regional, state, or utility level, as appropriate, and foster the discussions, decision-making, and commitments necessary to take investment in energy efficiency to a new level.

This Guide directly supports the Action Plan recommendations to "recognize energy efficiency as a high-priority energy resource" and "make a strong, long-term commitment to implement cost-effective energy efficiency as a resource." The Guide elaborates upon many of the options identified by the Action Plan, and makes more concrete many of the tools and techniques needed to implement the Action Plan's recommendations.

1: Introduction

Improving the energy efficiency of homes, businesses, schools, governments, and industries—which consume more than 70 percent of the natural gas and electricity used in the United States—is one of the most constructive, cost-effective ways to address the challenges of high energy prices, energy security and independence, air pollution, and global climate change. Mining this energy efficiency could help us meet on the order of 50 percent or more 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 (GHGs) and other air pollutants.[1]

Recognizing this large untapped opportunity, more than 60 leading organizations representing diverse stakeholders from across the country joined together to develop the National Action Plan for Energy Efficiency.[2] The Action Plan identifies many of the key barriers contributing to underinvestment in energy efficiency, outlines five key policy recommendations for achieving all cost-effective energy efficiency, and provides a number of options to consider in pursuing these recommendations (Figure 1-1). As of November 2007, nearly 120 organizations have endorsed the Action Plan recommendations and made public commitments to implement them in their areas. Conducting resource planning that includes energy efficiency is key to making the Action Plan a reality.

1.1 About the Guide

This Guide elaborates upon many of the options identified above by the Action Plan, and makes more concrete many of the tools and techniques needed to implement the Action Plan's recommendations. The Action Plan's Leadership Group (see Appendix A for a list of group members) identified the area of energy efficiency in resource planning as one where additional guidance is needed to help parties pursue the recommendations and meet their commitments to energy efficiency. Specifically, this Guide supports the Action Plan recommendations to "recognize energy efficiency as a high-priority energy resource" and "make a strong, long-term commitment to implement cost-effective energy efficiency as a resource."

The Guide has ten chapters, each of which focuses on an important step in the process and the associated technical issues, best practices, and information resources. When correctly used, the methods described here help ensure that energy efficiency programs can provide a resource as dependable and valuable to utilities and their customers as any supply-side resource.

Since multiple approaches exist, the best choice is generally the one that works well with existing practices, the institutional structure in place, the experience of the teams doing the analysis and developing the programs, the time and budget available, and not least the data available. With this in mind, the steps and techniques described in the Guide should be understood as a starting point for tailoring an approach that best fits conditions and existing planning processes for a given utility or jurisdiction.

Guide Objective

After reading this Guide, the reader should be able to use the methods described to help ensure that energy efficiency programs provide a resource as dependable and valuable to utilities and their customers as any supply-side resource.

This Guide should be of interest to several different types of readers. First, it aims to help utility resource planners who are early in the process of integrating energy efficiency into resource planning and have questions

Figure 1-1. National Action Plan for Energy Efficiency Recommendations and Options

Recognize energy efficiency as a high-priority energy resource.

Options to consider:

- Establishing policies to establish energy efficiency as a priority resource.
- Integrating energy efficiency into utility, state, and regional resource planning activities.
- Quantifying and establishing the value of energy efficiency, considering energy savings, capacity savings, and environmental benefits, as appropriate.

Make a strong, long-term commitment to implement cost-effective energy efficiency as a resource.

Options to consider:

- Establishing appropriate cost-effectiveness tests for a portfolio of programs to reflect the long-term benefits of energy efficiency.
- Establishing the potential for long-term, cost-effective energy efficiency savings by customer class through proven programs, innovative initiatives, and cutting-edge technologies.
- Establishing funding requirements for delivering long-term, cost-effective energy efficiency.
- Developing long-term energy saving goals as part of energy planning processes.
- Developing robust measurement and verification procedures.
- Designating which organization(s) is responsible for administering the energy efficiency programs.
- Providing for frequent updates to energy resource plans to accommodate new information and technology.

Broadly communicate the benefits of and opportunities for energy efficiency.

Options to consider:

- Establishing and educating stakeholders on the business case for energy efficiency at the state, utility, and other appropriate level, addressing relevant customer, utility, and societal perspectives.
- Communicating the role of energy efficiency in lowering customer energy bills and system costs and risks over time.
- Communicating the role of building codes, appliance standards, and tax and other incentives.

Provide sufficient, timely, and stable program funding to deliver energy efficiency where cost-effective.

Options to consider:

- Deciding on and committing to a consistent way for program administrators to recover energy efficiency costs in a timely manner.
- Establishing funding mechanisms for energy efficiency from among the available options, such as revenue requirement or resource procurement funding, system benefits charges, rate-basing, shared-savings, and incentive mechanisms.
- Establishing funding for multi-year period.

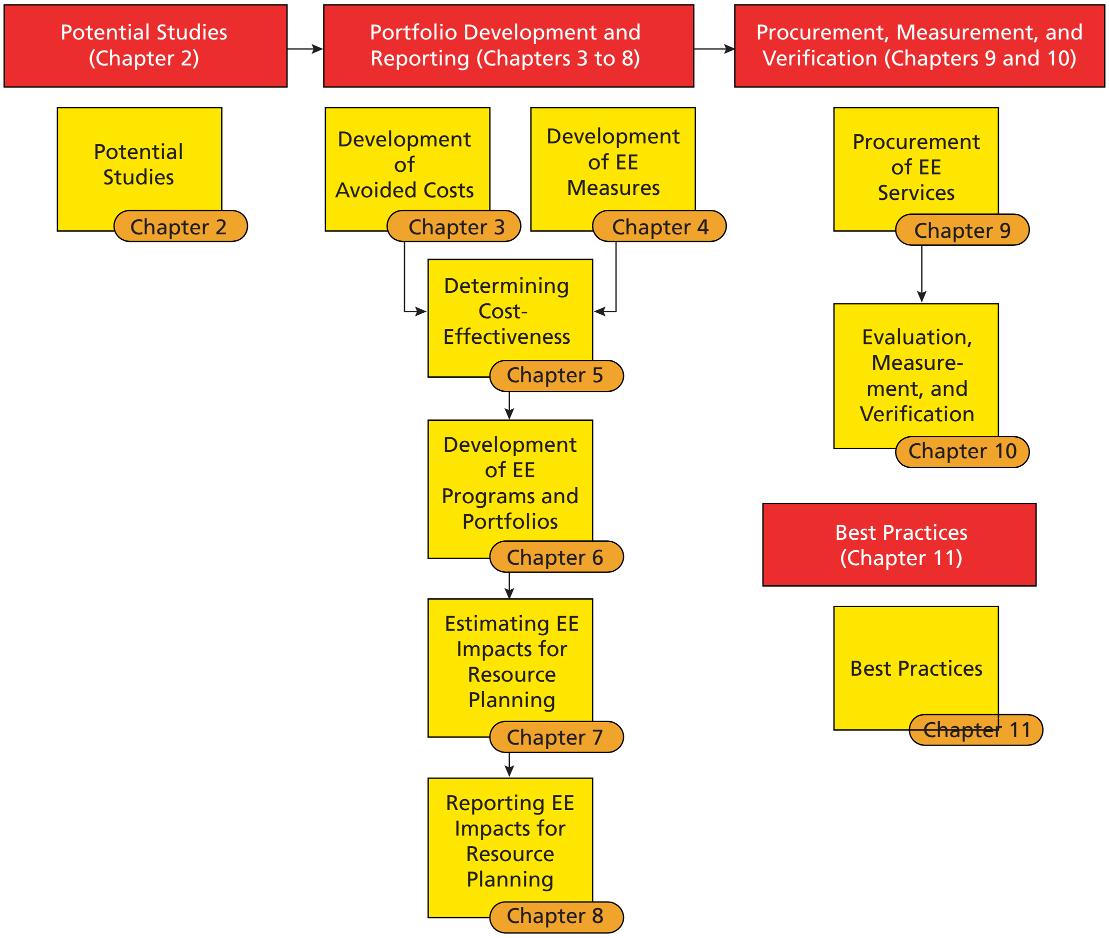
Modify policies to align utility incentives with the delivery of cost-effective energy efficiency and modify ratemaking practices to promote energy efficiency investments.

Options to consider:

- Addressing the typical utility throughput incentive and removing other regulatory and management disincentives to energy efficiency.
- Providing utility incentives for the successful management of energy efficiency programs.
- Including the impact on adoption of energy efficiency as one of the goals of retail rate design, recognizing that it must be balanced with other objectives.

Source: National Action Plan for Energy Efficiency Report.

Figure 1-2. Overall Organization of the Guide to Resource Planning with Energy Efficiency



about how to proceed. Second, it is meant to help those overseeing utilities, such as PUCs and city councils, to ask the right questions and understand the key issues when reviewing utility resource planning decisions. Finally, it assists stakeholders who are increasingly concerned with how to promote energy efficiency in resource decisions, as evidenced by the broad interest and participation in the Action Plan. This document benefits all Action Plan participants for its direct application to, and as a useful reference for, their resource planning activities.

1.2 Structure of the Guide

The following diagram shows the topics addressed in this Guide and their overall relationship in the energy efficiency planning process. The three main sequential topic areas are energy efficiency potential studies, portfolio development and reporting, and procurement, measurement and verification. This is followed by a discussion of emerging techniques and best practices.

1. Development of energy efficiency potential studies (Chapter 2). Chapter 2 describes the standard practices employed in potential studies, including methodologies for analyzing technical, economic, and achievable potential. Potential studies are generally the starting place in designing energy efficiency programs and incorporating them into resource planning. There are three main types of potential studies: (1) a high-level *policy study* to set program goals and budgets and to make the policy case to initiate or expand an energy efficiency program; (2) a *planning study* to identify energy efficiency alternatives to supply-side

investments, including generation, transmission, or distribution; and (3) a detailed *program-design study* to identify the best mix of energy efficiency measures to be offered to customers. Each type of potential study is described in the *Action Plan's Guide for Conducting Energy Efficiency Potential Studies*, available at www.epa.gov/eeactionplan.

2. Energy efficiency portfolio development and reporting (Chapters 3 to 8). Energy efficiency portfolio development entails generating good ideas about energy efficiency opportunities, evaluating cost-effectiveness, continuing established programs, offering programs to a full range of customers, and communicating expected reductions to energy procurement and planning. These chapters describe the details in developing the energy efficiency portfolio and reporting on program results.

3. Procurement, measurement, and verification (Chapters 9 and 10). How the energy efficiency portfolio is implemented is critical to the overall success of the programs. These chapters provide information on procurement of energy efficiency services and tracking overall performance through evaluation, measurement, and verification (EM&V).

In addition to these three topics, the Guide's last chapter discusses best practices, including coordination of each resource planning function into an integrated whole.

1.3 Development of the Guide

The Guide to Resource Planning with Energy Efficiency is a product of the Year Two Work Plan for the National Action Plan for Energy Efficiency. With direction and comment by the Action Plan Leadership Group, the Guide's development was led by Snuller Price, Energy and Environmental Economics, Inc., under contract to the U.S. Environmental Protection Agency (EPA). Chapters 7 and 8 were authored by Chuck Goldman and Nicole Hopper, Lawrence Berkeley National Laboratory, under contract to the U.S. Department of Energy (DOE). Additional preparation was performed by Dr. Jim Williams, Amber Mahone, Jack Moore, and Dr. C.K. Woo, all of Energy and Environmental Economics, Inc.

1.4 Notes

1. See the *National Action Plan for Energy Efficiency* (2006), available at <www.epa.gov/cleanenergy/actionplan/report.htm>.

2. See <www.epa.gov/eeactionplan>.

2: Potential Studies

Potential studies are often the first step taken in initiating or expanding energy efficiency programs. This chapter provides an overview of potential studies for use in resource planning. For a more detailed discussion of conducting a potential study, see the Action Plan's Guide for Conducting Energy Efficiency Potential Studies (National Action Plan for Energy Efficiency, 2007a).

High-Level Summary	Key Questions for Utilities and Regulators
• Potential studies are typically the first step taken in initiating or expanding energy efficiency programs. They are conducted to determine the potential for saving energy and capacity through energy efficiency measures. • Potential studies typically start by determining technical feasibility, then apply different screens such as customer eligibility, cost-effectiveness, and estimates of program uptake (i.e., customer participation) to determine what the program can be realistically expected to achieve. • Potential studies vary in scope and methods according to their objectives, of which there are three main kinds: (1) promoting efficiency at the policy/regulatory level, (2) integrating efficiency into the utility planning process, and (3) designing efficiency programs.	• Does the potential study establish the potential for long-term, cost-effective energy efficiency savings by customer class?[1] • What is this potential study's goal (promoting efficiency at the policy/regulatory level, integrating efficiency into the utility planning process, or designing efficiency programs)? Does it achieve that goal? • Are the potential study results realistic, reflecting what we are likely to achieve through energy efficiency programs? • How do the results of this study compare to the results for other jurisdictions? • Does the potential study highlight any new opportunities to add to the efficiency portfolio?

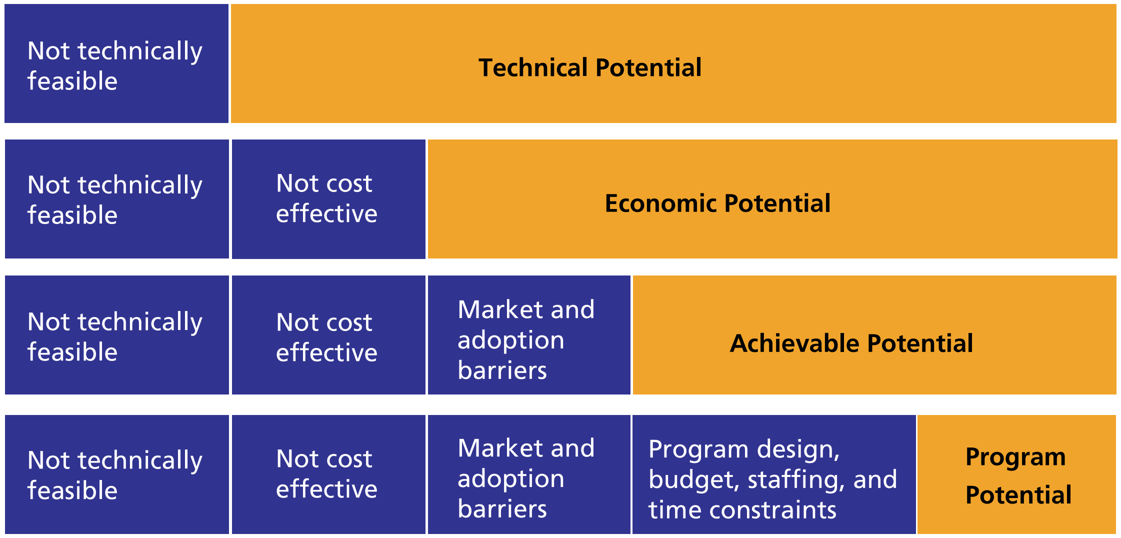
2.1 Determining Energy Efficiency Potential

Potential studies are conducted to determine the potential for saving energy (e.g., of electricity, MCF of natural gas) and capacity (e.g., MW, MCF/day) through energy efficiency measures. Since "energy efficiency potential" can have different meanings, Figure 2-1 lists the four definitions commonly used in resource planning.

These definitions mirror the sequential estimates in a typical potential study. The process begins with a *technical potential* estimate of what kWh and kW savings would be achieved if all technically feasible efficiency measures were implemented for all customers. The technical potential is then adjusted by applying a series of screens of real-world constraints. *Economic potential* is the result of reducing the technical potential by applying cost-effectiveness and program eligibility criteria. There are several tests for evaluating cost-effectiveness, each reflecting the different interests in energy efficiency of various stakeholders. Chapter 5 discusses in more detail how to determine cost-effectiveness. *Achievable potential* is the result of estimating how much market barriers and program uptake limits will reduce the economic potential. Examples of these barriers and limits are:

- Customer willingness to adopt efficiency measures.
- Customer criteria for cost-effectiveness.
- Customer awareness of energy efficiency opportunities.
- Customer access to information about energy efficiency.

Figure 2-1. Definitions of Energy Efficiency Potential



Note: For more complete definitions, see National Action Plan for Energy Efficiency, 2007a, and XENERGY, 2002.

- Rates of equipment turnover.
- Program incentives and activity.
- Availability of energy-efficient equipment in the marketplace.
- "Split incentive" barriers in which the person investing in the equipment is not in a position to receive the savings (e.g., landlords and tenants; institutions with separate operations and capital budgets and bureaucracies).

Finally, the *program potential* is the efficiency savings that can be realistically realized from the achievable potential, given the budget, staffing, and time constraints for the efficiency program. Program potential establishes the total, or gross, savings expected from a program.

As a final step, some potential studies net out "naturally occurring" energy efficiency improvements in order to identify the savings actually attributable to the program. For example, if a refrigerator rebate program pays 10 customers to upgrade to an ENERGY STAR® model, but two customers would have upgraded even without the program, then the net savings is 80% of the program potential (e.g., the program can take credit for eight out of every 10 participants). The 80% value is commonly known as a "net-to-gross" ratio (NTGR), useful for determining both the cost-effectiveness and achievements attributable to energy efficiency efforts.

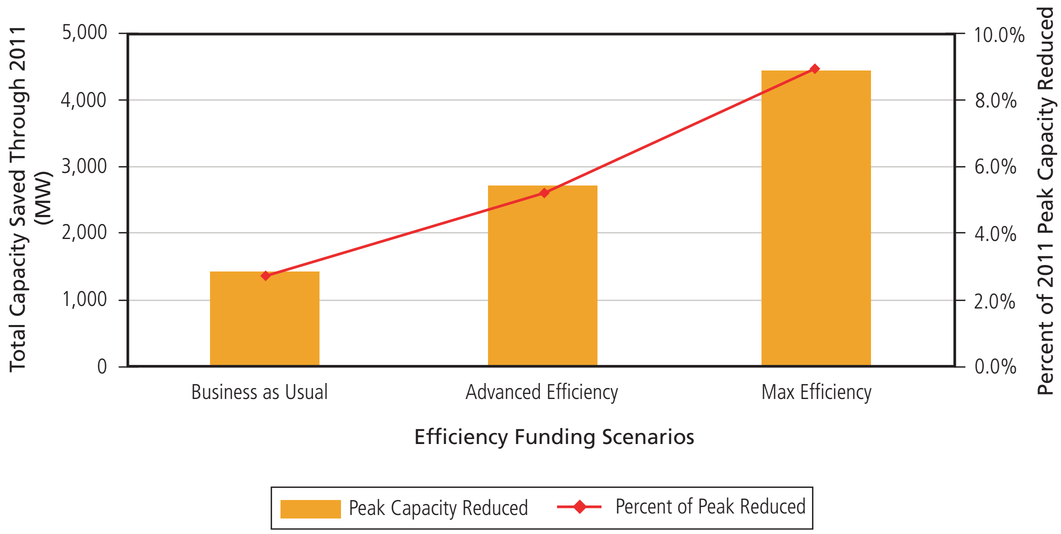
2.2 Types of Potential Studies

Potential studies differ in scope and methods as a function of their objectives and who is conducting them. They can be divided into three main types:

1. **Policy studies,** used to promote efficiency in policies and regulations.
2. **Planning studies,** used to integrate energy efficiency into utility resource planning.
3. **Program-design studies,** used to develop the details of energy efficiency programs.

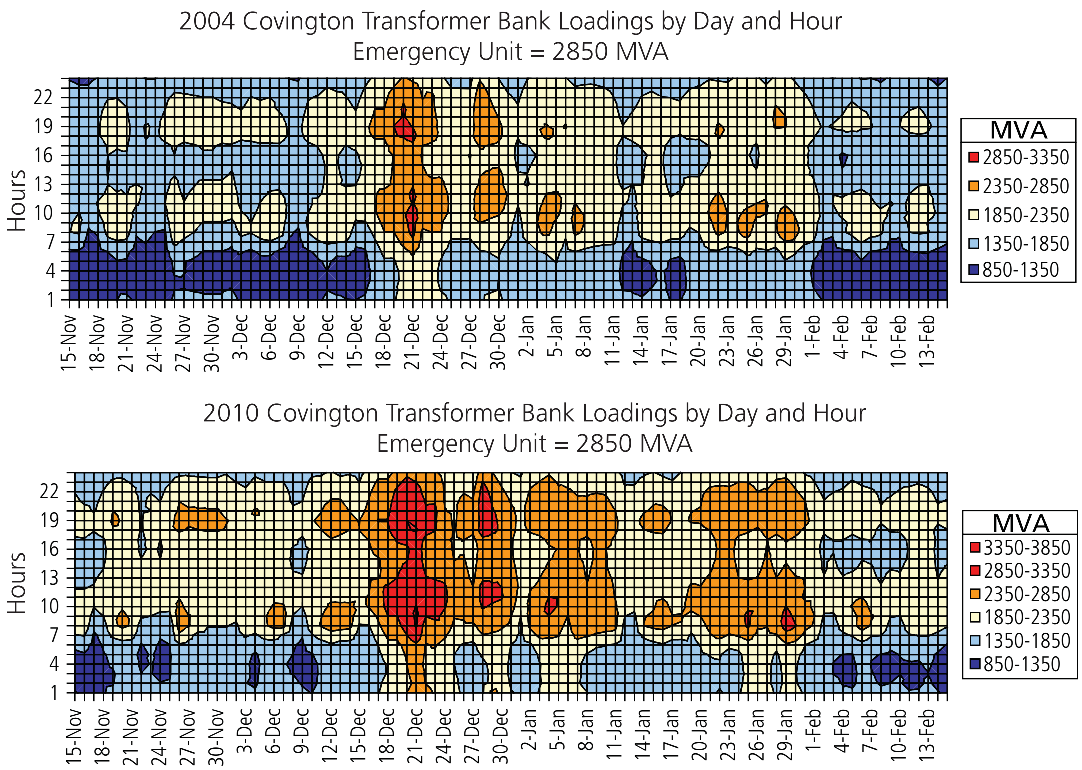
Potential studies for policy are typically high-level (i.e., not extremely detailed) studies, primarily designed to develop a policy consensus for initiating new energy efficiency programs or making changes to existing programs. A *policy study* might be commissioned by a utility regulator or legislative body that would like more information on the benefits of establishing a program, or by third-party energy efficiency advocates who want to bring energy efficiency

Figure 2-2. Example of Results From a Policy-Focused Energy Efficiency Potential Study



Source: XENERGY, 2002.

Figure 2-3. BPA Study Illustrates When Peak Load Reductions Are Needed to Avoid Transformer Bank Overload



Note: Thermal overload limit shown in red.

Source: Bonneville Power Administration [BPA] 2007. (In references section)

benefits to the attention of regulators and policy-makers. An example is a 2002 Energy Foundation study that played an important role in convincing California legislators to aggressively fund energy efficiency in that state (see Figure 2-2). Policy studies can also be designed jointly by a utility and its regulator to establish prudent spending on energy efficiency and to justify its cost recovery.

Planning studies of energy efficiency potential are used by demand-side planners within utilities to incorporate efficiency into an integrated resource planning (IRP) process. The objective of a planning study is to identify energy efficiency opportunities that are cost-effective alternatives to supply-side resources in generation, transmission, or distribution. This often means developing a case that specific efficiency measures have the potential to eliminate or defer the need for specific new investments in a supply resource plan, which may encompass generation, wires, substation upgrades, or gas pipelines. As an example, in the Bonneville Power Administration's (BPA's) Kangley-Echo Lake non-wires alternative planning study, the focus was on identifying energy efficiency improvements that would allow the deferral of a new transmission line and substation upgrades needed to prevent transformer thermal overloadings. Figure 2-3 illustrates what the peak loading hours were expected to be in 2004 and 2010, and therefore the kW impact shapes of energy efficiency that would be needed as an alternative to the conventional upgrades (BPA, 2007).

Potential studies for *program design* can be undertaken by utilities or third parties for the purpose of developing specific measures for the energy efficiency portfolio. They can also be used for developing customer program features, such as outreach and education, rate incentives, and rebates for customer purchases of energy efficient equipment. More details about the types of potential studies and the methodologies used can be found in the *Guide for Conducting Energy Efficiency Potential Studies* (National Action Plan for Energy Efficiency, 2007a) and in Section 2.3.

2.3 Resources on Energy Efficiency Potential

Title/Description		URL Address
National	**Emerging Energy-Saving Technologies and Practices for the Buildings Sector as of 2004.** This study identifies new research and demonstration projects that could help advance high-priority emerging technologies, as well as new potential technologies and practices for market transformation activities.	<http://aceee.org/pubs/a042toc.pdf>
	A Responsible Electricity Future: An Efficient, Cleaner and Balanced Scenario for the U.S. Electricity System. This report develops a scenario for the future evolution of the electric power system in the U.S., including increased investment in energy efficiency and in renewable and distributed generating technology, and compares it with the current situation.	<www.uspirg.org/uploads/J9/vu/J9vuJffJAiEQLJuNjf1BHg/responsibleelecfuture.pdf>
	Scenarios for a Clean Energy Future, 2000. This document reflects efforts of the Interlaboratory Working Group, commissioned by DOE, to examine the potential for public policies and programs to foster efficient and clean energy technology solutions.	<www.ornl.gov/sci/eere/cef/>

Title/Description		URL Address
National	**Screening Market Transformation Opportunities: Lessons from the Last Decade, Promising Targets for the Next Decade.** This report examines past and recent trends in the market transformation field and presents an updated screening analysis and categorization of the most promising opportunities.	<www.aceee.org/pubs/u022full.pdf>
	The Technical, Economic and Achievable Potential for Energy Efficiency in the U.S.—A Meta-Analysis of Recent Studies. This study compares the findings from 11 studies on the technical, economic, and/or achievable potential for energy efficiency in the U.S. to recent-year actual savings from efficiency programs in leading states.	<www.aceee.org/conf/04ss/rnemeta.pdf>
Midwest	**Examining the Potential for Energy Efficiency to Address the Natural Gas Crisis in the Midwest.** The results of this study suggest that a modestly aggressive, but pragmatically achievable energy efficiency campaign (achieving about a 5% reduction in both electricity and natural gas customer use over 5 years) could produce tens of billions of dollars in net cost savings for residential, commercial, and industrial customers in the Midwest.	<www.aceee.org/pubs/u051.htm>
	Repowering the Midwest: The Clean Energy Development Plan for the Heartland. This Web site is supported by the Environmental Law and Policy Center as a source for clean energy information in the Midwest. It provides information on the Clean Energy Development Plan for the Heartland, which proposes policies to implement underutilized energy efficiency technologies and to aggressively develop renewable energy resources.	<www.repowermidwest.org>

Title/Description		URL Address
Northeast	**Economically Achievable Energy Efficiency Potential in New England.** This report provides an overview of areas where energy efficiency could potentially be increased in the six New England states.	<www.neep.org/files/Updated_Achievable_Potential_2005.pdf>
	Electric Energy Efficiency and Renewable Energy in New England: An Assessment of Existing Policies and Prospects for the Future. This report applies analytical tools, such as economic and environmental modeling, to demonstrate the value of consumer-funded energy efficiency programs and renewable portfolio standards and addresses market and regulatory barriers.	<http://raponline.org/Pubs/RSWS-EEandREinNE.pdf>
	NEEP Initiative Review: Commercial/Industrial Sectors Qualitative Assessment and Initiative Ranking. Synapse Energy Economics. Submitted to Northeast Energy Efficiency Partnerships, Inc., October 1, 2004.	<www.neep.org/html/NEEP_C&IReview.pdf>
Northwest	**The Fifth Northwest Electric Power and Conservation Plan.** This plan is a blueprint for an adequate, low-cost, low-risk energy future. Technical appendices include conservation cost-effectiveness methodologies.	<www.nwcouncil.org/energy/powerplan/plan/Default.htm>
Southeast	**Powering the South: A Clean & Affordable Energy Plan for the Southern United States.** *Powering the South* shows that a clean generation mix can meet the region's power demands and reduce pollution without raising the average regional cost of electricity and lists the policy initiatives that can make the changes.	<www.crest.org/articles/static/1/binaries/pts_repp_book.pdf>
Southwest	**The Potential for More Efficient Electricity Use in the Western U.S.: Energy Efficiency Task Force Draft Report to the Clean and Diversified Energy Advisory Committee of the Western Governor's Association, Draft Report for Peer Review and Public Comment.** This report demonstrates how the adoption of the best practice energy efficiency policies and programs in all western states could reduce most of the projected load growth during 2005–2020, reduce overall electricity consumption, and yield economic and environmental benefits.	<www.westgov.org/wga/publicat/CDEAC06.pdf>

Title/Description		URL Address
Southwest	**The New Mother Lode: The Potential for More Efficient Electricity Use in the Southwest.** This report for the Southwest Energy Efficiency Project examines the potential for, and benefits from, increasing the efficiency of electricity use in the southwest states of Arizona, Colorado, Nevada, New Mexico, Utah, and Wyoming.	<www.swenergy.org/nml/index.html>
	Economic Assessment of Implementing the 10/20 Goals and Energy Efficiency Recommendations. This report examines the Grand Canyon Visibility Transport Commission's air pollution prevention recommendations. It articulates the potential emission reductions, costs, and secondary economic impacts of meeting the 10/20 goals and implementing the energy efficiency recommendations given the assumptions and scenarios developed by the Air Pollution Prevention (AP2) forum.	<www.wrapair.org/forums/ap2/docs.html>
	A Balanced Energy Plan for the Interior West. This report shows how energy efficiency, renewable energy, and combined heat and power resources can be integrated into the region's existing power system to meet growing electric demands in a cost-effective, reliable way that reduces risk and improves environmental quality for the Interior West region of Arizona, Colorado, Montana, New Mexico, Nevada, Utah, and Wyoming.	http://westernresources.org/energy/bep.html
California	**California's Secret Energy Surplus: The Potential for Energy Efficiency.** This study focuses on assessing electric energy potential in California through the assessment of technical, economic, and achievable potential savings over the next 10 years.	<www.ef.org/documents/Secret_Surplus.pdf>
Connecticut	**Independent Assessment of Conservation and Energy Efficiency Potential for Connecticut and the Southwest Connecticut Region.** This study estimates the maximum achievable cost-effective potential for electric energy and peak demand savings from energy efficiency measures in the geographic region of Connecticut served by United Illuminating Company and Connecticut Light and Power Company.	<www.env-ne.org/Publications/CT_EE_MaxAchievablePotential%20Final%20Report-June%202004.pdf>

Title/Description		URL Address
Georgia	**Assessment of Energy Efficiency Potential in Georgia.** This report presents a profile of energy use in Georgia; the potential for, and public benefits of, energy efficiency; and a public policy review.	<www.gefa.org/Modules/ShowDocument.aspx?documentid=46>
Iowa	**The Potential for Energy Efficiency in the State of Iowa.** This report uses existing programs, surveys, savings calculators, and economics simulation to estimate the potential for energy savings in Iowa.	<www.ornl.gov/sci/btc/apps/Restructuring/IowaEEPotential.pdf>
Massachusetts	**The Remaining Electric Energy Efficiency Opportunities in Massachusetts.** This report addresses the remaining electric energy efficiency opportunities in the residential, commercial, and industrial sectors in Massachusetts.	<www.mass.gov/Eoca/docs/doer/pub_info/e3o.pdf>
Nevada	**Nevada Energy Efficiency Strategy.** Nevada has taken a number of steps to increase energy efficiency. This report provides 14 policy options for further increasing the efficiency of electricity and natural gas and reducing peak power demand.	<www.swenergy.org/pubs/Nevada_Energy_Efficiency_Strategy.pdf>
New Jersey	**New Jersey Energy Efficiency and Distributed Generation Market Assessment.** This study estimates mid- and long-term potential for energy and peak-demand savings from energy efficiency measures and for distributed generation in New Jersey.	http://www.policy.rutgers.edu/ceeep/images/Kema%20Report.pdf
New York	**Energy Efficiency and Renewable Energy Resource Development Potential in New York State.** Final Report Volume One: Summary Report. This study examines the long-range potential for energy efficiency and renewable energy technologies to displace fossil-fueled electricity generation in New York by looking at the potential available from existing and emerging efficiency technologies and practices and by estimating renewable electricity generation potential.	<//www.nyserda.org/sep/>EE&ERpotentialVolume1.pdf
Oregon	**Energy Efficiency and Conservation Measure Resource Assessment for the Residential, Commercial, Industrial and Agricultural Sectors.** This report is designed to inform the project development and selection process for a list of potential energy efficiency and renewable energy measures that could provide electricity savings for Oregon consumers.	<www.energytrust.org/library/reports/Resource_Assesment/ETOResourceAssessFinal.pdf>

Title/Description		URL Address
Oregon	**Natural Gas Efficiency and Conservation Measure Resource Assessment for the Residential and Commercial Sectors.** This is a resource assessment to evaluate potential natural gas conservation measures that can be applied to the residential and commercial building stock serviced by Northwest Natural Gas.	<www.energytrust.org/library/reports/Resource_Assesment/GasRptFinal_SS103103.pdf>
Texas	**Potential for Energy Efficiency, Demand Response, and Onsite Renewable Energy to Meet Texas's Growing Electricity Needs.** This report assesses the potential for energy efficiency, demand response, and onsite renewable energy resources to meet the immediate and long-term demand growth in Texas.	<www.aceee.org/pubs/e073.htm>

2.4 Notes

1. This key question is based on the National Action Plan for Energy Efficiency recommendation to "make a strong, long-term commitment to implement cost-effective energy efficiency as a resource" and options to consider.

3: Development of Energy Efficiency Avoided Costs

This chapter provides a discussion of how to calculate the economic benefits of energy savings through an avoided cost methodology. This includes discussion of the typical components of avoided costs, considerations for developing avoided costs, and the forecasting methods required to value the long-term nature of energy efficiency measures.

High-Level Summary	Key Questions for Utilities and Regulators
• Avoided costs are the forecasted economic "benefits" of energy savings. • The avoided costs should be evaluated in enough detail to reflect any significant cost variations by time and area. • Avoided costs can include the value of reduced GHG emissions.	• How transparent will we require our assumptions to be? Will we rely on proprietary internal forecasts of avoided costs or non-proprietary avoided costs in our energy efficiency planning?[1] • Do our avoided costs capture the major costs that can be avoided with energy efficiency? • Do we want to include the value of GHG reductions in the avoided cost? • Do we want to use hourly, time-of-use (TOU), or annual average avoided costs for different end-uses?

3.1 Overview

The typical approach for quantifying the benefits of energy efficiency is to forecast long-term "avoided costs," defined as costs that would have been spent if the energy efficiency had not been put in place. For example, if an electric distribution utility expects to purchase energy at a cost of $70/MWh on behalf of customers, then $70/MWh is the value of reduced purchases from energy efficiency. In addition, the utility may not have to purchase as much system capacity (installed or unforced),[2] make as many upgrades to distribution or transmission systems, buy as many emissions offsets, or incur as many other costs. All such cost-saving components due to energy efficiency are directly counted as avoided cost benefits. In addition to the directly counted benefits, the state PUCs or governing councils may request that the utility account for indirect cost savings that are not priced by the market (e.g., reduced CO_2 emissions).

3.2 Components of Avoided Costs

There are two main categories of avoided costs: energy-related avoided costs and capacity-related avoided costs, as discussed in the Action Plan report. "Energy-related avoided costs" refers to market prices of energy, losses, natural gas commodity prices, and other benefits associated with energy production such as reduced air emissions and water usage. "Capacity-related avoided costs" refers to infrastructure investments such as power plants, transmission and distribution lines, pipelines, and liquefied natural gas (LNG) terminals. From an environmental point of view, saving energy reduces air emissions including GHGs, and saving capacity reduces land use and siting issues such as new transmission corridors and power plants.

Table 3-1 describes the main components in avoided costs and the primary options for their development. Electric utilities typically include both energy and capacity components of avoided costs. Natural gas utilities will typically include energy, and may or may not include capacity. These components make up the majority of the overall avoided cost. Depending on the utility and the focus of the state PUC or governing council, additional avoided cost components may be included, as shown in Table 3-1.

3.3 Considerations When Developing Avoided Costs

Depending on the utility type and market structure in a region, there are several choices for methodology in developing avoided costs.

Table 3-1. Typical Components of Avoided Costs Energy Efficiency Program Types

Avoided Component	Description
Electricity energy (with losses)	• Market-forecast of electricity procurement, or • Operating cost of power plants if using production simulation. • Loss factors.
Electricity capacity (with losses)	• Market-forecast of capacity, or • Assessment of deferred power plant construction based on adjusted load forecast. • Loss factors.
Natural gas commodity (with losses)	• Market-forecast of natural gas procurement with basis adjustment for delivery to utility city-gate. • Loss and compression factors.
Natural gas capacity (with storage and compression)	• Assessment of deferred infrastructure including pipelines, storage facility, and LNG terminals.
Other Components	**Description**
Ancillary services	• Reduced costs of ancillary services associated with reduced energy and capacity.
Transmission and distribution capacity	• Deferral value of additional transmission and distribution capacity to meet customer peak demand growth. • For electricity, the transmission and distribution capacity avoided costs vary by sub-area within the utilities. Capacity costs also vary by hour, coincident with the timing of the local area peak demands. Peak demand is correlated to local climate. • For natural gas, the avoided transmission and distribution costs vary by utility service territory and are typically driven by gas loads in the winter heating season.

Table 3-1. Typical Components of Avoided Costs Energy Efficiency Program Types (continued)

Avoided Component	Description
Hedge of fossil fuel prices	• Depending on the approach taken to forecast market prices, this may already be included. For example, natural gas forward prices already contain the risk premium for changes in natural gas prices. Fundamental forecasts based on cost also include the risk premium.
Price effect of demand reduction	• Reduction in total spot market purchase costs attributable to reduction in demand curve. • Depending on the market conditions, the change in wholesale market prices may be large or small.
Savings in water, fuel oil, or other value streams	• Depending on region and the types of programs, additional avoided cost streams may be included.

3.3.1 Forecast Approaches

For the purposes of developing avoided costs, there are two primary market structures that result in a different approach to forecasting avoided energy costs—market forecast and production simulation. The choice depends on the assumption that best reflects actual avoided costs.

1. For utilities that are tightly integrated into the wholesale energy market, such as distribution utilities that buy electricity or natural gas, or vertically integrated electric utilities that are active buyers or sellers of electricity in the wholesale market, a forecast of future market prices establishes avoided costs. This is typically called a "market forecast." See Section 3.4.1, "Market-Based Approaches," for a more detailed discussion of this approach.

   The market price is the preferred approach here because if the utility is buying electricity or natural gas in the market (whether a distribution utility or a vertically integrated utility), fewer purchases due to energy efficiency result in energy savings valued at market. If the utility is selling excess electricity, energy savings from energy efficiency enables additional sales, resulting in incremental revenue. In either case, the market price is the per kWh value of energy efficiency.

2. For self-reliant electric utilities that do not have wholesale market access or actively trade electricity, a "production simulation" forecast that produces the expected production costs may be the best approach. See "Production Simulation Modeling" in Section 3.4.2 for a more detailed discussion of this approach.

Table 3-2 summarizes the approaches for developing avoided costs by utility type.

3.3.2 Proprietary Versus Public Forecasts

The easiest approach for a utility to develop long-term avoided costs may be to simply use their internal forecast of market prices, or to benchmark the avoided costs to the costs of building and operating the next power plant or resource. This results in a proprietary methodology specific to the utility. The methodology may be confidential, since utilities actively involved in procuring electricity or natural gas on the market will probably not want to reveal their expectations of future prices publicly.

To develop a more open process for energy efficiency evaluation and planning, public forecasts of avoided

Table 3-2. Summary of Approaches to Value Energy and Capacity by Utility Type

	Near Term (Market Data Available)	Long Term (No Market Data Available)
Distribution electric or natural gas utility	Current forward market prices of energy and capacity	Long-term forecast of market prices of energy and capacity
Electric vertically integrated utility	Current forward market prices of energy and capacity *or* Expected production cost of electricity and value of deferring generation projects	Long-term forecast of market prices of energy and capacity *or* Expected production cost of electricity and value of deferring generation projects

costs can be developed. California, Texas, the Northwest Power and Conservation Council, Ontario, and others use a non-proprietary methodology. An open process allows non-utility stakeholders to evaluate and comment on the methodology, and to have confidence that the analysis is fair. This approach also makes it possible for energy efficiency contractors to evaluate the cost-effectiveness of proposed energy efficiency upgrades, as is done in California.

Rather than create a forecast, it is common to use a publicly available forecast of electricity or natural gas. The most universal source of forecasts is DOE's Energy Information Agency Annual Energy Outlook (AEO). This public forecast provides regional long-term forecasts of electricity and natural gas. In addition to the AEO, state energy agencies or regional groups may provide their own independent forecasts, which may include sensitivity analysis.

3.3.3 Simple Versus Complex

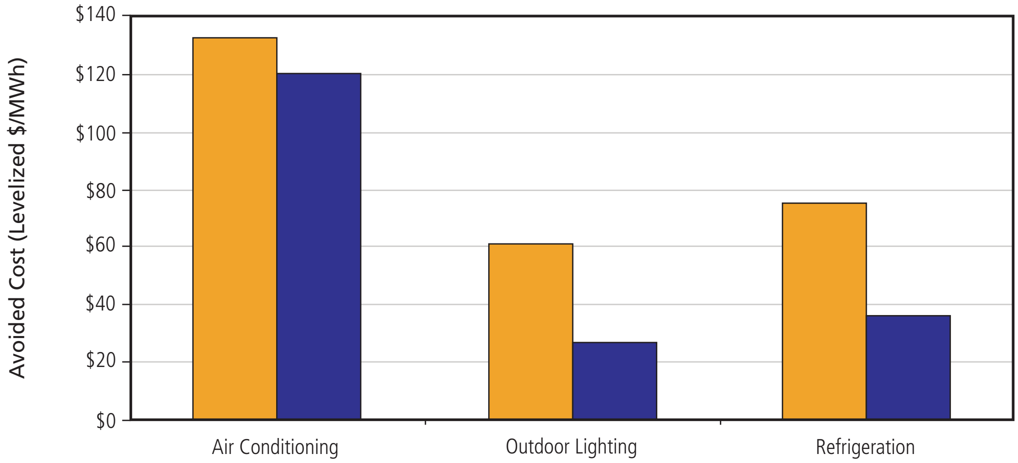
Avoided costs for energy efficiency do not necessarily require significant precision to the fractions of a cent to be useful. With long-term forecasts (up to 30 years), it is inherently impossible to be exact in predicting future market prices and the amount of energy and capacity savings ultimately achieved. Therefore, the methodology should be as complex as necessary to get the major decisions correct, but still should be workable and transparent to the stakeholders involved in their calculation. The level of detail and complexity in the methodology will depend on the jurisdiction and its unique circumstances.

In Texas, for instance, avoided costs are assumed to be the estimated cost of a new gas turbine. They do not vary by time or area. The energy avoided cost was initially set in PUCT Section 25.181-5 at $0.0268/kWh saved annually at the customer's meter. The capacity avoided cost was set at $78.5/kW saved annually at the customer's meter (PUCT, 2000). Environmental benefits of up to 20% above this cost-effectiveness standard can also be applied to projects in an area not meeting ambient air quality standards.

In California, hourly avoided costs for a typical year (8,760 hourly values) were developed for each of 16 climate zones in the state. This approach adds significant detail to the area- and time-specific differences in the value of energy savings. This level of detail reflects the state's extreme summer peak and possible capacity shortfall, thus capturing the capacity value of energy efficiency.

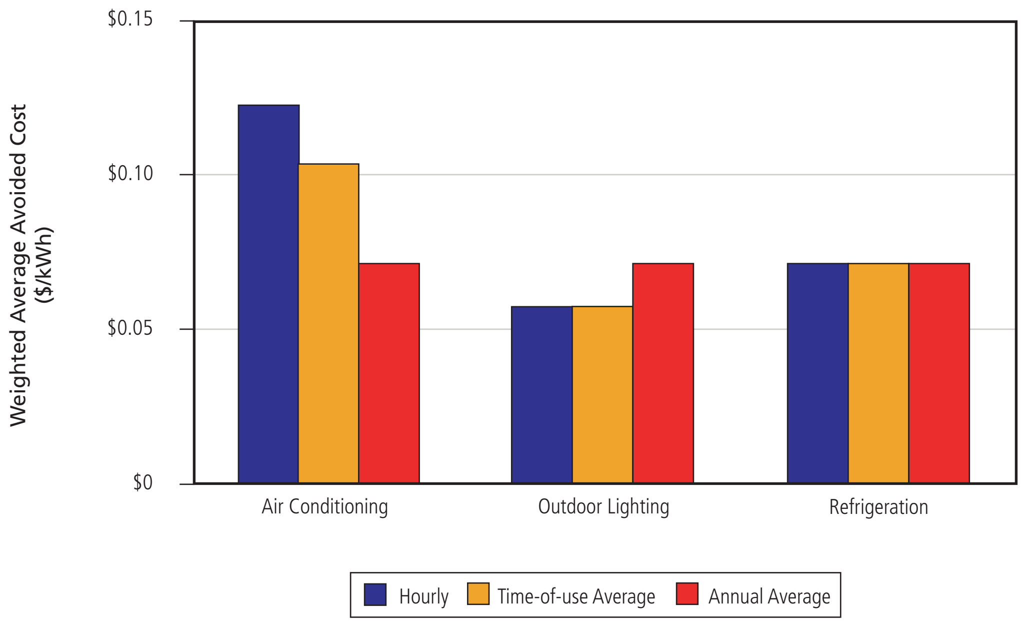
Figure 3-1 presents a comparison of Texas's and California's avoided costs for three types of loads: air conditioning, outdoor lighting, and refrigeration. The calculations for both states are based on the hourly normalized load shape for air conditioning, outdoor lighting, and refrigeration for one climate zone in California (climate zone 12). Both states place a higher value on energy efficiency that reduces peak demand (such as efficiency for air conditioning units, which operate substantially more

Figure 3-1. Comparison of Avoided Costs in Texas and California



Source: Public Utilities Commission of Texas, 2000. Energy & Environmental Economics, Inc. and Rocky Mountain Institute, 2004.

Figure 3-2. Implication of Time-of-Use Avoided Costs



Source: Energy & Environmental Economics, Inc. and Rocky Mountain Institute, 2004.

often during peak demand hours) compared to reductions in baseload demand (such as efficiency for refrigeration units, which represent a constant load across time). Since the Texas legislation was passed in September 2005, the state's avoided cost values have not risen in tandem with higher natural gas prices (as of early August 2007). This has resulted in lower avoided costs in Texas than in California using the current adopted values.

Figure 3-2 shows the differences in results in using hourly, TOU, and annual average avoided costs for different end-uses based on the California study. Hourly avoided costs are definitely most detailed, capturing the cost variance within and across major time periods. In contrast, annual average ignores the timing of energy savings.

In California, the decision to use hourly avoided costs was made in part because the system peak is so closely correlated with air conditioning load that hourly results are necessary to fully capture the value of air conditioning energy efficiency. While a summary to the established TOU periods would provide an avoided cost of approximately $0.10/kWh, the hourly evaluation provides over $0.12/kWh in benefits for an air conditioning energy efficiency program. In the cases of other end-uses, such as outdoor lighting efficiency, there is very little difference between hourly and TOU, and in the case of end-uses that operate evenly within a 24-hour period (e.g., refrigeration), there is no difference in method.

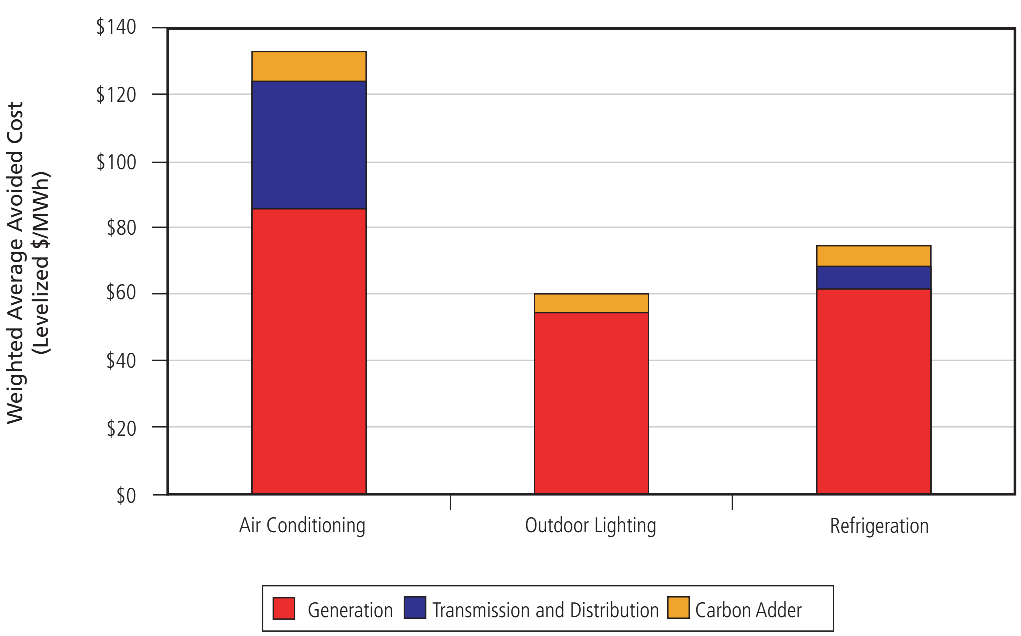
Another consideration of time-dependent avoided cost analysis is to correctly evaluate the tradeoffs between different types of energy efficiency measures. For example, with an annual average methodology, low-cost lighting such as compact fluorescent light bulbs (CFLs) or outdoor lighting efficiency will receive the same value as air conditioning energy efficiency, even if they do not reduce the peak load significantly.

3.3.4 Value of Avoided GHG Emissions

Another factor to consider when determining the avoided cost of energy efficiency programs is whether to value the commensurate reductions in GHG emissions associated with the efficiency program and, if so, how. The first step is to determine the quantity of avoided CO_2 emissions from the efficiency program (see Chapter 7). Once the amount of CO_2 reductions has been determined, its economic value can be calculated and added to the net benefits of the energy efficiency measures used to achieve the reductions.

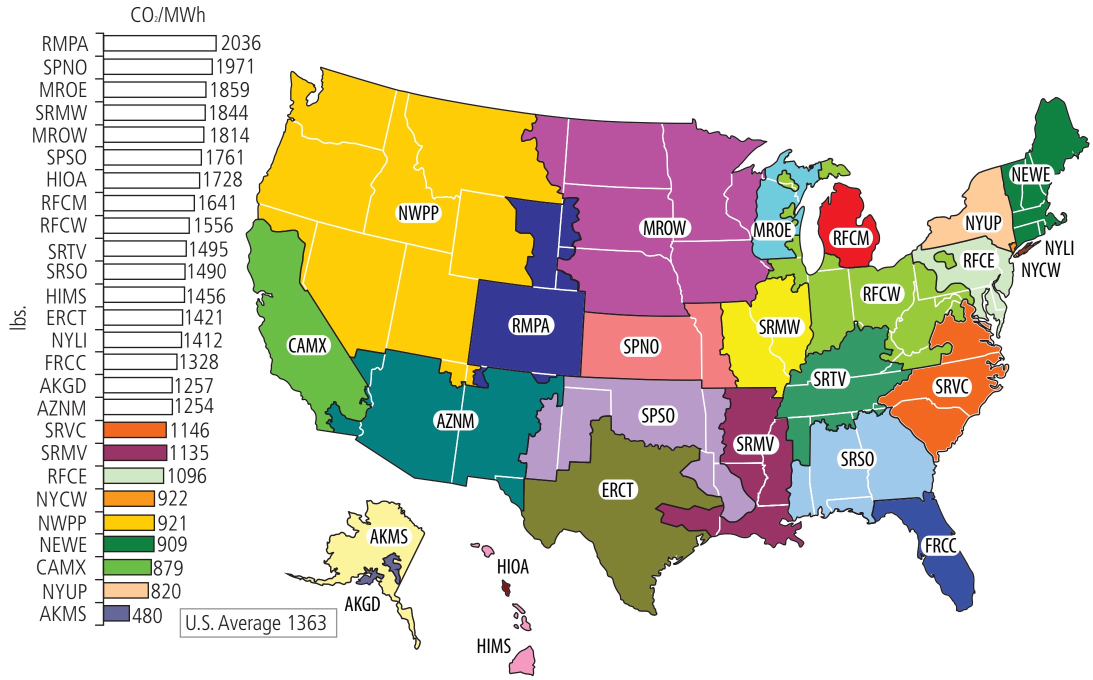
Currently, some jurisdictions have an explicit monetary CO_2 value to use in cost-benefit calculations, and some do not. For example, in California, CO_2 is one of the air emissions (along with NO_X and PM) included in the California Public Utilities Commission's (CPUC's) avoided costs for energy efficiency. The CO_2 avoided cost adder had an initial value of $8 per ton of carbon dioxide equivalent in 2004, and escalates annually thereafter at 5% per year. As Figure 3-3 shows, the carbon adder in California has a measurable impact on the average avoided cost of efficiency programs, although relative

Figure 3-3. Average Avoided Costs for Air Conditioning, Outdoor Lighting, and Refrigeration in California



Source: Energy & Environmental Economics, Inc. and Rocky Mountain Institute, 2004.

Figure 3-4. Average Electricity Sector CO_2 Emission Rate by Region in 2004



Note: Regions are as defined on the map.

Source: EPA, 2007a.

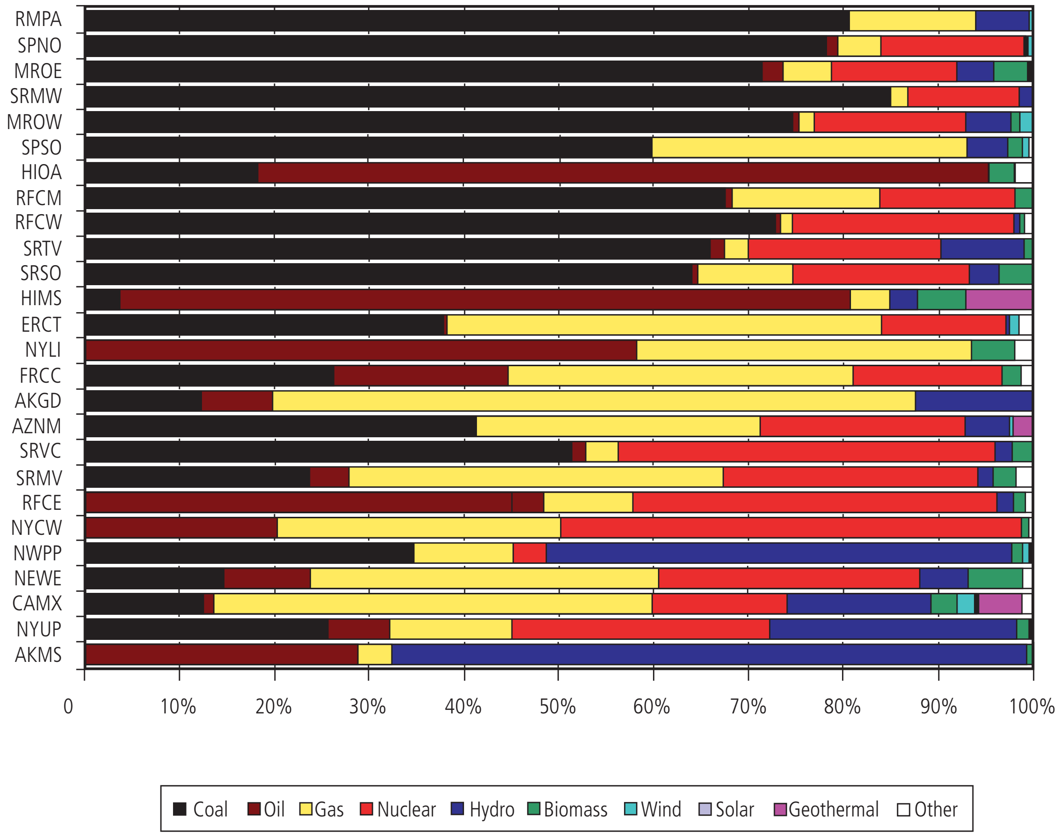
to savings from generation, the carbon adder impact remains fairly modest.[3]

The GHG profiles of electricity generation in the United States differ greatly by technology, fuel mix, and region. Figure 3-4 shows the variation among the 26 regions defined in the U.S. EPA's eGRID emissions tracking database. The highest annual average emission rate in 2004 was 2,036 lbs CO_2/MWh, and the lowest was 480, with a national average of 1,363.

A very rough estimate of GHG emissions savings from energy efficiency can be obtained by multiplying the kWh saved by an average emission factor, which can be taken from a data source such as the eGRID regional average emissions factors in Figure 3-5. Alternatively, it can be estimated based on a weighted average of the heat rates and emission factors for the different types of generators in a utility's generation mix. Such "back of the envelope" methods are not a substitute for using marginal emission rates in formal calculations, but they can be useful for agency staffs and others who wish to check quickly whether results from more sophisticated methods are approximately accurate.

Marginal emissions rates that more accurately reflect the change in emissions due to energy efficiency have an hourly profile that varies by region. For states in which natural gas is both a baseload and peaking fuel, marginal emissions will be higher during peak hours because of the lower thermal efficiency of peaking plants, and therefore energy efficiency measures that focus their kWh savings on-peak will have the highest avoided GHG emissions per kWh saved. However, in states in which coal is the dominant fuel, off-peak marginal emission rates may actually be higher than on-peak, if the off-peak generation is coal and on-peak generation is natural gas. An illustration of this is shown in Figure 3-6, which compares reported marginal emission rates for California and Wisconsin.

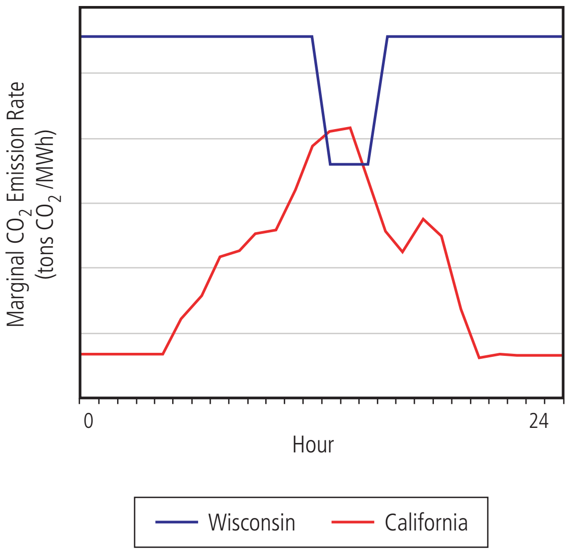
Figure 3-5. Generation by Fuel Type and Region in 2004



Note: See Figure 3-4 for region definitions.

Source: EPA, 2007b.

Figure 3-6. Comparison of Marginal CO_2 Emission Rates for a Summer Day in California and Wisconsin



Note: The on-peak marginal emissions rates of both states are set by natural gas peaking units. The off-peak rates are quite different, reflecting the dominance of coal baseload generation in Wisconsin and natural gas combined cycle in California.

Source: California Energy Commission. Erickson, J. et al., 2004.

3-8 Guide to Resource Planning with Energy Efficiency

3.4 Forecasting Methodologies and Data Sources

Since energy efficiency measures are often long-lasting, the forecasting methods required to evaluate energy efficiency must span a long time-frame. For example, if a new residential heating, ventilation, and air conditioning (HVAC) system is expected to operate for 20 years, then a 20-year forecast must be developed to value an HVAC measure. Typically, a minimum length of 20 to 30 years must be developed to include all of the possible measures. A combination of market-based and forecast-based approaches, as described in Section 3.4.1, can be used to estimate avoided costs.

3.4.1 Market-Based Approaches

Market Price of Energy

One approach to valuing savings is to use the current market price of energy for future delivery. In most markets, transaction price data can provide the value of energy savings for 4 to 6 years. Beyond the available market period, a forecast approach must be used. The following list shows the common sources of market data that are available.

Electricity markets (available out ~4 years):

- Electricity futures price data from futures exchanges (e.g., NYMEX and IntercontinentalExchange [ICE]).
- Forward price data from bilateral wholesale electricity trades (e.g., summaries by Platt's MW Daily).
- Daily locational marginal prices for next day delivery (e.g., ERCOT, PJM, ISO-NE, and NY ISO), which provide hourly price "shape" information, but are only available a day ahead.

Natural gas markets (available out ~6 years):

- Futures price data from futures exchanges (e.g., NYMEX futures contract for Henry Hub delivery).
- Basis price data for a delivery point that differs from the cash market underlying the futures contract (e.g., PG&E Citygate basis data from NYMEX ClearPort trading).

Market Prices of Capacity

Some U.S. regions (e.g., the Northeast) have capacity markets for electricity that require a utility to purchase capacity to meet its expected peak load. In these markets, generators bid to supply, and utilities bid to purchase, capacity to meet their forecasted peak loads and reserve margins. These payments support the carrying costs of existing power plants and provide a price signal for power plant investment. Depending on the market, different time-frames will be available. In some regions (e.g., New England), capacity prices are being developed for several years into the future. In other jurisdictions, capacity auctions establish prices the season prior to delivery. For example, the New York ISO's ICAP auction establishes capacity prices for the upcoming season in 6-month intervals (NYISO, 2007).

In regions without a capacity market, there can still be a capacity value of energy efficiency. In this case, the value of electric capacity is the reduced cost of building or contracting with new power plants to serve peak load.

3.4.2 Modeling Approaches

Beyond the near term for which actual market price data for future delivery may be available, a forecast must be used to quantify long-term avoided costs. There are several main approaches to developing such long-term forecasts.

Production Simulation Modeling

One approach to valuing electricity energy and capacity is to develop a forecast using production simulation modeling. A production simulation model is a software tool that performs system dispatch decisions to serve load, as driven by the transmission constraints and economics of each type of generation resource. The operating cost of the least efficient power plant, the "marginal unit," is used to establish the avoided cost of energy. In addition to the marginal energy cost, the production simulation tools can be used to determine when new power plants and transmission lines are needed, and how additional power plants would change the dispatch of the system. Increasing the load forecast over time allows a forecast of marginal energy costs to be developed.

The downside of production simulation models is that they are complex, rely on sophisticated algorithms that can appear as a "black box" to stakeholders, and have to be updated when market prices of inputs such as natural gas change. They can also have difficulty predicting market prices, since the marginal energy cost is based on production cost, rather than supply and demand interactions in a competitive electricity market.[4]

Developing a Long-Term Forecast for Electricity

The typical approach to developing a long-term forecast for electricity price is to use the Cost of New Entrant (CONE). In this approach, the avoided cost is set at the "all-in" cost of the next generation resource, which may be a new natural gas combined-cycle gas turbine, but possibly also a pulverized coal plant or integrated gasification combined cycle (IGCC) plant. The term "all-in" means both the costs of building the power plant (e.g. the capacity costs) and the costs of generating electricity such as fuel, maintenance, and other costs (e.g. energy costs). For regions with an energy market, the idea is that if the market prices rise above this level, they induce entry and competition will drive down prices. For vertically integrated utilities, the "all-in" cost is the cost savings of not having to build and operate the next new power plant. The method works in both cases.

A similar approach is to develop a long-term forecast of electricity capacity value using the cost of a new combustion turbine (CT). Since a CT is often the least cost technology to serve peak load, it is often used as the value of peak load relief.

The two approaches are related by the economic tradeoff between a baseload plant (e.g., IGCC) and a peaking plant (e.g., CT). A baseload plant has higher capacity cost but lower fuel cost than a peaking plant. The decision to build a baseload plant reflects an expectation that the plant's many operation hours per year will yield fuel cost savings that will more than offset the capacity cost difference between the two plant types. This line of reasoning also explains the use of the capacity cost of a peaking plant to value energy efficiency's kW impact, as the plant has lower capacity cost than a baseload plant.

3.5 Integration with Supply-Side Capital Planning

In addition to the avoided costs of displaced electricity and natural gas, integration of energy efficiency and supply-side capital planning can defer investments in supply-side infrastructure and lead to additional value from energy efficiency. Through coordination with the supply-side planning process, energy efficiency programs can target areas where peak loads are forecasted to exceed ratings of existing infrastructure, thereby deferring or eliminating the need to invest. Potential targets include transmission and distribution facilities, power plants, natural gas pipelines, and LNG terminals.

Coordination with the supply-side planning processes is important to capture value. Typically, supply-side planners use a set of pre-defined reliability criteria, and build new supply-side investments when the existing infrastructure is expected not to reliably serve the forecasted peak load. Depending on the type of investment, the reliability criteria may be different. For example, a new electric distribution transformer may be added when the existing substation can no longer serve the forecasted load with the single largest piece of equipment out of service (called N-1 criteria). For natural gas infrastructure, the reliability criteria may be based on the pressure available when winter temperatures drop and natural gas usage spikes. In both cases, energy efficiency can reduce the peak load and delay the need for investment to maintain the target reliability level. However, if the supply-side planners do not anticipate the load reductions from energy efficiency, they may proceed with their project and no savings will be achieved.

Calculating the value of deferring supply-side investments is typically done with a differential revenue requirement method, also known as the Present Worth Method. The approach calculates (a) the present value revenue requirement without the investment in energy efficiency and (b) the present value revenue requirement with the investment in energy efficiency. If the supply-side investments can be delayed because of the load

reduction achieved with energy efficiency, (a) exceeds (b) and the positive difference between (a) and (b) is the savings due to the energy efficiency investment.

Equation 3.1 can be used to calculate the value of energy efficiency using the Present Worth Method. The present value of deferring capacity in year 1 for Δt years is:

$$PW = \sum_{t=0}^{n} \frac{k_t}{(1+r)^t} - \sum_{t=0}^{n} \frac{k_t(1+i)^{\Delta t}}{(1+r)^{t+\Delta t}} \qquad \textit{(eq. 3.1)}$$

Where: n = planning horizon in years

k_t = distribution investment in year t

i = infl ation rate net of technological progress

r = a utility's cost of capital (discount rate)

Δt = deferral time, i.e., peak load reduction divided by annual load growth

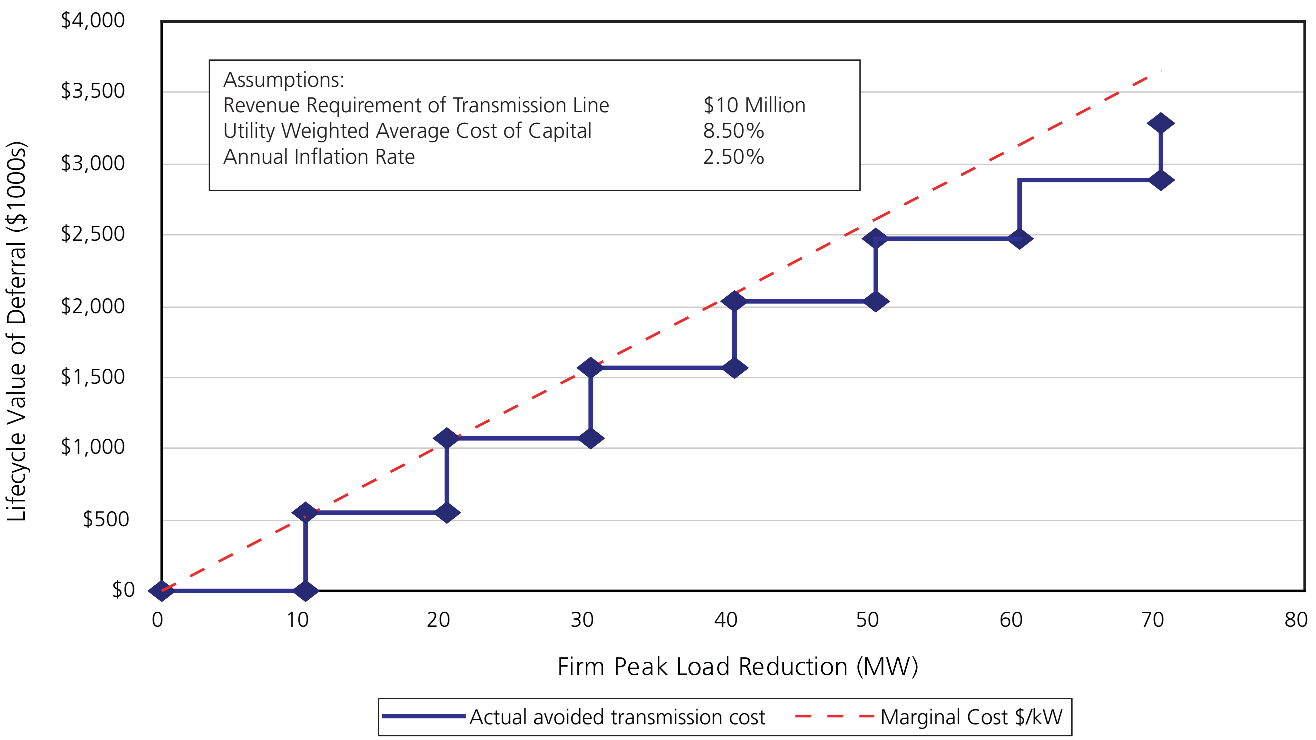
The decision to invest in supply-side infrastructure is typically made year by year. If the existing infrastructure is sufficient to reliably supply an area through the annual peak period (summer or winter, depending on the region and fuel type), then it will be sufficient until the following year. The size of supply-side investments and the annual decision of investments make the value of avoiding supply-side investments "blocky" in nature. The value of a one-year deferral is achieved only if enough load reduction is achieved to defer a project for a year. No additional savings are achieved until enough energy efficiency is implemented for a two-year deferral, and so on.

However, for simplicity in evaluation of energy efficiency programs, a "marginal avoided capacity cost" is often calculated and expressed as the value per kW of peak reduction. The \$/kW marginal cost is calculated by dividing the deferral value by the amount of load reduction required to defer the plan by a year. Equation 3.2 can be used to calculate the marginal avoided capacity cost.

$$\text{\$/kW marginal cost} = \frac{\text{PW deferral value}}{\text{deferral kW}} \qquad \textit{(eq. 3.2)}$$

Where: PW deferral value = result in Equation 3.1 above

Figure 3-7. Example of the Value of Deferring a Transmission Line



Note: Marginal cost is an approximation that ignores (1) 'blocky' nature of avoided transmission cost, and (2) decreasing returns to additional MWs. For illustrative value based on author's calculations and not an actual system representation.

deferral kW = the amount of load reduction needed to get a 1-year deferral (i.e., Δt = 1 in Equation 3.1)

For example, Figure 3-7 shows that the value of deferring a transmission investment is the solid line with the "step" shape calculated using Equation 3.1, under the assumptions that the revenue requirement of this line is $10 million present value, the load growth is 10 MW per year, r = 8.5% WACC, and i = 2.5% inflation. In addition, we assume that the line can be deferred for Δt = 1 year for every 10 MW of peak load reduction from energy efficiency. Based on Equation 3.2, these assumptions imply a marginal avoided capacity cost of $52.30/kW of load reduction, as shown by the dotted line.

If 30 MW of load reduction is achieved, the transmission line is deferred for 3 years, yielding a total deferral value of is $1,569,000. If only 5 MW of load reduction are achieved, the transmission line is not delayed, resulting in no cost savings. Hence, while it is convenient to use the marginal value and apply avoided cost per kW, it is important to check (1) if sufficient load reduction can be achieved and (2) if that load reduction is realistic and acceptable to the supply-side planners.

The Present Worth method based on Equations 3.1 and 3.2 produces $/kW capacity costs. Sometimes it is more convenient to express the value of load reduction in $/kW-year estimates. For example, the $/kW-year estimate is useful to gauge the size of an annual incentive to be paid to a customer to reduce load. Equations 3.3 and 3.4 use a capital recovery factor (CRF) to annualize the avoided costs calculated in Equations 3.1 and 3.2.[5]

$$\text{annual value (\$/Year)} = \text{lifecycle value (\$)} \times \text{CRF} \qquad \textit{(eq 3.3)}$$

$$\text{annual marginal value (\$/kW-year)} = \text{marginal cost (\$/kW)} \times \text{CRF} \qquad \textit{(eq 3.4)}$$

Where: $\text{CRF} = \dfrac{r(1+r)^n}{(1+r)^n - 1}$

n = planning horizon in years

r = a utility's cost of capital (discount rate)

3.6 Resources on Energy Efficiency Avoided Costs

Title/Description		URL Address
Sources of Market Value of Energy	NYMEX Natural Gas Futures prices show current market estimates of natural gas traded at Henry Hub.	<www.nymex.com/ng_fut_csf.aspx?product=NG>
	Basis Swap Contracts between Henry Hub and other location in the U.S. are also traded at NYMEX.	<www.nymex.com/cp_produc.aspx#ngb>
	Platt's MW Daily reports broker quotes of long-term forward electricity transactions.	<www.platts.com>
Sources of Publicly Available Forecasts	*DOE EIA Annual Energy Outlook* uses the National Energy Modeling System (NEMS) to publish a publicly available long-term forecast of electricity and natural gas prices.	<www.eia.doe.gov/oiaf/aeo/index.html>
	Forecasts of fuel prices to electric generation	<www.eia.doe.gov/oiaf/aeo/excel/figure65_data.xls>

Title/Description		URL Address
Sources of Publicly Available Forecasts	Forecast of well-head and Henry Hub Natural Gas prices.	<www.eia.doe.gov/oiaf/aeo/excel/figure71_data.xls>
Integration of Energy Efficiency and Supply-Side Planning	*Expansion of BPA Transmission Planning Capabilities* (November 2001) describes an improved transmission planning process for BPA to incorporate energy efficiency, distributed generation, and demand response.	<www.transmission.bpa.gov/PlanProj/bpa_tbl_planning.pdf>
	The Non-Wires Solutions Roundtable is a group organized by the BPA to evaluate issues surrounding using non-wires solutions, including energy efficiency, to avoid the need for transmission projects.	<www.transmission.bpa.gov/PlanProj/Non-Wires_Round_Table/default.cfm?page=news>

3.7 Resources on Energy Efficiency and Greenhouse Gases

Title/Description	URL Address
EPA's eGRID (Emissions and Generation Resource Integrated Database). A comprehensive inventory of environmental attributes of all U.S. power plants that provide electricity to the grid, including CO2 emissions data.	<www.epa.gov/cleanenergy/egrid/index.htm>
Power Profiler.	<www.epa.gov/cleanenergy/powerprofiler.htm>
Personal Greenhouse Gas Emissions Calculator.	<www.epa.gov/climatechange/emissions/ind_calculator.html>
Climate Leaders: Indirect Emissions from Purchases/Sales of Electricity and Steam.	<www.epa.gov/climateleaders/docs/indirectelectricityguidance.pdf>
EIA (Energy Information Administration, U.S. Department of Energy). Energy-related greenhouse gas emissions data and reporting.	<www.eia.doe.gov/environment.html>
California Climate Action Registry. California emissions inventories and reporting protocols.	<www.climateregistry.org>
The Climate Registry. A multi-state and -tribe collaboration aimed at developing and managing a common greenhouse gas emissions reporting system.	<www.theclimateregistry.org/>

3.8 Notes

1. This key question is based on the National Action Plan for Energy Efficiency recommendation to "recognize energy efficiency as a high priority energy resource" and options to consider.

2. Installed capacity (ICAP), or unforced capacity (UCAP) in some markets, is an obligation of the electric utility (load serving entity, or LSE) to purchase sufficient capacity to maintain system reliability. The amount of ICAP an LSE must typically procure is equal to the LSE's forecasted peak load plus a reserve margin. Therefore, reduction in peak load due to energy efficiency reduces the ICAP obligation.

3. The calculations for hourly avoided costs are based on the hourly normalized load shape for air conditioning, outdoor lighting, and refrigeration for one climate zone in California (climate zone 12).

4. Some commonly used production models include GE MAPS™, PROSYM™, IPM™, and PLEXOS for Power Systems™.

5. Note that CRF is equivalent to the PMT function in MS Excel.

4: Development of Energy Efficiency Measures

This chapter provides a discussion of how to develop energy efficiency measures.[1] Measures are specific actions taken to reduce a specific type of load and are the building blocks of a utility's energy efficiency portfolio.

High-Level Summary

- Specific actions to improve energy efficiency are called *measures*.
- Measures are the building blocks for energy efficiency efforts. Measures are typically aggregated together into *programs* that focus on delivery mechanisms, market segments, or end uses. Programs are then aggregated into a *portfolio* at the utility or program administrator level.
- For planning, the key elements of a measure are its kWh and kW impacts, and its incremental cost.
- Measure impacts can be estimated by performing engineering calculations, often done with building energy simulation software models such as DOE-2, and by referring to existing databases. Estimated impacts are often referred to as *deemed savings*.
- Evaluation, measurement, and verification is performed to obtain actual impacts, which can be used for performance evaluation and to improve future impact estimates.

Key Questions for Utilities and Regulators

- Are we missing any good energy savings opportunities?[2] Measures are the building blocks for energy efficiency efforts. Measures are typically aggregated together into programs that focus on delivery mechanisms, market segments, or end uses. Programs are then aggregated into a portfolio at the utility or program administrator level.
- Have we developed measures and programs that provide savings to the range of residential, commercial, industrial, agricultural and other energy user types? For example, do we have measures to address the harder-to-reach customers such as low-income and small commercial customers? Measure impacts can be estimated by performing engineering calculations, often done with building energy simulation software models such as DOE-2, and by referring to existing databases. Estimated impacts are often referred to as deemed savings.
- Do we have a mix of measures so that we are able to reach customers at different stages of the energy efficiency purchase decision? (New construction, retrofit, replacement of failed old equipment, early replacement to high efficiency devices, etc.)
- Have we considered the way that energy efficiency measures can be integrated together into a comprehensive approach that considers the interactions and potential for overlap between measures?

4.1 Developing Energy Efficiency Measures

The building block of a utility's energy efficiency portfolio is the *measure*. A measure is a specific action taken to reduce a specific type of load. For example, replacing T-12 lamps with T-8 lamps is a lighting efficiency measure, and replacing a SEER 10 air conditioner with a SEER 13 air conditioner is a space conditioning efficiency measure. A lighting efficiency *program* typically consists of many different lighting measures, and a *portfolio* is the aggregate of all of the programs including lighting, space conditioning, and others.

Developing efficiency measures involves identifying the loads on the system and determining the cost and impact of the different means available for reducing them. The importance of developing efficiency measures in a thorough, bottom-up fashion cannot be overemphasized, although it is sometimes obscured by the availability of large databases of measures—which may or may not be applicable—and by the challenges of data management. Measures, by definition, are critical because they are the point at which creative ideas and new technologies can best be incorporated into the efficiency portfolio.

4.1.1 Measure Costs and Impacts

From the planning standpoint, the key elements of each measure are its load impact and its incremental cost. There are two types of impact: energy and demand. Energy impact is the decrease in kWh due to the measure, and demand impact is the decrease in peak kW. (Chapter 7 details the different ways in which energy and demand impacts are defined and calculated.)

Ideally, efficiency improvements would occur the first time an end-user decides to buy a piece of energy-using equipment—appliances for the home, the building design and structure for a new office building, or the manufacturing devices and processes in a new factory. Quite often, however, energy efficiency measures are applied after the initial purchase. Some occur when an old device reaches the end of its useful life, for example when a water heater wears out. However, some energy efficiency programs offered by a utility seek to motivate energy users to replace inefficient devices with high-efficiency devices years earlier than the device's natural lifetime. Incremental cost depends on the manner in which the measure is implemented. For example, the incremental cost of "early replacement" differs from the cost of "failure replacement," since early replacement incremental costs are the whole amount of the new efficient equipment being purchased and failure replacement incremental costs are only the costs to upgrade from the standard device that the customer would have purchased to the efficient device.

Table 4-1 summarizes the basic method for quantifying the impacts and incremental costs of efficiency measures for different types of replacement. In the table, "Efficient Device" refers to the equipment that replaces an existing less-efficient piece of equipment. "Standard Device" refers to the equipment that would be used in industry standard practice to replace an existing device. "Old Device" refers to the existing equipment to be replaced. All of the formulas in the table can also be expanded to include an adjustment term, for example a weather adjustment in the case of an air conditioning measure.

Estimation of Measure Impacts

There are three principal methods by which utilities develop and refine estimates of the impact of energy efficiency measures. These methods are described below, followed by a list of links to some frequently used examples of each method.

- **Engineering calculations and building energy simulation software models.** Utilities can do their own calculations of the energy and demand impacts for a particular measure, given an existing set of technologies, building stock, load patterns, etc. This is typically done with the help of software tools that model energy consumption under different weather conditions and over the course of a year. Some of the more sophisticated models can be quite complex and require specialized training to use.
- **Energy efficiency databases.** Utilities can obtain information from existing databases that contain

Table 4-1. Defining Costs and Impacts of Energy Efficiency Measures

Type of Measure	Incremental Cost ($/unit)	Impact Measurement (kWh/unit and kW/unit)
Failure replacement	Cost of efficient device minus cost of standard device	Consumption of standard device minus consumption of efficient device
New construction	Cost of efficient device minus cost of standard device	Consumption of standard device minus consumption of efficient device
Retrofit	Cost of efficient device plus installation costs	Consumption of old device minus consumption of efficient device
Early replacement	Present value of (efficient device plus installation costs) minus present value of (standard device plus installation costs)	*During remaining expected life of old device:* Consumption of old device minus consumption of efficient device *After normal replacement time for old device:* Consumption of standard device minus consumption of efficient device

Note: The early replacement case is essentially a combination of retrofit treatment (for the period when the existing measure would have otherwise remained in service) and the failure replacement treatment for the years after the existing device would have been replaced. "Present value" indicates that the early replacement costs should be discounted to reflect the time value of money associated with the installation of the efficient device compared to the installation of the standard device that would have occurred at a later date.

energy consumption data for a wide variety of appliances and efficiency measures. While these databases can provide useful information about available measures, the applicability of the data must be carefully considered, particularly for end-uses with weather-dependent consumption. Since the databases are usually specific to a certain geographical area or set of climate zones, their impact estimates may not be transferable for use in a different location (for example, it would be inappropriate to apply California's DEER data to the climate zones of the eastern or southern United States). While corrective adjustments can be made to database impact estimates, they often require an understanding of the underlying methodology.

- **EM&V.** EM&V (also known by other names and acronyms, such as monitoring and evaluation, or M&E) is the use of actual data collected from the operation of already installed measures to determine the actual impacts of these measures. The determination may be based on direct metering and other methods (e.g., statistical inference). EM&V is discussed more thoroughly in Chapter 10 (and in the Action Plan's Model Energy Efficiency Program Impact Evaluation Guide [National Action Plan for Energy Efficiency, 2007b]); in short, it aims to refine estimates obtained from existing databases or engineering models, or to develop a new database that is specific to a utility's climate zone and area if one does not already exist.

4.2 Resources for Energy Efficiency Measure Development

4.2.1 Engineering Software Models

Title/Description		URL Address
DOE-2	Industry standard building energy simulation model, developed by LBNL.	<http://gundog.lbl.gov/dirsoft/d2whatis.html>
EnergyPlus	DOE building energy model based on DOE-2 with additional features.	<www.eere.energy.gov/buildings/energyplus/>
Building Energy Software Tools Directory	Directory of 300+ software tools.	<www.eere.energy.gov/buildings/tools_directory/>
Home Energy Saver	Consumer home energy simulator with simple Web interface.	<http://hes.lbl.gov/>

4.2.2 Databases of Programs, Measures, and Impacts

Title/Description		URL Address
Database of Energy Efficiency Resources (DEER)	California measures database.	<www.energy.ca.gov/deer/>
EPA Energy Star	Savings calculators for ENERGY STAR certified products.	<www.energystar.gov/index.cfm?c=bulk_purchasing.bus_purchasing>
EPRI Database of Energy Efficiency Measures (DEEM)	Available for purchase.	<www.epriweb.com/public/000000000001008848.pdf>
ACEEE Energy Efficiency Program Database	Programs and measures in 20 states.	<www.aceee.org/new/eedb.htm>
Northwest Power and Conservation Council	BPA qualified measures and impacts.	<www.nwcouncil.org/energy/rtf/supportingdata/default.htm>

4.2.3 State Programs and Studies

Title/Description		URL Address
California	**2005 Measure Cost Study.** Final Report. CALMAC Study ID: PGE0235.01. This report provides cost information on the non-weather-sensitive and weather-sensitive residential and nonresidential measures and refrigeration measures that are included in the Database for Energy Efficiency Resources (DEER) and used by energy efficiency program planners in California to estimate potential demand and energy savings and costs.	<http://calmac.org/publications/MCS_Final_Report.pdf>
New Jersey	**New Jersey Clean Energy Program Protocols to Measure Resource Savings.** These protocols were developed to measure energy capacity and other resource savings. Specific protocols are presented for each eligible measure and technology.	<www.njcleanenergy.com/files/file/Protocols_REVISED_VERSION_1.pdf>
Texas	**Deemed Savings, Installation & Efficiency Standards: Residential and Small Commercial Standard Offer Program, and Hard-to-Reach Standard Offer Program.** This document contains all of the approved energy and peak demand deemed savings values established for energy efficiency programs in Texas.	<www.puc.state.tx.us/rules/subrules/electric/25.184/25.184fig(d)(1).pdf>
Vermont	**Technical Reference User Manual (TRM) No. 4-19. Measure Savings Algorithms and Cost Assumptions Through Portfolio 19.** Vermont provides a set of deemed-savings methods in this manual.	<www.efficiencyvermont.org/>

4.3 Notes

1. Projects, one or more measures at a single facility or site, are also aggregated into programs. Considerations at the measure level are applicable to resource planning.
2. This key question is based on the National Action Plan for Energy Efficiency recommendation to "make a strong, long-term commitment to implement cost-effective energy efficiency as a resource" and options to consider.

5: Determining Cost-Effectiveness

This chapter provides a discussion of the various tests used to determine the cost-effectiveness of energy efficiency programs and portfolios. Each test reflects various stakeholder perspectives on the impact of energy efficiency. A discussion on the importance of discount rates is also provided.

High-Level Summary	Key Questions for Utilities and Regulators
• There are several tests for evaluating energy efficiency's cost-effectiveness, each reflecting a different stakeholder perspective on the impact of energy efficiency. • The utility cost test (UCT), also called the program administrator cost test, is consistent with least cost utility resource planning. The UCT compares the utility costs and benefits of energy efficiency. • The total resource cost (TRC) test is typically used to define what is cost-effective from a regulatory perspective. The TRC test compares all of the direct costs that both utilities and customers pay with the regional benefits received from energy efficiency. • Other tests are used to evaluate impacts of energy efficiency on other stakeholders and include such perspectives as the impact on retail rates, participating customers, and society.	• What perspective(s) should we use to determine cost-effectiveness?[1] The utility cost test (UCT), also called the program administrator cost test, is consistent with least cost utility resource planning. The UCT compares the utility costs and benefits of energy efficiency. • Have we defined the appropriate costs and benefits to get the right program trade-offs? Other tests are used to evaluate impacts of energy efficiency on other stakeholders and include such perspectives as the impact on retail rates, participating customers, and society. • Are we using the correct discount rate? • Do we have a Standard Practice Manual for determining cost-effectiveness of energy efficiency to ensure that the criteria used are transparent to stakeholders?

5.1 Overview

For this discussion, we use the criteria developed by the California Energy Commission and CPUC for defining cost-effectiveness: the California Standard Practice Manual.[2] This manual publicly and transparently sets the state standard for determining cost-effectiveness, and helps to further the development and use of consistent definitions of categories, programs, and program elements. Other states now also refer to the California Standard Practice Manual as the source of their own cost-effectiveness criteria. The benefit of having such a standard practice manual is that it both encourages transparency and consistency. The California criteria include five major tests. While other jurisdictions may modify cost-effectiveness definitions to suit their needs, these five tests are generally inclusive of the different perspectives that most jurisdictions consider.

- **Participant cost test (PCT).** Measures the economic impact to the participating customer of adopting an energy efficiency measure.

- **Ratepayer impact measure (RIM).** Measures the impact on utility operating margin and whether rates would have to increase to maintain the current levels of margin if a customer installed energy efficient measures.
- **Utility cost test (UCT).** Measures the change in the amount the utility must collect from the customers every year to meet earnings target, e.g. change in revenue requirement. In a number of states, this test is referred to as the program administrator cost test (PACT). In those cases, the definition of the "utility" is expanded to program administrators (utility or third party).
- **Total resource cost test (TRC).** Measures the net direct economic impact to the utility service territory, state, or region.
- **Societal cost test (SCT).** Measures the net economic benefit to the utility service territory, state, or region, as measured by the TRC, plus indirect benefits such as environmental benefits.

A common misperception is that there is a single best perspective for evaluation of cost-effectiveness. Each test is useful and accurate, but the results of each test are intended to answer a different set of questions. The key questions answered by each cost test are shown in Table 5-1. Note that throughout this discussion we use the term "utility." In some jurisdictions that term should be expanded to include third-party administrators of the energy efficiency programs.

Table 5-1. Questions Addressed by the Various Cost Tests

Cost Test	Questions Addressed
Participant Cost Test	Is it worth it to the customer to install energy efficiency? Is the customer likely to want to participate in a utility program that promotes energy efficiency?
Ratepayer Impact Measure	What is the impact of the energy efficiency project on the utility's operating margin? Would the project require an increase in rates to reach the same operating margin?
Utility Cost Test (Also Called Program Administrator Cost Test)	Do total utility costs increase or decrease? What is the change in total customer bills required to keep the utility whole (the change in revenue requirement)?
Total Resource Cost Test	What is the regional benefit of the energy efficiency project including the net costs and benefits to the utility and its customers? Are all of the benefits greater than all of the costs (regardless of who pays the costs and who receives the benefits)? Is more or less money required by the region to pay for energy needs?
Societal Cost Test	What is the overall benefit to the community of the energy efficiency project, including indirect benefits? Are all of the benefits, including indirect benefits, greater than all of the costs (regardless of who pays the costs and who receives the benefits)?

Table 5-2. Benefits and Costs of Various Test Perspectives

Tests and Perspective	Energy Efficiency Benefits	Energy Efficiency Costs
Participant Cost Test	Incentives from utility and others, plus reduction in electricity bill	Participants' direct cost of participation
Ratepayer Impact Measure	Avoided supply costs (production, transmission, and distribution) based on net energy and load reductions	Utility program costs (including administration costs plus incentives to participants) plus net lost utility revenues caused by reduced sales
Utility Cost Test (Also Called Program Administrator Cost Test)	Same as above	Utility program costs (including administration costs plus incentives to participants)
Total Resources Cost Test	Same as above plus benefits that do not affect the utility (e.g., water savings, fuel oil savings)	Utility program costs (excluding incentives to participants) plus net participant costs (prior to any cost reduction due to incentives from the utility)
Societal Cost Test	Same as above plus externality benefits; excludes some tax credit benefits	Same as above

Consideration of Non-Monetary Costs and Benefits

The five cost tests presented above do not explicitly recognize changes in customer non-monetary costs and benefits such as comfort. Generally, energy efficiency programs provide the same service (lighting, refrigeration, cooling, heating) as the inefficient base units they replace, so there is no appreciable change in non-monetary costs or benefits. For other types of programs there can be positive and negative impacts on comfort. For example, the cost of lower comfort during a demand response event that turns off air conditioning should be included. Conversely, the benefit of increased comfort of low-income participants with better heating and insulation should be included. Customer value of service studies can be used to monetize the value of customer comfort as well as the value of avoiding an outage.

The TRC test, which measures the regional net benefits, is the appropriate cost test from a regulatory perspective. All energy efficiency that passes the TRC will reduce the total costs of energy in a region. Thus, regulators of most states use the TRC as the primary cost test for evaluating their energy efficiency programs. The TRC cost test includes only direct costs and benefits, not externalities or non-monetized factors. Regulators who want to consider these factors in the cost test can use the SCT, which does include externalities. The TRC and SCT do not differentiate who pays for the energy efficiency and who receives the benefits. Therefore, the other cost tests are used to evaluate the impact on specific stakeholders.

The UCT is the appropriate cost test from a utility resource planning perspective, which typically aims to minimize a utility's lifecycle revenue requirements. Adoption of an energy efficiency measure that is cost-effective according to the UCT will reduce the utility revenue requirement relative to traditional utility procurement. The UCT and TRC cost tests are related, and most measures that are cost-effective from the TRC

are also cost-effective from the utility perspective. If two measures have the same net benefits from a TRC perspective, but different incentive levels, using the UCT to choose between them will favor the measure with lower incentives, since the costs to the utility are lower to implement this measure.

Table 5-2 lists the specific benefit and cost components in each test for economic screening. Note that the term "net" in Table 5-2 refers to values that are reduced by the net-to-gross ratio (NTGR). Thus, the test focuses on the costs and benefits attributable solely to the program activities.

5.2 Use of Discount Rates

The choice of discount rate can have a large impact on the cost-effectiveness results for energy efficiency. As each cost-effectiveness test compares the net present value of costs and benefits for a given stakeholder perspective, its computation requires a discount rate assumption.

A discount rate measures the time value of money. When expressed in percent per year (say, 10%), it converts a future year's monetary amount (say, $1,100) to an equivalent amount in today's dollars (that is, $1,000 = $1,100 ÷ (1 + 0.1)). In the context of an energy efficiency investment, spending money today to install a measure makes economic sense if the cost today is less than the sum of discounted benefits in future years. Thus, the higher the discount rate, the greater the future benefits are discounted and the harder it is for an energy efficiency investment to be cost-effective.

As each perspective portrays a specific stakeholder's view, each perspective comes with its own discount rate. Thus, the five cost-effectiveness tests listed in Table 5-2 can have different discount rates. Using the appropriate discount rate, the cost-effectiveness tests correctly calculate the net benefits from making an investment in energy efficiency.

Three kinds of discount rates are used, depending on which test is being calculated. For the PCT, the discount rate of an individual is used. For a household, this is taken to be the consumer lending rate, since this is the debt cost that a private individual would pay to finance an energy efficiency investment. It is typically the highest discount rate used in the cost-effectiveness tests. However, since there are potentially many different participants, with very different borrowing rates, it can be difficult to choose a single appropriate discount rate. Based on the current consumer loan market environment, a typical value may be in the 8% to 10% range; this is notwithstanding that a credit card rate can often exceed 20%. For a business firm, the discount rate is the firm's weighted average cost of capital (WACC). In today's capital market environment, a typical value would be in the 10% to 12% range; even though it can be as high as 20%, depending on the firm's credit worthiness and debt-equity structure.

Table 5-3. The Use of Discount Rates in Cost Tests

Tests and Perspective	Discount Rate Used	Illustrative Value	Present Value of $1 a Year for 20 Years	Today's Value of the $1 Received in Year 20
Participant Cost Test	Participant's discount rate	10%	$8.51	$0.15
Ratepayer Impact Measure	Utility WACC	8.5%	$9.46	$0.20
Utility Cost Test	Utility WACC	8.5%	$9.46	$0.20
Total Resources Cost Test	Utility WACC	8.5%	$9.46	$0.20
Societal Cost Test	Social discount rate	5%	$12.46	$0.38

For the SCT, the social discount rate is used. The social discount rate reflects the benefit to society over the long term, and takes into account the reduced risk of an investment that is spread across all of society, such as the entire state, or region. This is typically the lowest discount rate. For example, California uses 3% real discount rate (~5% nominal) for evaluation of cost-effectiveness of the Title 24 Building Standards.

Finally, for the TRC, RIM, or UCT/PACT, the utility's WACC is typically used as the discount rate. The WACC takes into account the average cost of borrowing of the utility, and is the same rate used to borrow money for other utility resource investments on the supply-side. The WACC is typically between the participant discount rate and the social discount rate. The correct application of discount rates to the five SPM cost-effectiveness tests is shown in Table 5-3. For example, California currently uses 8.6% for evaluation of the investor-owned utility energy efficiency programs.

Using these illustrative values for each cost test, Table 5-3 shows the value of receiving $1 per year for 20 years from each perspective. This is analogous to the value of not having to purchase $1 of electricity per year. From a participant perspective assuming a 10% discount rate, this stream is worth $8.51; from a utility perspective it is worth $9.46; and from a societal perspective it is worth $12.46. The effect of discount rate increases over time. The value today of the $1 received in the 20th year ranges from $0.15 from the participant perspective to $0.38 in the societal perspective, more than twice as much. Since the present value of a benefit decreases more over time with higher discount rates, the choice of discount rate has a greater impact on energy efficiency measures with longer expected useful lives.

5.3 Resources for Determining Cost-Effectiveness

Title/Description		URL Address
California	**The California Standard Practice Manual: Economic Analysis of Demand Side Programs and Projects.** This manual describes cost-effectiveness procedures for conservation and load management programs from four major perspectives: participant, RIM, PACT, and TRC. A fifth perspective, the societal test, is treated as a variation on the TRC test.	<http://calmac.org/publications/MCS_Final_Report.pdf> <www.energy.ca.gov/greenbuilding/documents/background/07-J_CPUC_STANDARD_PRACTICE_MANUAL.PDF>
Oregon	**Cost-Effectiveness Policy and General Methodology for the Energy Trust of Oregon.** This report describes the Energy Trust of Oregon's policy for analyzing the cost-effectiveness of its energy efficiency investments. This policy encompasses three generic perspectives: consumer, utility system, and societal.	<www.energytrust.org/library/policies/4.06_CostEffect.pdf>
All States	**Tools and Methods for Integrated Resource Planning: Improving Energy Efficiency and Protecting the Environment.** This report provides information on calculating and analyzing the cost-effectiveness of energy conservation measures against supply-side options, as well as methods for IRP.	<www.uneprisoe.org/IRPManual/IRPManual.pdf>

5.4 Notes

1. This key question is based on the National Action Plan for Energy Efficiency recommendation to "make a strong, long-term commitment to implement cost-effective energy efficiency as a resource" and options to consider.

2. For more details, including specific formulas for each cost test, download the California Standard Practice Manual: <www.energy.ca.gov/greenbuilding/documents/background/07-J_CPUC_STANDARD_PRACTICE_MANUAL.PDF>.

6: Development of Energy Efficiency Programs and Portfolios

This chapter provides a discussion of the types of energy efficiency programs and their characteristics and objectives. A brief discussion of the importance of including criteria beyond cost-effectiveness is also provided.

High-Level Summary	Key Questions for Utilities and Regulators
• There are different types of energy efficiency programs, each with their own advantages and disadvantages.The utility cost test (UCT), also called the program administrator cost test, is consistent with least cost utility resource planning. The UCT compares the utility costs and benefits of energy efficiency. • More than cost-effectiveness should be considered when building up an energy efficiency program: criteria include energy savings, cost-effectiveness, continuity of programs, service for all customer classes, education, and other factors.	• Have we clearly defined the program and portfolio criteria? • Have we developed a program that is cost-effective, achieves energy savings, and meets other criteria appropriate for our service territory?[1] Are we using the correct discount rate? • Does the portfolio of programs reach all of the customer classes and consider all of the energy efficiency opportunities?

6.1 Types of Programs

There are different types of energy efficiency programs, each of which has its own advantages, disadvantages, and considerations. Table 6-1 summarizes the major different types.

Another way to categorize energy efficiency programs is by their intended objective. The following list summarizes common efficiency program objectives:

- **Resource acquisition.** Primary objective is to directly achieve energy and/or demand savings, and possibly avoid emissions through specific actions.
- **Market transformation.** Primary objective is to change the way in which energy efficiency markets operate (how manufacturers, distributors, retailers, consumers, and others sell and buy energy-related products and services); tends to cause energy and/or demand savings in a more indirect manner.
- **Increased stringency of codes and standards.** Primary objective is to define and enforce mandated levels of efficiency in buildings and products.
- **Education and training.** Primary objective is to inform consumers and providers about energy efficiency and encourage them to act on that information.
- **Multiple objectives.** Objectives can include some or all of the above-listed objectives.

Other programs often associated with efficiency, but which are aimed at reducing capacity requirements, not energy consumption, are load shifting and demand response programs. These programs are intended to modify energy (typically electricity) TOU patterns and may increase consumption, decrease consumption, or not affect consumption at all.

Table 6-1. Energy Efficiency Program Types

Program Type	Characteristics
Energy Audit	An energy audit is a survey or site visit to a customer premise by a knowledgeable contractor or utility representative. The audit is part review of customer equipment, part education of the customer, and part marketing of appropriate energy efficiency programs to the customer. Best practices in energy audits both increase awareness of how to improve building efficiency and encourage building-owners to follow through in the implementation of the audit's recommendations. In EPA and DOE's program "Home Performance with ENERGY STAR," specially trained contractors evaluate homes, recommend comprehensive improvements, and may encourage homeowners to take advantage of federal tax credits for energy efficiency improvements.
Rebate Program	**Cash rebate program:** Provides customers with a cash rebate toward the purchase of a high-efficiency appliance or device. **Upstream rebate program:** provides a rebate to the manufacturer or wholesaler so that they can discount the final price to the customer. Eliminates the need for the customer to apply for the rebate to receive the discount.
Direct Install Program	Utilities, or utility-hired third-party contractors, directly install energy efficiency measures for customers. For example, a commercial lighting retrofit program may directly install new, energy-efficient lighting. This type of program can improve the quality of the installation and make it easier for customers to participate in the program.
Education and Training Program	Efforts to educate and train customers, retailers, architects, contractors, and building inspectors to identify energy efficiency opportunities, properly install energy savings measures, and maintain equipment so that it continues to operate as efficiently as possible.
Loans and On-Bill Financing or Grants	Programs to remove the disincentive caused by the initial cost of energy efficiency measures.
Bidding/Standard Performance Contracts	Allow contractors to develop programs and deliver savings to the program administrator. The contractor can often leverage existing relationships with customers more effectively than a utility or program administrator's agent.
Upstream and Midstream Incentives	Program administrators provide incentives or assistance to manufacturers, distributors, or dealers to promote energy-efficient products.

Table 6-1. Energy Efficiency Program Types (continued)

Program Type	Characteristics
Failure Replacement Program	Targets customers to purchase and install high-efficiency equipment or appliances at the time that they replace old energy using equipment—for example, encouraging customers to purchase ENERGY STAR–certified equipment. Informing participants of the program when they are replacing equipment can help keep recruitment costs low. This can be done through working with retailers and rebates at the cash register, or working with contractors whose business is in equipment replacement (e.g., HVAC contractors).
Early Replacement Program	Replaces existing equipment/appliances that are currently working and in use with more efficient units. Generally more costly than failure replacement because it requires an incentive closer to the entire cost of the efficient unit to attract customers. As in failure replacement, targeting the most likely participants can keep recruitment costs low. This can be done by approaching customers with the most opportunity. Commercial lighting retrofits are a successful example of this approach.
New Construction Program	Targets new construction as the time to install energy efficiency measures that go above and beyond the building standard. Sometimes called "lost opportunity" programs because many of the energy efficiency upgrades that must be designed into the building are expensive or impossible to develop once the building is complete (Northwest Power and Conservation Council, 2005).[2]
Commissioning	After an energy efficiency project or new building is completed, confirms that the building is operating properly. For example, confirms that the building shell is tight and the ducts are not crushed or bent. It is possible to reward builders who construct an energy-efficient home with a cash rebate and/or certification/award.

6.2 Criteria to Use in Developing Programs

Developing an energy efficiency program is not just about maximizing cost-effective energy and capacity savings. There are often additional criteria to consider, such as making sure that there are programs for all classes and for low-income and hard-to-reach customers, that programs have continuity, and that programs provide for education. There may also be other utility, regional, or policy factors to consider in developing the energy efficiency program.

Another common example is a focus on initiatives to serve the new construction market to minimize lost opportunities for energy efficiency. While new buildings are more efficient than the existing building stock, failure to capture opportunities at the initial construction stage can result in long-term energy efficiency losses.

Generally, programs are designed so that they meet some minimum level of aggregate cost-effectiveness at

the portfolio level. In the case of requests for proposals (RFPs) for energy efficiency, cost-effectiveness could be required at the program level, although this requirement is often relaxed for programs that target low-income and underserved market segments.

As the requirements for a satisfactory program and portfolio are driven by jurisdictional policies, there is no single definition. However, as an example, we have listed the criteria that the Public Utilities Commission uses in evaluating utility and contractor energy efficiency programs in California.

Criteria from California

The portfolio must adhere to available funding by utility territory and have a total resources cost (TRC) ratio greater than one, and we ask staff to compile a portfolio of programs that balances the following goals:

- Maximized energy savings.
- Strong cost effectiveness.
- Equitable geographic distribution.
- Diversity of target markets.
- Equity by rate class.
- Equity between gas and electric program offerings and energy savings.
- Diversity of program offerings.
- Multiple languages offered to program participants

(CPUC, 2004)

6.3 Resources for Developing Energy Efficiency Programs and Portfolios

Title/Description	URL Address
Electric and Gas Conservation Improvement Program Biennial Plan for 2005 and 2006. Docket No. E, G002/CIP-04. This plan was submitted to the Minnesota Department of Commerce by Xcel Energy, June 1, 2004.	URL not available.
Portfolio Management: How to Procure Electricity Resources to Provide Reliable, Low-Cost, and Efficient Electricity Services to All Retail Customers. Biewald, B., T. Woolf, A. Roschelle, and W. Steinhurst (2003). Synapse Energy Economics. October 10.	<www.synapse-energy.com/Downloads/SynapseReport.2003-10.RAP.Portfolio-Management.03-24.pdf>
Interim Opinion: Energy Efficiency Portfolio Plans and Program Funding Levels for 2006–2008—Phase 1 Issues. California Public Utilities Commission [CPUC] (2005). Decisions 05-09-043. (See pp. 122-123 and Attachment 6.) September 22.	<www.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/49859.htm>
Energy Efficiency: Investing in Connecticut's Future. Energy Conservation Management Board [ECMB] (2005). Prepared for the Connecticut Legislature Energy & Technology Committee, Environment Committee. March 1.	<www.env-ne.org/Publications/ECMB%20Annual%20Legislative%20Report%202005.pdf>
The Fifth Northwest Electric Power and Conservation Plan. The Northwest Power and Conservation Council (2005). Document 2005-7. May.	<www.nwcouncil.org/energy/powerplan/plan/Default.htm>

6.4 Notes

1. This key question is based on the National Action Plan for Energy Efficiency recommendation to "make a strong, long-term commitment to implement cost-effective energy efficiency as a resource" and options to consider.

2. A lost-opportunity program seeks to take advantage of the limited time-frame when some conservation measures can be cost-effectively implemented, due to physical or institutional limitations for implementing energy efficiency.

7: Estimating Energy Efficiency Impacts for Resource Planning

Recognizing the demand and capacity impacts of energy efficiency in utility planning creates opportunities to capture additional value from the programs. This chapter provides a discussion of how to estimate and report on the impacts of energy efficiency programs for use in utility planning. In addition, a discussion of how to measure or estimate the greenhouse gas emission reductions is provided.

High-Level Summary	Key Questions for Utilities and Regulators
• The recognition of energy efficiency's kWh and kW impacts in utility planning provides opportunities to capture additional value from the energy efficiency activities. More than cost-effectiveness should be considered when building up an energy efficiency program: criteria include energy savings, cost-effectiveness, continuity of programs, service for all customer classes, education, and other factors. • There are several methods for developing impact estimates, as well as information available from jurisdictions across the United States.	• Do the estimates, especially of peak reductions, reflect the unique characteristics of our region? There are several methods for developing impact estimates, as well as information available from jurisdictions across the United States. • Do the estimates reflect expected or overly optimistic levels?

7.1 Overview

Energy efficiency delivers value to the utility and its customers through reductions in energy usage and reductions in capacity requirements. Depending upon the regulatory structure and markets in which the utility operates, the value provided from energy and capacity reductions can vary widely. Generally, utilities have analysts that perform energy and capacity forecasts for planning or procurement purposes, and this Guide is not meant to replicate or supplant that work. Rather, the Guide focuses on forecasting energy efficiency reductions for use in resource planning.

7.2 Estimation of Energy Efficiency Reductions

There are two main approaches for estimating energy efficiency reductions: top-down or bottom-up. EM&V studies can also be used to refine estimates produced from either approach.

The top-down approach is generally less time-consuming than the bottom-up approach that relies on detailed impact data by end-use. For estimating impacts, this approach commonly employs statistical comparison (e.g., regression techniques) of participant and non-participant billing data, or pre- and post-measure-installation billing data. Absent detailed information, data from other utilities or states can also be used at aggregate levels to develop estimates of energy efficiency impacts. This type of analysis may be more applicable for jurisdictions that are newly entering or resurrecting energy efficiency efforts. Potential sources of energy efficiency impact information are listed in Chapter 4. Of course, for weather-sensitive measures, the validity of transferred information will depend upon the similarity of climate characteristics with the original data source.

Bottom-up models construct estimates of energy efficiency program reductions based on savings from specific types of energy efficiency measures. Engineering models are often used in bottom-up analyses to estimate reductions in energy usage based on the performance characteristics of efficient versus standard measures. The level of effort required to utilize engineering models varies widely. In some cases, the analysis can be based on single line engineering formulas such as the difference in wattage for equivalent lumen incandescent and CFLs. In other cases, it can be based on complex building simulation models[1] or detailed industrial process simulations. The basic bottom-up energy formula is shown below. This calculation would be performed separately for each type of energy efficiency measure.

Energy efficiency annual net energy savings:

$$NetkWh_{m,TOU} = \Delta kWh_{m,TOU} \times NTG_m \times Installs_m \quad \text{(eq. 7.1)}$$

Where: $NetkWh_{m,TOU}$ = energy efficiency energy reductions, by TOU period for measure m, that are at tributable to the utility or third-party energy efficiency programs under evaluation

$\Delta kWh_{m,TOU}$ = annual gross reduction in energy during the TOU period

$Installs_m$ = number of installations for measure m

$NTGR_m$ = net-to-gross ratio of the measure

The program-specific NTGR converts the gross annual reductions in energy usage to a net value, thus excluding reductions that would have occurred absent the program. For example, in evaluating a rebate program, the NetkWh should exclude impacts associated with measures that would have been installed to meet building code compliance. NTGR is typically viewed as an adjustment to eliminate free rider[2] effects, but should also account for free-driver effects.[3]

Energy efficiency lifecycle net energy savings:

$$NetkWh\_LC_{m,TOU} = NetkWh_{m,TOU} \times EUL_m \quad \text{(eq. 7.2)}$$

Where: $NetkWh\_LC_{m,TOU}$ = lifecycle energy efficiency energy reductions by TOU period measure for m

EUL_m = expected useful life of the measure (years)

For jurisdictions with deep energy efficiency experience, it is common for utilities to begin with engineering estimates and then refine the estimates as they gain experience and data on both measure performance and NTGR adjustments from actual measure installations. EM&V studies are primary sources of the information needed for these refinements.

Whichever method or methods are used to develop the energy reduction forecast, the forecast should be at a level of time granularity that matches the utility's cost structure. For example, a utility may require forecasts of energy reductions by peak and off-peak periods to match procurement costs.

7.3 Estimation of Peak Capacity Reductions

The estimation of peak capacity uses the same methods discussed for energy estimates. However, the term "peak capacity" can have various meanings, even within the same utility. Following are some example definitions of peak capacity, with potential applications in parentheses.

- **System coincident peak.** Maximum MW demand at the utility level for a single hour in the year. (Long-run generation planning.)
- **"Summer" peak.** Average demand from 2 p.m. to 5 p.m. during the three contiguous business days with the highest average maximum temperature. (Value of peak load reduction.)

- **Monthly peak.** Average of the demands at the time of the single highest demand for each of the 12 months. (Transmission reservation costs.)

- **Loss of load probability (LOLP)–weighted peak.** LOLP is the probability that generation will be insufficient to meet demand at some point over a specified period of time. Demand weighted by relative LOLP values from the utility's production cost models. The LOLPs are normalized so that they sum to 1.0. (Allocation of costs to customer classes using regulatory cost of service model.)

- **100-hour coincident peak.** Average of demands during the utility's 100 highest-load hours. (Regulatory cost of service model.)

In addition to the various definitions of peak capacity, there are different ways to count the energy efficiency impacts. The most straightforward method is to use the expected, or average, impact. However, in some cases, a more conservative measure may be required that de-rates the energy efficiency impacts for any uncertainty in how much load reduction might be provided (the "dependable" reductions). Successful integration of energy efficiency into resource planning will require close coordination between the energy efficiency and planning group to ensure that the appropriate capacity values are estimated.

To incorporate energy efficiency into resource planning, the energy efficiency peak demand reduction should use a definition that corresponds to how the resource planners value capacity. Care must be exercised, however, to ensure that other groups within the utility do not use those same estimates if they do not match that group's application. It is common for numbers to become "set in stone" and misused in applications for which the numbers were not intended. For example, a peak value may be developed for a transmission study that is based on the energy efficiency reduction during the 12 monthly peaks, but then misused in a generation planning application that is concerned only with the single annual peak.

The analysts can use the same engineering or statistical models that they develop for producing energy reduction estimates (assuming that the models have sufficient hourly information to match the peak definitions). Bottom-up forecasts tend to overestimate reductions. A common pitfall is to assume that the largest kW reduction from an energy efficiency measure is the same as that measure's peak demand reduction. This largest kW reduction is the non-coincident peak reduction, and a value typically cited in measure databases. The coincident peak reduction is generally lower than the non-coincident peak reduction because, for example, the timing of the largest reduction does not match the timing of the utility peak, not all measures will be operating at the time of the peak (people are not home), or equipment is not installed or maintained properly. In addition, there are interactive effects that will increase or decrease the reductions depending upon other energy efficiency measures that the customer may or may not have installed.

Another pitfall is to assume that percentage energy savings is the same as percentage demand savings. For example, in California, SEER was used as the primary measure of air conditioning unit efficiency. Codes and standards were written to promote high SEER units in the state, with the untested expectation that the more efficient unit would also help reduce capacity needs. In reality, many manufacturers responded to the SEER metric with high SEER units that had two compressors and could actually cause higher peak demands.

The SEER example also highlights the difference between end use shapes and impact shapes. Utilities often have end use shapes, which are hourly representations of the demand of various classes of equipment, such as indoor lighting, outdoor lighting, refrigeration, heating, air conditioning, and motors. For energy efficiency planning and evaluation, however, the focus is the impact shape—the hourly demand reductions due to the energy efficiency measure.

$$ImpactkW_{m,h} = EndUsekW_h - EndUseEEkW_{m,h} \quad \text{(eq. 7.3)}$$

Where: $ImpactkW_{m,h}$ = energy efficiency impact shape for measure m in hour h

$EndUsekW_h$	=	hourly shape for the end use affected by energy efficiency (prior to energy efficiency)
$EndUseEEkW_{m,h}$	=	hourly shape for end use after energy efficiency is installed

A common way to produce a first order estimate of the energy efficiency reductions is to multiply the percentage energy reduction provided by the measure by the demand shape.

$$ImpactkW_{m,h} = EndUsekW_h - \%EEReduction_m \quad \text{(eq. 7.4)}$$

Where: $\%EEReduction_m$ = reduction in usage due to energy efficiency ÷ total end use kWh prior to energy efficiency

This method is fine for measures such as high-efficiency lighting, for which the energy efficiency reduction occurs evenly across all hours.

In other cases, the reduction shape may not follow the end use shape. For example, increased insulation may reduce usage during moderate times, but not affect usage during the hottest and coldest times. In that case, the impact shape will look less peaky than the end use shape, and Equation 7.3 should be used.

Because of the variety of ways to measure and define peak demand, as well as timing differences across utilities, peak information is generally less transferable than energy impacts. This caution applies to both bottom-up and top-down approaches. The analyst should exercise additional care when using peak demand impacts from other jurisdictions

7.4 Energy Efficiency and Greenhouse Gas Emissions

Growing concerns about climate change are leading many utilities and regulatory bodies to develop resource portfolios that reduce GHG emissions. An important question, then, is how to measure or estimate the reductions in GHG emissions from energy efficiency programs.

In the electricity sector, the most important GHG by far is carbon dioxide (CO_2), although relatively small amounts of other GHGs such as methane (CH_4), nitrous oxide (N_2O), and sulfur hexafluoride (SF_6) are also emitted. To put all of these GHGs on a common footing in terms of their global warming potential, the unit "carbon dioxide equivalent" (CO_2eq) is often used. In 2006, energy-related emissions from the United States as a whole were 5,940 million metric tons CO_2eq, of which 2,357 million metric tons, or about 40%, were from the electricity sector (DOE, 2007).

Energy efficiency indirectly reduces GHG emissions, since for each kWh not consumed the GHG emissions associated with the supply of that electricity are avoided. Energy efficiency can be a highly cost-effective way to reduce GHG emissions, since the non-GHG-related benefits often exceed the costs; incorporating an additional benefit of avoided GHG emissions improves energy efficiency's cost-effectiveness. The calculation of avoided GHG emissions requires two components: the amount of GHG emissions reduced by energy efficiency and the related per unit value of GHG reductions.

7.4.1 Calculating GHG Savings from Energy Efficiency

In general, the higher the GHG emissions associated with electricity supply, the greater the benefit of energy efficiency. For each kWh to be consumed, a larger amount of kWh (up to 110%) must be generated to account for transmission and distribution losses, causing a certain amount of GHG emissions. In addition, small amounts of additional GHGs are emitted in the transmission and distribution system (for example, SF_6 is emitted from high-voltage circuit breakers). For generators that burn fossil fuels, the amount of GHGs emitted per kWh generated is the product of two factors: the carbon content of the fuel and the heat rate (thermal efficiency) of the plant.[4] The carbon content of fuel is primarily a function of the type of fuel, though among a given fuel type such as coal, there can also be some

variation.[5] Table 7-1 shows illustrative CO_2 emission factors for different fuels and heat rates. For actual emissions reporting for a power plant, calculations must be based on actual plant heat rates and the correct emission factors for the specific fuel types used, if the plant does not have a continuous emissions monitoring system in place to measure CO_2 emissions directly.

In addition to the GHG emissions from fuel combustion, there are "upstream" emissions associated with the mining, cleaning, and transportation of fuels to the power plant. Table 7-2 shows estimates in one DOE study of average upstream emission factors for coal and natural gas. In this case, a total emission factor can be obtained by adding the upstream and combustion emission factors together (since both are given in units of lbs/MMBtu), then multiplying the combined factor by the heat rate.

Both fossil fuel and non-fossil-fuel generators, including nuclear, hydroelectric, wind, biomass, and solar, have additional GHG emissions associated with plant construction and decommissioning, shipment of fuel, and the manufacturing and shipment of the generating equipment. These emissions, plus those from actual operation of the generator over its operating life, are considered the plant's lifecycle emissions. At present, total lifecycle emissions are not generally included in resource planning, but the lifecycle emissions of different types of generators are often compared in policy discussions.

The method for calculating emissions savings is to combine marginal emission rates with matching kWh savings from efficiency. ("Marginal emission rates" refers to the emissions associated with the marginal generating unit in each hour of the day. Since peaking units are typically less efficient than baseload units, they have higher emission factors if they use the same fuel, and the marginal emission rate will be higher during peak hours than during off-peak hours. See Section 3.3.4 for exceptions to this rule.)

The first step in the GHG savings calculation is to obtain the regional emissions profile. Figure 7-1 shows the simulated marginal emission rate by hour for a two-week period for California.

The second step in the calculation is to obtain the hourly profile of energy savings due to energy efficiency. This should take into account the time- and location-dependent effect on energy consumption of the different

Table 7-1. Illustrative CO_2 Emissions Factors for Fossil Fuel Combustion

Fuel Type	Fuel Emissions Factor (lbs CO_2/MMBtu)	Heat Rate (Btu/kWh)	Generation Emissions Factor (lbs CO_2/MWh)
Coal	210	12,000 9,500 7,000	2,519 1,995 1,470
Natural gas	117	12,000 9,500 7,000	1,403 1,111 819

Note: Average values based on high heating value and 100% combustion.

Source: DOE, 2006.

Table 7-2. Illustrative Upstream CO_2 Emission Factors for Fuels Used in Electricity Generation, from Mining, Cleaning, and Transportation in California

Fuel Type	Emissions Factor (lbs/MMBtu)	% of Combustion Emissions
Coal	4.6	2.7
Natural gas	11.4	11.9

Source: DOE, 2000.

kinds of energy efficiency measures in the portfolio. For example, the hourly MWh savings from air conditioning, outdoor lighting, and refrigeration efficiency measures have quite different profiles. An example of this is shown in Figure 7-2 for California, on the same days used in Figure 7-1.

Figure 7-3 shows the three different kinds of efficiency measures superimposed on each other and on the marginal emissions profile for the same hours of the year. In this case, air conditioning efficiency measures save kWh during peak hours, when marginal emission rates are highest, and therefore the CO_2 savings per kWh are greatest. On the other hand, outdoor lighting measures save kWh during off-peak hours, when marginal emission rates are lowest. Refrigeration measures save kWh uniformly across peak and off-peak hours.

The third step in calculating the avoided CO_2 emissions is to multiply the marginal emissions rate (in tons CO_2 per MWh) for each hour by the MWh savings in that hour due to each energy efficiency measure. This step is shown in Equation 7.5

avoided tons of CO_2 emissions =

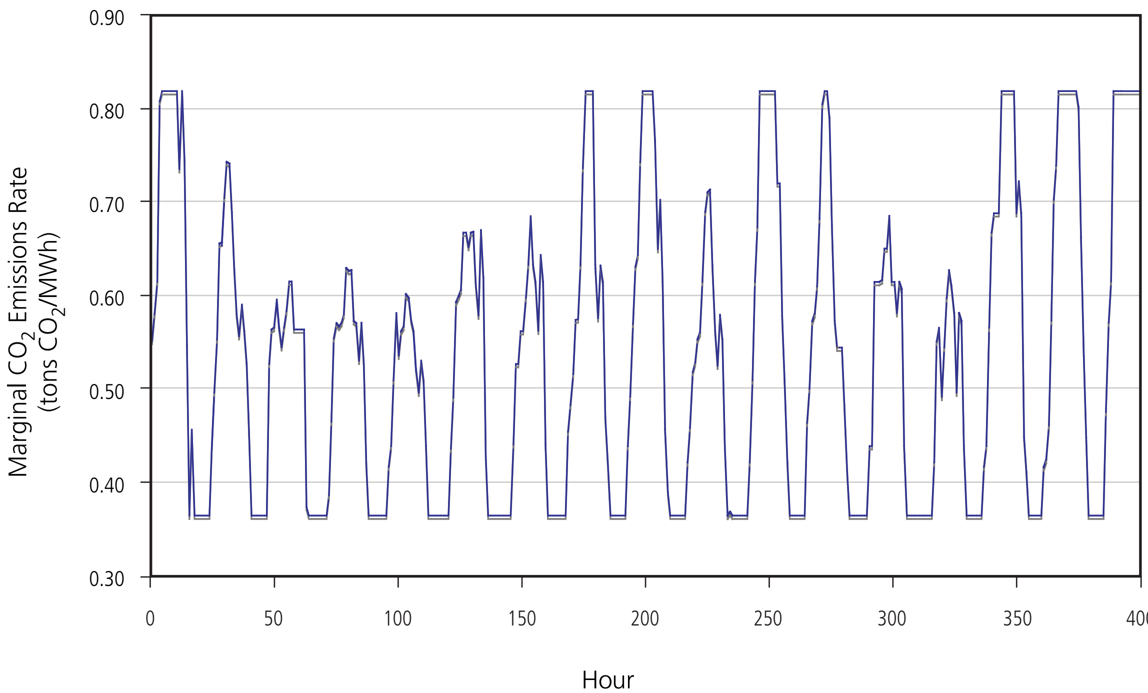
$$\sum_{hours}\sum_{measures}\left(\text{tons } CO_2 \div \text{MWh}\right)\times\left(\text{MWh}_{saved}\right)$$

(e.q. 7.5)

As an example, 100 kWh saved by each of the three energy efficiency measures discussed above results in a different emissions saving for the California emissions profile: the avoided CO_2 emissions are 118 pounds for air conditioning efficiency measures, 93 pounds for refrigeration efficiency measures, and 86 pounds for outdoor lighting efficiency measures.

This calculation can be performed by TOU periods if hourly data are not available. The calculation can also be made more accurate by accounting for reductions in the marginal heat rate due to the energy efficiency measures. However, this effect is likely to be small.

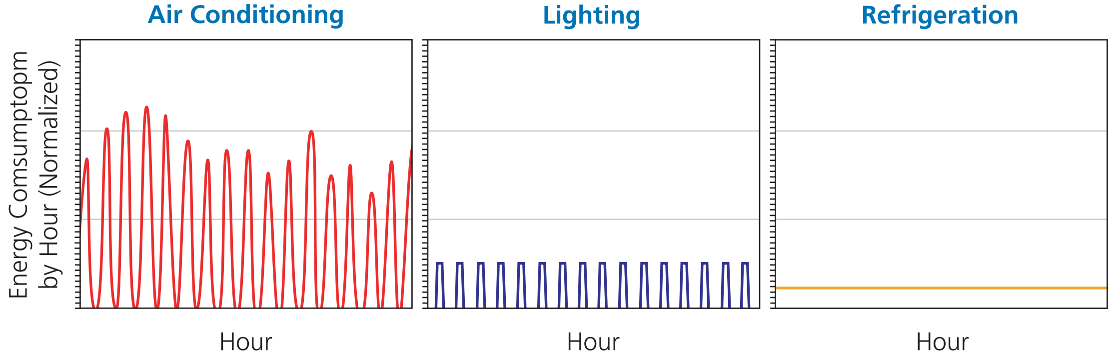
Figure 7-1. Marginal CO_2 Emissions Rate by Hour for California Over a Two-Week Period



Note: The minimum value represents the emissions from baseload generation, which in California consists predominantly of natural gas combined cycle plants. The maximum value represents emissions from peaking units, which consist mainly of natural gas combustion turbines.

Source: California Energy Commission adopted simulation for Title 24 building standards.

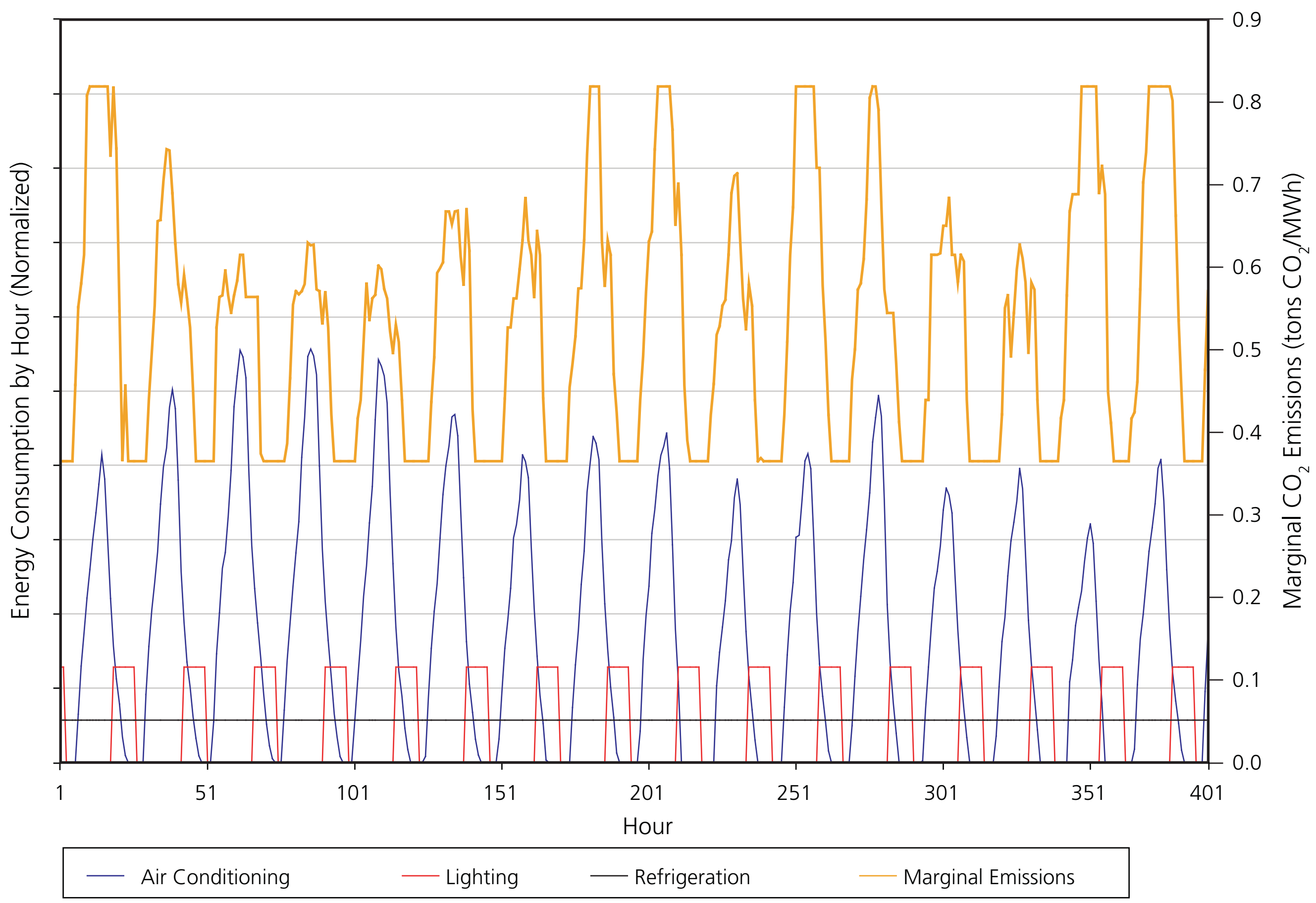
Figure 7-2. Hourly Shape of MWh Savings From Energy Efficiency Measures in California



Note: Results shown for the same two-week period as in Figure 7-1.

Source: Energy & Environmental Economics, Inc. and Rocky Mountain Institute, 2004.

Figure 7-3. Hourly Shape of MWh Savings from Energy Efficiency Measures



Source: Energy & Environmental Economics, Inc. and Rocky Mountain Institute, 2004.

7.5 Incorporating Energy Efficiency Forecasts into Integrated Planning

The previous section discusses the estimation of energy, capacity, and GHG reductions for energy efficiency measures. The analyst, however, must take care in incorporating these results into the planning process, as there are two adjustments that need to be considered:

1. Reductions associated with installations that occur after the peak period (be that summer or winter) should not count for that year.
2. Reductions already included in the status quo load forecast should be explicitly identified to avoid double counting.

The first adjustment is straightforward and easy to incorporate into the planning process; the key is to manage installation forecasts using a time period that ends prior to the peak period. For example, for a summer peaking utility, the second quarter of the year would be the ending period for counting installations for peak reduction purposes.

The second adjustment requires the analyst to have a sound understanding of the data and methods used to develop the base planning forecast. While the details of load forecasting are beyond the scope of this document, double counting can be avoided by (1) removing energy efficiency impacts from the base forecast prepared by the load forecast group or (2) removing energy and demand impacts from the forecast of energy efficiency impacts. This "counting" issue is explored further in the next section.

7.6 Building Codes and Standards

Building energy codes are an additional, significant source of energy savings that should be integrated in load forecasting and reporting of energy efficiency savings. The California Energy Commission estimates the cost savings from the Title 24 Building Standards begun in 1978 will total $41 billion by 2011. California is not alone—41 other states have building codes and standards. For residential buildings, most of the states apply the IECC model energy code or an equivalent or more stringent code. For commercial buildings, most states apply ASHRAE 90.1 or IECC. Still other states allow local municipal control of the building energy efficiency standards.[6] The Action Plan Building Codes and Standards Fact Sheet contains more details on benefits and implementation of building codes (National Action Plan for Energy Efficiency, 2007a).

The methodology described in Equation 7.1, above, can be used to produce a forecast of the energy savings associated with increased stringency in the building codes. These savings are additive to the forecasted savings of the energy efficiency program and can be reported separately as described in Chapter 8, "Reporting Energy Efficiency Impacts for Resource Planning."

As with the forecast of energy efficiency program savings, savings from a change in building standards are computed relative to a baseline of energy usage that would occur without the change in the standard. In the case of improvements attributable to the building standards change, the term in Equation 7.1 represents the increased stringency in the building codes and the $installs_m$ term represents the forecasted number of new buildings where the building code change applies.

For example, if the building code changes the minimum energy efficiency of a residential air conditioner from SEER 12 to SEER 13, then the $\Delta kWh_{m,TOU}$ is the change in energy consumption between these two units and the $installs_m$ term is the number of new and retrofit residential buildings expected to comply. Once this code change is implemented, a new construction program to provide incentives for efficient air conditioning would have a new baseline based on SEER 13 efficiency.

Increasing the efficiency of the building standards is an effective way to reduce energy usage because the standards apply to all new and retrofit buildings. Once the requirement is in place, there is no need to market a new construction program. Compliance with the standard leads to energy efficiency improvements that are widespread and persistent. From a program cost standpoint, building standards impose low cost on the

utility and ratepayers, because the additional costs of the buildings are mainly borne by the owner. In order to prevent onerous requirements on new construction, however, there are generally some controls on the standards that can be implemented. In the California Title 24 process, technical, economic, cost-effectiveness, and feasibility criteria are considered with stakeholders, including builders, architects, consumers, environmental advocates, and others, before any changes are adopted.

7.7 Resources for Forecasting Load

Title/Description	URL Address
Building Codes for Energy Efficiency Fact Sheet. Describes the building codes adopted in each state, along with an estimate of potential benefits.	<www.epa.gov/eeactionplan>
ASHRAE 90.1 Standard. The basis of most states' commercial building energy codes.	<www.ashrae.org/technology/page/548>
International Energy Conservation Code. A common basis of most states' residential building energy standards.	<www.energycodes.gov>
California Title 24 Building Energy Efficiency Standards. These develop the building standards in California in 3-year program cycles, beginning in 1978.	<www.energy.ca.gov/title24/>
Tools and Methods for Integrated Resource Planning: Improving Energy Efficiency and Protecting the Environment. UNEP Collaborating Centre on Energy and Environment, Riso National Laboratory, 1997.	<www.uneprisoe.org/IRPManual/IRPmanual.pdf>
Inventory of Available Methods and Processes for Assessing the Benefits, Costs, and Impacts of Demand-Side Options: Volume 1—Overview of Methods Models and Techniques. 1996.	<http://dsm.iea.org/Files/Tasks/Task%20IV%20-%20Development%20of%20Improved%20Methods%20for%20Integrating%20Demand-Side%20Options%20into%20Resource%20Planning/Reports/Vol1.doc>
2004–2005 Database for Energy Efficiency Resources (DEER) Updated Study.	<http://eega.cpuc.ca.gov/deer/downloads/reports/FinalReport_Jan2006-Pdf_Only.zip>

7.8 Notes

1. Building simulation models include DOE-2, BLAST, ADM2, and Micropas.

2. A free rider is someone who would have installed a measure in the absence of the program.

3. A free-driver effect reflects that someone installs a measure but does not participate in a program.

4. For greater accuracy, incomplete combustion must be taken into account, because it leads to fugitive emissions of methane and nitrous oxide, which are potent GHGs.

5. For example, carbon dioxide emission factors for U.S. coal range from an average of 227 lbs/MMBtu for anthracite to 204 lbs/MMBtu for bituminous. See U.S. DOE, "Carbon Dioxide Emission Factors for Coal," <www.eia.doe.gov/cneaf/coal/quarterly/co2_article/co2.html>.

6. For status on residential and commercial building codes by state, see the DOE Energy Codes Web site: <www.energycodes.gov/implement/state_codes/state_status_full.php>.

8: Reporting Energy Efficiency Impacts for Resource Planning

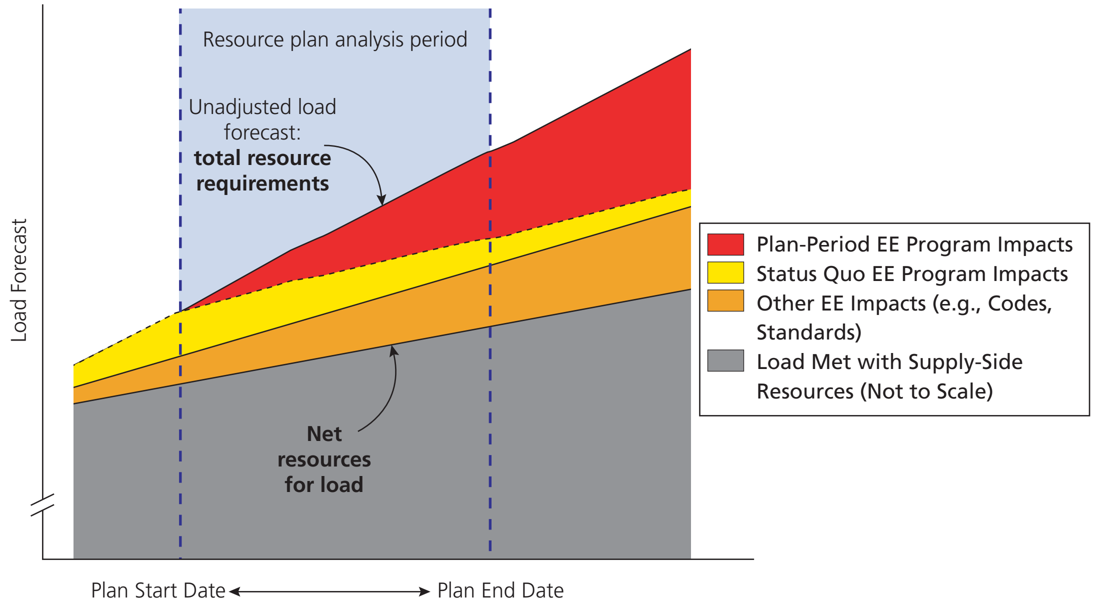
This chapter provides guidance on reporting energy efficiency impacts in resource plan documents, with the goal of making them transparent and useful to a broad audience, as well as improving the ability of utilities to demonstrate their progress toward energy efficiency goals or climate change targets.

High-Level Summary	Key Questions for Utilities and Regulators
• Resource plan documents are an increasingly important source of information on energy efficiency impacts that can be used to measure progress toward state, regional, or national energy efficiency goals or GHG reduction targets.Program administrators typically procure various types of energy efficiency services from contractors (e.g., consultants, vendors, engineering firms, architects, academic institutions, community-based organizations) as part of managing, implementing, and evaluating their portfolio of energy efficiency programs. • Regardless of the methods used to forecast the energy and capacity impacts of energy efficiency programs, they should be reported clearly and consistently. • Two key concepts—total resource requirements and net resources for load—can help distinguish energy efficiency impacts in load forecasts. • A spreadsheet tool to facilitate the reporting and accounting of loads and resources in the resource plan, with adaptable data reporting forms and tables, is available at <http://eetd.lbl.gov/ea/EMS/rplan-pubs.html>.	• Are energy efficiency impacts reported clearly enough that an outsider could easily distinguish energy efficiency load impacts from load met with supply resources? What functions are most appropriate for a program administrator and/or contractors? (Use this question to guide staffing and contracting needs.) • Does the resource plan provide enough information to determine my utility's progress toward energy efficiency or GHG goals or targets? • Does the resource plan provide energy efficiency impacts as share (%) of the growth in total resource requirements and as a share (%) of total resource requirements?

8.1 Reporting Energy Efficiency Impacts for Resource Planning

Utility resource plan documents summarize the results of the resource planning process, typically including load and resource forecasts, the relative cost-effectiveness of a series of contending resource portfolios, results of any other tests that the portfolios underwent (e.g., risk analysis), and the preferred portfolio the utility intends to pursue. The resource plan document constitutes the public record of the utility's planning process and is often the only publicly accessible information on projected energy efficiency and other resources in a specific utility's service territory.

Figure 8-1. Tracking Energy Efficiency Resources in Load Forecasts



Source: Hopper, N. et al., 2006.

Throughout the United States, there is increasingly broad interest in projecting and tracking energy efficiency resources over time. For example, the Western Governors' Association (WGA) has set a goal of meeting 20% of total electricity needs with energy efficiency by 2020. Other states and regions are beginning to set similar goals, in many cases drawing from the National Action Plan for Energy Efficiency's recommendations. Additionally, as governments set mandatory targets for GHG emissions, the need for information on utility energy efficiency program impacts will intensify. However, a study of recent resource plans in the western United States conducted by Lawrence Berkeley National Laboratory (LBNL) found that most did not report energy efficiency impacts clearly enough to support such needs.[1]

The LBNL study provided a series of recommendations for improving the reporting of energy efficiency impacts in utility resource plans, and developed a series of spreadsheet forms for utilities to use and adapt for their resource plans. This tool provides a standardized approach for collecting, entering, and reporting forecasted loads and resources, including energy efficiency.

The focus is on standardizing and clarifying the contribution of energy efficiency resources to the load forecast, both in terms of energy (MWh) and capacity (MW) impacts (see Figure 8-1). Energy efficiency impacts from various sources (e.g., status quo energy efficiency programs, new programs proposed for implementation, and other energy efficiency impacts such as codes and standards) are each shown as separate components of the load forecast, stacked on top of load met with supply-side resources.

Once this has been accomplished, two load-forecast definitions can be defined:

- Total resource requirements represents total expected (energy or capacity) demand in the absence of any energy efficiency measures or strategies. It can also be thought of as the sum of all supply-side and demand-side resources in the utility's portfolio.
- Net resources for load is the load forecast net of all energy efficiency impacts. It is the amount of load that is expected to be met with supply-side resources (i.e., the load that actually materializes).

Utilities should report both of these concepts in their resource plans, as well as the relative contribution of each tracked energy efficiency resource. Doing so clearly distinguishes energy efficiency impacts from supply resources. The following additional considerations will

ensure that the resource plan document can support long-term tracking of energy efficiency program contributions toward state, regional, or federal goals, as well as their regulatory compliance:

1. Provide information on all demand-side resources (energy efficiency and other demand-side resources) included in the resource plan, by type of resource. Demand-side management (DSM) savings data should be reported separately for energy efficiency, demand response, fuel conversion, load management, and any other resources counted among the broader family of DSM.
2. Clearly identify the distinct types of energy efficiency strategies that are included in the resource plan—i.e., ratepayer-funded energy efficiency programs and other sources of energy efficiency such as building energy codes and appliance efficiency standards.
3. Clearly and separately identify the effects of energy efficiency measures to be installed during the resource plan forecast period, as well as the residual effects of status quo energy efficiency measures.
4. Provide both energy savings (MWh or GWh) and summer coincident peak demand reductions (MW) for energy efficiency resources.
5. Provide energy efficiency savings data for all years of the resource plan analysis period.
6. Include key metrics describing the relationship between energy efficiency resources and key resource issues. Specifically, the following are recommended:
   - *Energy efficiency impacts as a share (percentage) of the growth in total resource requirements*—this provides a basis for evaluating the extent to which

Table 8-1. Example Summary Table for Long-Term Energy Efficiency Impacts

Energy Efficiency Strategy Summary Cumulative Impacts of EE Strategies Implemented Starting in 2006	2010		2015		2020	
	GWh	MW*	GWh	MW*	GWh	MW*
EE Strategy Impacts						
Cumulative EE Strategy Impacts[1]	4,579	254	11,953	664	22,914	1,273
Forecast Total Resource Requirements (TRR)[2]	106,136	5,307	114,339	5,717	123,176	6,159
EE Strategies as Percent of TRR	4%	5%	10%	12%	19%	21%
EE Strategies as Percent of TRR Growth (since 2006)	75%	83%	83%	93%	99%	110%
Impact of EE Strategies on Forecast Load Growth						
Average Annual growth in TRR (Since 2006)	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
Net Resources for Load (NRL)[3]	101,558	5,052	102,386	5,053	100,262	4,886
Average Annual Growth in NRL	0.6%	0.5%	0.3%	0.2%	0.1%	-0.1%
Percentage Reduction in Growth Rate	62%	69%	77%	86%	95%	107%

Notes: MW is the summer-peak capacity. (1) EE strategy savings include EE programs, EE standards, and building codes; are cumulative since 2006; and include losses. (2) Total resource requirements include system losses, but do not include demand reductions from energy efficiency strategies or reserve margins. (3) Net resources for load includes demand reductions from all EE strategies. Reserve margins are not included.

the utility plans to meet projected load growth with energy efficiency resources in a given year or over a defined time period.

– *Energy efficiency impacts as a share (percentage) of total resource requirements*—this measures how much load is projected to be met with energy efficiency in a given year.

Table 8-1 is an example summary table from the LBNL spreadsheet forms. It includes both of the above metrics, as well as information on load growth with and without energy efficiency, and could be included in a resource plan as a high-level summary of state and utility energy efficiency resources.

8.2. Resources for Reporting Energy Efficiency Impacts

Title/Description		URL Address
California	**Regulatory-Energy Efficiency Filings: Monthly Program Reports.** This Web site contains monthly program reports on energy efficiency filed by Southern California Edison.	<www.sce.com/AboutSCE/Regulatory/eefilings/Monthly/MonthlyReports.htm>
Minnesota	**Electric and Gas Conservation Improvement Program Biennial Plan for 2005 and 2006.** Docket No. E, G002/CIP-04. Submitted to the Minnesota Department of Commerce by Xcel Energy. June 1, 2004.	URL not available.
New York	**New York Energy $mart Program Cost-Effectiveness Assessment.** This report is a benefit-cost analysis to assess the cost-effectiveness of 18 individual New York Energy $mart public benefits programs.	<www.nyserda.org/Energy_Information/ContractorReports/Cost-Effectiveness_Report_June05.pdf>
Northwest	**The Fifth Northwest Electric Power and Conservation Plan.** This plan is a blueprint for an adequate, low-cost, and low-risk energy future. Technical appendices include conservation cost-effectiveness methodologies.	<www.nwcouncil.org/energy/powerplan/plan/Default.htm>
Vermont	**Efficiency Vermont. 2005 Annual Report.** The Power of Efficient Ideas. This summary highlights the 2005 accomplishments of Efficiency Vermont.	<www.efficiencyvermont.com/stella/filelib/2005%20SummaryREVISED.pdf>

8.3 Notes

1. *Energy Efficiency in Western Utility Resource Plans: Impacts on Regional Resource Assessment and Support for WGA Policies* can be downloaded at http://eetd.lbl.gov/ea/EMS/rplan-pubs.html.

9: Evaluation and Measurement

Program administrators typically procure various types of energy efficiency services from contractors as part of managing, implementing, and evaluating their energy efficiency program portfolio. This chapter provides an overview of considerations for the program administrator related to the scope of contractor responsibilities, methods to stimulate innovative new program concepts and designs, the types of performance risks borne by contractors, and alternative procurement methods.

High-Level Summary	Key Questions for Utilities and Regulators
• The utility is the program administrator in many states; however, in some states, it is the state energy agency or a third party. • Program administrators typically procure various types of energy efficiency services from contractors (e.g., consultants, vendors, engineering firms, architects, academic institutions, community-based organizations) as part of managing, implementing, and evaluating their portfolio of energy efficiency programs. • In order to utilize contractors effectively, a program administrator should consider issues related to the scope of functional responsibilities of contractors, methods to stimulate innovative new program concepts and designs, the types of performance risks to be borne by contractors, and alternative procurement methods (e.g. competitive solicitations involving requests for qualifications or requests for proposals, or partnership arrangements with contractors).	• Has the energy efficiency program administrator been clearly designated?[1] • What functions are most appropriate for a program administrator and/or contractors? (Use this question to guide staffing and contracting needs.) • Does the approach used by a program administrator in procuring energy efficiency services contribute to the longer term goal of creating a vibrant, private sector energy efficiency services industry?

9.1 Procurement of Energy Efficiency Services

Administrators of ratepayer-funded energy efficiency programs, whether they be utilities or other types of entities (e.g., state agencies, private or nonprofit firms), must undertake a number of functional activities to effectively administer, manage, and deliver a portfolio of energy efficiency programs. Table 9-1 highlights these major functions, including a brief description of the types of activities under each function.

The program administrator may be the utility, the state, or a third party; this Guide uses the term "program administrator" to encompass these different options. The program administrator is ultimately responsible and accountable for the proper use of ratepayer funds and for

Table 9-1. Functional Overview of Energy Efficiency Program Management and Delivery

Function	Descriptions
General administration and coordination	• Financial/budget management: develop/maintain financial accounting systems; propose and manage budget for portfolio of programs
	• Contract management: maintain contracts with primary contractors
	• Reporting/information management systems: prepare annual reports, highlight accomplishments, maintain information technology system for reporting, tracking to PUC, advisory committees
Program development, planning, and budgeting	• Facilitate public planning process
	• Develop program designs: propose general program descriptions and budgets for regulatory approval
	• Program and measure screening: initial screening for cost-effectiveness
Program administration and management	• Manage and oversee individual programs (e.g., budgets, sub-contractors)
	• Provide detailed program design and propose changes based on experience and market response
	• Quality assurance: develop QA standards and tracking mechanisms to ensure effective program delivery (e.g., assuring and validating contractor performance quality)
	• Dispute resolution processes
Program delivery and implementation	• Program marketing/outreach: market individual programs; mass advertising
	• Provide program delivery services: energy efficiency audits, technical/design assistance, financial assistance/incentives, commissioning, contractor certification and training
	• Participate in and implement regional and/or national market transformation initiatives
	• EM&V of savings: develop EM&V procedures; focus on verification to determine payments to contractors
	• Project development: develop individual energy efficiency projects at customer facilities
Market assessment and program evaluation	• Market assessment: characterize specific energy efficiency markets and opportunities
	• Assess program impacts
	• Process evaluation: review program processes and administration for purposes of improving program effectiveness

achieving objectives and goals established by regulators. The program administrator must decide the most effective way to procure various types of energy efficiency services, given the core competencies and capabilities of the program administrator and contractors and policy direction from regulators. For example, the program administrator typically takes sole or primary responsibility for general administration/coordination and program development, planning, and budgeting functions. For some functions and activities (e.g., program administration and management, program delivery and implementation, and market assessment and program evaluation), both the program administrator and contractors will be involved with some division of assigned roles or responsibility: primary, secondary, or shared.

In thinking about how to utilize contractors effectively, regulators, program administrators and other stakeholders must resolve such issues as:

- The scope of functional responsibilities of contractors (e.g., turnkey program design and delivery vs. implementation services only).
- Procurement approaches that can stimulate innovative new program concepts.
- The types of performance risks that should be borne by contractors (e.g. pay-for-performance based on verified savings).
- Alternative procurement methods (e.g., competitive solicitations involving requests for qualifications or requests for proposals, partnership arrangements with contractors).

The decision to outsource should be balanced against the program administrator's staff development and core competencies. Figure 9-1 provides an overview of these issues.

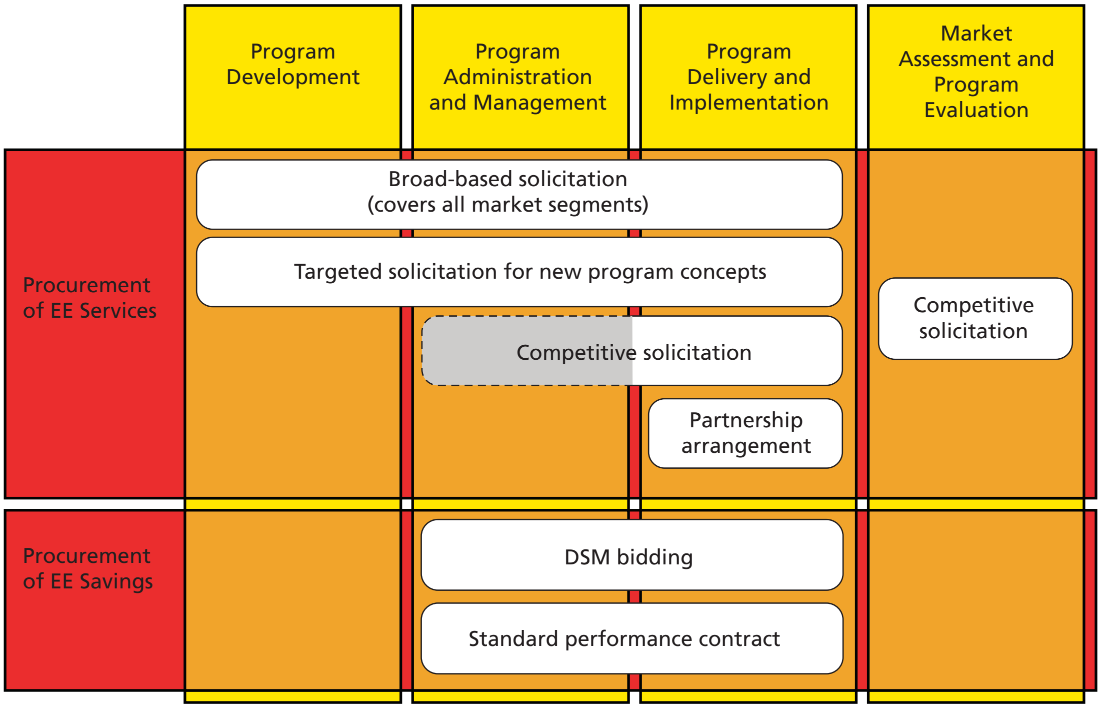
In procuring energy efficiency services, program administrators in a number of states have chosen or been directed by their regulators to issue either "*broad-based*" or "*targeted*" solicitation for program development/design, management and delivery/implementation. In a "broad-based" solicitation, the program administrator issues a request for proposals with a broad scope in the sense that relatively few limits are placed on eligible markets, program areas, or preferred delivery mechanisms.[2] A "targeted" solicitation often focuses on specific program areas and/or under-served markets (e.g., multifamily buildings, small commercial, residential renovation and remodeling).[3] Under both options, contractors have primary responsibility for design and implementation of their proposed program concept.

The functional scope of these "broad-based" and targeted solicitations is larger than the traditional *competitive solicitation for services* approach in which the program administrator seeks and selects third-party contractors through a competitive procurement to deliver a well-specified set of implementation services (e.g., energy audits, design assistance, training) for *existing* energy efficiency programs.[4] In some cases, these services may also include aspects of program administration and management (e.g., they may provide detailed program design or quality assurance), but usually the procurement is limited to various implementation services. Those program administrators that participate in regional and/or national market transformation initiatives often develop procurements targeted to "upstream" market players (e.g., lighting manufacturers, retailers) that involve procurement and bulk purchase of large volumes of high-efficiency products in order to lower retail prices to consumers purchasing at retail stores (e.g., bulk purchase of CFLs).

Energy efficiency services can also be procured through various types of "*partnership*" *arrangements*. In this option, the program administrator develops a relationship with a third-party "partner" to deliver an element of an energy efficiency program (or an entire program) whose design has been well-specified by the program administrator.[5] These partnering arrangements allow the program administrator to form a strategic alliance with an organization that is uniquely suited to manage and deliver energy efficiency programs. Services for which partnering arrangements are most common include training, education/information, and certification of contractors.

Another approach to acquiring energy efficiency resources is to use competitive processes to procure

Figure 9-1. Potential Roles of Third-Party Contractors in Providing Energy Efficiency Services and Savings



energy savings rather than *services* from contractors, most of whom are performance contractors (i.e., ESCOs). The program administrator develops and issues an RFP that solicits bids for energy savings projects to be developed at customer facilities, and contractors (called "DSM bidders" in this context) propose a pay-for-performance incentive (e.g. cents/kWh payments over x years) for verifiable energy savings. The program administrator evaluates bids and then selects and negotiates long-term contracts with winning DSM bidders. This approach is referred to as "DSM bidding," and was implemented by over 40 utilities in the 1990s, either as part of an "all-source" or integrated supply and demand auction, or "DSM bidding only" if limited only to ESCOs and customers offering energy savings projects. Based on experience, many utilities concluded that it was sub-optimal to procure supply and demand resources as part of an "integrated," all-source RFP because poorly designed integrated bidding programs resulted in high prices for DSM resources.[6] Since the late 1990s, those utilities that were mandated by PUCs or chose to procure "savings" through competitive processes gravitated toward DSM-only bidding procurements.

In response to some of the limitations and problems with DSM bidding programs, program administrators in several states (New Jersey, California, New York, and Texas) worked with the ESCO industry to develop another approach to procure energy savings from third-party contractors (or large C/I customers), resulting in the Standard Performance Contract (SPC) program. In an SPC program, the program administrator posts a price per unit saved (e.g. $/kWh, $/therms) with standard program rules, contract, and EM&V protocols. Project sponsors (either contractors or customers) that meet the eligibility guidelines apply for the pre-specified incentive payments for projects under development on a first-come, first-served basis. If funds are available, they enter into a standard contract with the program administrator and then develop the project at a commercial or industrial customer's facilities. Project sponsors are typically paid for delivered savings

over the contract term, which is typically one to three years (Rufo, 1999; Schiller et al., 2000; WECC, 1998).

In the market assessment and program evaluation area, it is quite common for the program administrator to issue a request for qualifications to pre-qualify a number of "independent" evaluation consultants that specialize in different aspects of program evaluation. In some states, other entities that are not the program administrator are responsible for managing and/or overseeing some or all of the market assessment and program evaluation activities (e.g., Vermont Department of Public Service; the California PUC manages impact evaluations).

9.2 Resources for Procurement of Energy Efficiency Services

Title/Description	URL Address
Role of Third Parties in Energy Efficiency Programs: A Review of Alternative Approaches and Experiences. Goldman, C. (2000). Prepared for Connecticut Light and Power, December 2000.	URL not available.
Financing for Assisted Home Performance with Energy Star Request for Proposals. NYSERDA (2006). RFQ 925, July 1.	<www.nyserda.org/Funding/funding.asp?i=2>
Request for Proposals for a Vermont Energy Efficiency Utility. Vermont Public Service Board (1999). October.	<www.state.vt.us/psb/orders/document/EEURFPFINAL.pdf>
Energy Efficiency Accomplishments of Texas Investor Owned Utilities: Calendar Year 2005. Frontier Associates LLC (2006). June 20.	<www.texasefficiency.com/EUMMOT_REPORT_2005_Final_062206.pdf>

9.3 Notes

1. This key question is based on the National Action Plan for Energy Efficiency recommendation to "make a strong, long-term commitment to implement cost-effective energy efficiency as a resource" and options to consider.

2. Examples include the California Utilities Summer Reliability Initiative RFP for Cross-Cutting Demand Reduction Projects ($6.8 million statewide in 2000), the Third Party Initiatives program ($8.5 million in 1998), and the Southern California Edison Third Party Initiative ($2.1 million in 2000).

3. Examples include SDG&E RFPs issued in 2000 for Residential Renovation and Remodeling, Residential New Construction, and Local Government Commission, which were each for about $300,000–$400,000.

4. NYSERDA is an example of an agency that frequently issues competitive solicitations for program delivery. For examples, see <www.nyserda.org/Funding/funding.asp?i=2>.

5. Examples include Pacific Gas and Electric's relationship with the Electric Gas Industries Association, Southern California Edison's and San Diego Gas and Electric's partnership with the League of California Homeowners, and NYSERDA's relationship with the Lighting Research Center.

6. High DSM prices resulted from strategic bidding of DSM resources to come in just below the cost of new supply resources. See Goldman and Kito, 1995.

10: Evaluation, Measurement, and Verification

Evaluation, measurement, and verification (EM&V) is the process of determining the effectiveness and impacts of an energy efficiency program. This chapter provides an overview of EM&V for use in resource planning. The lessons learned from EM&V results provide the information needed to improve impact estimates in resource plans prior to implementation, as well as inform future resource plans. For a more detailed discussion of EM&V, see the Action Plan's Model Energy Efficiency Program Impact Evaluation Guide (National Action Plan for Energy Efficiency, 2007b).

High-Level Summary

- EM&V is the process of determining and documenting the results, benefits, and lessons learned from an energy efficiency program. This information can be used for planning future programs and determining the value and potential of energy efficiency in an IRP process. This information can also be used for retrospectively determining the performance (and payments, incentives, and/or penalties) of contractors and administrators (such as utilities) that are responsible for implementing efficiency programs. EM&V is an essential part of energy efficiency program design.
- A rough rule of thumb is to spend 2% to 5% of the energy efficiency budget on EM&V activities, though some entities spend outside this range. The specific funding level is a function of the scope and purpose of EM&V and the scale of the efficiency program. It also depends on whether EM&V is conducted at the level of the individual utility or statewide.

Key Questions for Utilities and Regulators

- Are our EM&V procedures robust? Do we have the appropriate protocols for EM&V?[1] What functions are most appropriate for a program administrator and/or contractors? (Use this question to guide staffing and contracting needs.)
- Is responsibility for conducting EM&V clearly assigned, and is its independence assured? Have we ensured that the EM&V analysis and results will be transparent and robust?
- Do we have the right level of resources allocated to EM&V?
- Are retrospective EM&V results being used to improve programs and determine cost-effectiveness in the planning phase?

10.1 Overview

EM&V is the process of determining the effectiveness and impacts of an energy efficiency program (i.e., a group of individual projects with similar characteristics that are installed in similar applications). The term "evaluation" refers to any real time and/or retrospective assessment of the performance and implementation of a program. "Measurement and verification" is a subset of evaluation that includes activities undertaken in the calculation of energy and demand savings from individual sites or projects. Such activities include data collection, direct metering, computer modeling, and other techniques to verify project-level savings. Entities including utilities, third-party contractors, and private firms use EM&V to estimate energy efficiency on an ex post

basis. The lessons learned from EM&V results provide the information needed to improve impact estimates in resource plans prior to implementation.

In contrast to EM&V, which measures the performance of program installations, some program impacts are evaluated using the "deemed savings approach." Deemed savings are based on stipulated values, which come from historical savings values of typical projects. As with the EM&V approach, the savings determined for a sample of projects is applied to all the projects in the program. However, with the use of deemed savings there are no, or very limited, measurement activities and only the installation and operation of measures is verified. This approach is only valid for projects with fixed operating conditions and well-known, documented stipulation values (e.g., energy-efficient appliances such as washing machines, computer equipment and refrigerators, lighting retrofit projects with well-understood operating hours).

As states and regions turn to energy efficiency as a planning resource, the establishment of robust, independent, and transparent EM&V is critical. A model approach for EM&V of energy efficiency programs is provided in the Action Plan's *Model Energy Efficiency Program Impact Evaluation Guide*, or EM&V Guide (National Action Plan for Energy Efficiency, 2007b). The objective of the EM&V Guide is to provide a framework which jurisdictions and organizations can use to define their "institution-specific" or "program-/portfolio-specific" evaluation requirements. To this end, the EM&V Guide defines a standard evaluation planning and implementation process, describes several standard approaches that can used for calculating savings, defines terms, provides advice on key evaluation issues, and lists efficiency evaluation resources. While each jurisdiction, or entity, will need to define its own policy requirements, the EM&V Guide provides a structure for consistent approaches and definitions which would, in particular, ease implementation of "cross-border" GHG energy efficiency programs. The primary audiences for the EM&V Guide include program designers, evaluators, and policy-makers participating in the energy planning process.

EM&V consists of three main types of activities:

1. **Process evaluation:** Used to verify whether the program was (or is being) correctly implemented, and to understand any problems or issues that arose (or may arise) in program implementation. Customer feedback and acceptance information can also be part of process evaluation. All energy efficiency program categories can have process evaluations.

2. **Impact evaluation:** Used to determine the actual savings achieved by different programs and specific measures. Impact evaluation has several functions:

   - Evaluating whether a program is achieving its expected impacts (deemed savings).
   - Evaluating whether a utility is meeting its benchmarks or goals and paying shareholder incentives (if such incentives are in place).
   - Verifying that a contractor is performing well, with payments sometimes linked to verified savings of a program.
   - Updating measure definitions used to design programs.
   - Maintaining public confidence in programs.

3. **Market effects evaluation:** Used to estimate a program's influence on encouraging future energy efficiency projects because of changes in the energy marketplace. Market effects evaluation can be used for all categories of programs, but it is primarily associated with market transformation programs that indirectly achieve impacts.

Broadly speaking, the methodologies for measuring and verifying energy efficiency projects at individual sites have been increasingly formalized over time through the development of detailed evaluation protocols. For example, the Federal Energy Management Program and ASHRAE have separately developed guidelines for evaluating energy and demand savings from energy efficiency projects. Similarly, the Efficiency Valuation Organization (EVO) recently updated their International

Performance Measurement and Verification Protocol (IPMVP), which is widely used for evaluating third-party ESCO projects.[2]

At the program level, California utilities follow a detailed series of EM&V protocols officially adopted by CPUC.[3] Other states and regions investing in energy efficiency have developed technical reference manuals describing how entities operating in their jurisdictions should evaluate savings from rate payer–funded programs. These state and regional manuals adopt many of the approaches previously established in project-level guidelines, but are increasingly being used to evaluate the overall portfolio of utility energy efficiency programs.[4]

10.2 EM&V Strategies

A rough rule of thumb for spending on EM&V is 2% to 5% of total energy efficiency program expenditures, although some entities and jurisdictions spend more than this. California is planning to allocate approximately $110 million to evaluate approximately 200 programs in the 2006–2008 cycle, out of a total $2 billion spent on utility energy efficiency programs. Other jurisdictions spend a smaller fraction. For example, NYSERDA spends approximately 2%, choosing to allocate more of the energy efficiency money on programs and less on EM&V. To minimize EM&V costs and focus on running programs, it is important to develop an EM&V strategy prior to program implementation. The key to cost-effective EM&V is focusing evaluation efforts and resources on the largest drivers of overall impacts in the efficiency portfolio.

Among EM&V approaches, the simplest technique is a commissioning process to verify that installations have been carried out properly in a site visit.[5] Once the measure is verified it may be appropriate to apply a "deemed savings" value for energy savings. At the next level, inspection can be supplemented by spot metering a sample of participants pre- and post-installation. In many cases, inspection requires more expensive techniques such as direct metering and computer modeling. Full metering and analysis of metering data can be valuable but typically adds considerably to the cost of EM&V.

Where energy efficiency strategies target whole buildings, the EM&V approach is typically done through billing analysis or a computer simulation. Both options capture efficiency savings at the building level from an integrated set of measures while accounting for the "interactive effects" between measures. An example of a billing analysis measurement approach is ENERGY STAR's Portfolio Manager software. It is an online tool that uses built-in regression models to analyze building performance over time compared to a baseline rating. Portfolio Manager has been used by approximately 30,000 buildings to date.

Overall, evaluators recommend that EM&V efforts achieve the highest degree of rigor that is consistent with the program or project budget and objectives. Experience with EM&V suggests that there are diminishing returns beyond some level of rigor, and it is best to follow a rule of thumb like "10% of the effort to achieve verification within 90%." Thus, one strategy for doing impact assessment is to reduce the propagation of estimation errors by verifying the important but uncertain drivers of the impact. For example, consider a lighting program in which the impact is equal to the number of hours the lighting is in operation multiplied by the change in watts due to more efficient lamps. If the hours of operation are already well established, one would focus the EM&V effort on measuring the change in watts.

Some common sources of error in developing evaluation impacts include:

- Measurement error (meters are not accurate).
- Non-response bias (systematic difference between people who talk to you and people who do not).
- Model specification error (since you cannot directly measure energy savings, calculation of savings from metering requires a statistical baseline, whose underlying regression model can be inaccurately specified).
- Invalid measures.
- Internal validity (whether the program actually caused the savings to occur).

- Self-selection bias (systematic difference between participants and non-participants).

10.3 Estimating the Net-to-Gross Ratio

A key requirement for program-level EM&V is estimating the NTGR. The NTGR accounts for only those energy efficiency gains that are attributed to, and the direct result of, the energy efficiency program in question. It gives evaluators an estimate of savings that would have occurred even without program incentives. Establishing the NTGR correctly is critical to understanding overall program success and identifying ways to improve program performance. If the program is not achieving cost-effective impacts, money spent on the program can be re-allocated for other activities. Calculating the NTGR is facilitated by first having an understanding of gross energy savings and net energy impacts (descriptions modified from IEA, 2005):

- **Estimation of gross energy savings (more generally called impacts).** "Gross energy impacts" refers to the change in energy consumption and/or demand that results directly from program-related actions taken by energy consumers that are exposed to the program. Estimates of gross energy impacts always involve a comparison of changes in energy use over time among customers who installed measures and some baseline level of usage.
- **Estimation of net energy impacts.** Net energy impacts refer to the percentage of the gross energy impact that is attributable to the program. Estimating net energy impacts primarily involves the application of free ridership and/or spillover considerations. "Free ridership" refers to the portion of energy savings that participants would have achieved in the absence of the program through their own initiatives and expenditures. "Spillover" refers to the adoption of measures by (1) non-participants and (2) participants who did not claim financial or technical assistance for additional installations of measures supported by the program. Other considerations that can be evaluated include the "rebound" effect, transmission and distribution losses (for grid-connected electricity projects) and other broader issues such as energy prices and economic conditions that affect production levels.

It is important to note that gross energy savings can be determined and reported on a project-by-project or program-wide basis, whereas net savings (though they can also be determined on a project-by-project or program-wide basis) are almost always reported on a program-wide basis. This program-wide reporting is done in terms of an NTGR. For example, an NTGR of 90% would indicate that, on average, 90% of the indicated gross savings could actually be attributed to the influences of the program.

There are three main techniques for developing NTGRs[6]:

- "Self-reporting" is an approach in which participants are asked whether or not they would have carried out the program anyway. Past program evaluations have shown that self-reporting, while simple, gives a low estimate of NTGR. In other words, participants report that they would have performed the measures more than they actually would have in real life. This bias has resulted in post-survey adjustment of some programs in California of about 10%.
- Discrete choice analysis, which focuses on the determinants of consumer behavior, as a way to distinguish customers into three groups: (1) those who would not participate in the program, (2) those who would install the measure without the program, and (3) those who would install the measure because of the program. The customers in group 2 are "free riders," and should be not counted as the program's effect on participation.
- Analysis of the pre- and post-measure bills of participants who would install the measure because of the program provides the net savings directly.

If NTGRs are a way to capture free riders, market spillover captures the opposite effect (sometimes called the "free driver effect"). This refers to consumers who adopt efficiency measures themselves because they are influenced by an efficiency program, but without being participants

in the program. In making adjustments to gross impacts, both NTGRs and market spillover should be included.

10.4 Isolating Program Effects

An important issue in EM&V is isolating the effects for a specific program so that not all programs take credit for the same savings. For example, an education and outreach program designed to teach retailers about energy-efficient lighting might count the same benefits as the rebates for efficient lighting. For planning purposes, the best solution is often to focus attention on the combined impact, thus avoiding double counting.

10.5 Resources on EM&V

Title/Description	URL Address
Applications Team: Energy-Efficient Design Applications. This site provides numerous resources, ranging from implementation guidelines to checklists and other resources, to help organizations implement an EM&V program.	http://ateam.lbl.gov/mv/
ASHRAE Guideline 14-2002. Measurement of Energy and Demand Savings. American Society of Heating, Refrigerating and Air Conditioning Engineers. June 2002. This guidance describes how to reliably measure energy savings of commercial equipment, using measured pre- and post-retrofit data.	<www.ashrae.org/pressroom/detail/13615>
California's 2003 Non-Residential Standard Performance Contract Program EM&V Procedures Manual. This manual provides general guidelines for preparing an EM&V plan, choosing an EM&V option and method, defining and adjusting baselines, and collecting and submitting EM&V data.	<www.pge.com/docs/pdfs/biz/rebates/spc_contracts/2000_on_peak_incentive/III-m&v.pdf>
The California Evaluation Framework. Prepared for the California Public Utilities Commission and the Project Advisory Group, June 2004.	<www.cee1.org/eval/CEF.pdf>
California Measurement Advisory Council Web Site. California's statewide CALMAC evaluation clearinghouse contains resources for deemed savings and project-specific EM&V techniques. Large searchable database of EM&V results for California.	<www.calmac.org> <www.calmac.org/search.asp>
The CEE Market Assessment and Program Evaluation (MAPE) Clearinghouse. This is a fully searchable Web-based database that contains more than 300 evaluation reports, market characterization studies, and market assessments.	<www.cee1.org/eval/clearinghouse.php3>

Title/Description	URL Address
Creating an Energy Efficiency and Renewable Energy Set-Aside in the NO_X Budget Trading Program: Measuring and Verifying Electricity Savings. This forthcoming EPA report describes key EM&V resources.	Contact EPA; <www.epa.gov/cleanenergy>
EE/RE Measurement and Verification and Emissions Quantification: General Considerations. State Technical Forum on EE/RE: Call #3—December 16, 2004. This is a PowerPoint presentation comparing EM&V with emissions quantification procedures.	<http://epa.gov/cleanenergy/pdf/keystone/Overview_M_and_V_Dec_16.pdf>
Evaluation, Measurement and Verification Workshop. CPUC held several workshops on EM&V. The primary purpose of these workshops was to discuss the performance basis, metrics, and protocols for evaluating and measuring energy efficiency programs, including incentive, training, education, marketing, and outreach programs.	<www.cpuc.ca.gov/static/energy/electric/energy+efficiency/ee+policy/22b370bc-7b20-4360-aab0-093245613a12.htm> The final decision can be found at: <www.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/45783.htm>
California Energy Efficiency Evaluation Protocols: Technical, Methodological, and Reporting Requirements for Evaluation Professionals. Detailed description of CPUC's adopted EM&V methods.	<www.calmac.org/events/EvaluatorsProtocols_Final_AdoptedviaRuling_06-19-2006.pdf>
Federal Energy Management Program EM&V Resources.	<www1.eere.energy.gov/femp/financing/superespcs_mvresources.html>
Highly Cost-Effective Savings—Appliance Efficiency Standards and Utility Programs. Mahone, D. (2005). Heschong Mahone Group, Inc. This is a presentation made at the 2005 IEPEC Program Evaluation conference.	<http://iepec.org/2005Sessions.pdf>
International Energy Program Evaluation Conference Abstracts. This Web site provides abstracts of peer-reviewed evaluation research from past conferences.	<http://iepec.org/2005Sessions.pdf>
International Performance Measurement and Verification Protocol Web Site. IPMVP Inc. is a nonprofit organization that develops products and services to aid in the EM&V of energy and water savings resulting from energy/water efficiency projects—both retrofits and new construction. The site contains the IPMVP, a series of documents for use in developing an EM&V strategy, monitoring indoor environmental quality, and quantifying emission reductions.	<www.evo-world.org/>

Title/Description	URL Address
New York State Energy Research and Development Authority (NYSERDA) Standard Performance Contracting Program Measurement and Verification Guideline, 2003. This Web site presents NYSERDA's New York Energy $mart program application and guidelines for contractors for performance-based incentives to implement cost-effective electrical efficiency improvements or summer demand reduction for eligible customers.	<www.nyserda.org/funding/855PON.html>
The Need for and Approaches to Developing Common Protocols to Measure, Verify and Report Energy Efficiency Savings in the Northeast. Northeast Energy Efficiency Partnerships' report on EM&V development in New England.	<www.neep.org/files/Protocols_report.pdf>
Oncor Commercial & Industrial Standard Offer Program 2003. Measurement and Verification Guidelines. These EM&V guidelines include retrofit and new construction and default savings values for lighting, motors, and air conditioning equipment.	
Standardized Methods for Free-Ridership and Spillover Evaluation—Task 5 Final Report. PA Knowledge Limited (2003). Sponsored by National Grid, NSTAR Electric, Northeast Utilities, Unitil, and Cape Light Compact. This report is used by Massachusetts utilities to estimate free ridership and spillover effects.	Contact PA Consulting at: <www.paconsulting.com>
Technical Reference User Manual (TRM) No. 4-19. Measure Savings Algorithms and Cost Assumptions Through Portfolio 19. Efficiency Vermont provides a set of deemed-savings methods in this manual.	<www.efficiencyvermont.org> or Contact Efficiency Vermont at 1-888-921-5990
Measurement and Validation Guidelines. Texas Public Utilities Commission (2005). This report, conducted as part of the Texas PUC Energy Efficiency Implementation project #30331, includes detailed information about the EM&V requirements of the Commercial and Industrial Standard Offer Program, as well as guidance for project sponsors on how to prepare and execute an EM&V plan.	<www.puc.state.tx.us/electric/projects/30331/052505/m%26v%5Fguide%5F052505.pdf>
Evaluating Energy Efficiency Policy Measures and DSM Programmes. IEA (2005). Prepared by Harry Vreuls.	<http://dsm.iea.org>
EERE Program Analysis and Evaluation Management Guide. U.S. Department of Energy Office of Energy Efficiency and Renewable Energy [U.S. DOE EERE] (2003).	<www1.eere.energy.gov/ba/pdfs/pm_guide_chapter_7.pdf>

Table 10-1. EM&V Resources

Report Section	Includes	Purpose in EM&V
EM&V Guidelines	• IPMVPs • FEMP • ASHRAE 14-2002	Provide EM&V standards based on accepted, proven strategies.
Utility & State Program EM&V Guidelines, Including Lighting Wattage Tables	• California SPC • NYSERDA • State of Hawaii • State of Texas Utility Programs • Texas Loan Star Program	Provide EM&V standards based on accepted, proven strategies, which may be simplified and specified for certain applications.
Case Studies	• California SPC Program • FEMP • NYSERDA • Rebuild America	Example applications of EM&V strategies.
Training Opportunities	• Building energy simulation software • System performance simulation software • Utility cost management software	Upcoming training classes and tools in topics related to EM&V.
Software Tools	• Tools for data acquisition and management • Sources for guidance on tool selection	Available tools that can be used to: model building and systems to estimate savings; track utility costs to verify savings.
Hardware Tools	• Tools for data acquisition and management • Sources for guidance on tool selection	Many data logging and measurement equipment are available to measure and record operating parameters.
Other Resources	• Commissioning and retro-commissioning resources • Other resources	Other resources that could be utilized when preparing for and implementing the EM&V of energy savings.

Source: Federal Energy Management Program, 2005.

10.6 Notes

1. This key question is based on the National Action Plan for Energy Efficiency recommendation to "make a strong, long-term commitment to implement cost-effective energy efficiency as a resource" and options to consider.

2. The EVO Web site can be found at <www.evo-world.org>.

3. The California EM&V protocols can be found at <www.calmac.org/events/EvaluatorsProtocols_Final_AdoptedviaRuling_06-19-2006.pdf>.

4. A special case for EM&V is developing in New England. ISO-NE will be managing a capacity market, and the ISO has determined that energy efficiency will be a biddable resource in this market. Stakeholders are now writing rules governing EM&V that will meet the ISO's standards for reliability and markets, while also being practical for prospective bidders, such as energy efficiency program administrators and energy service companies. The first bid will occur later in 2007.

5. Commissioning is discussed at http://epb1.lbl.gov/commissioning/index.html for residential buildings and at http://imds.lbl.gov/ for commercial buildings.

6. For additional discussion of net-to-gross ratios, see the Action Plan's *Model Energy Efficiency Program Impact Evaluation Guide* (National Action Plan for Energy Efficiency, 2007b).

11: Best Practices

This chapter summarizes the best practices for integrating energy efficiency into the utility planning process. These best practices center on increased coordination between different energy efficiency planning functions.

High-Level Summary	Key Questions for Utilities and Regulators
• Coordination between different energy efficiency planning functions can improve the accuracy and confidence of energy efficiency projections. Areas to improve coordination include: – Potential studies and utility energy efficiency resource plans should be coordinated or, at a minimum, there should be an understanding of differences. – Supply-side resource investment decisions should made in coordination with forecasted energy efficiency impacts. – EM&V results should be used to adjust expected future energy efficiency measure and program impacts, with improved assumptions on program participation, NTGR, expected useful life and other factors.	• Is each energy efficiency function coordinated with other energy efficiency planning processes to take advantage of available information? • Are EM&V results being used to improve program designs and accuracy of savings forecasts? • Are expected peak load savings incorporated into estimates of avoided capacity costs?

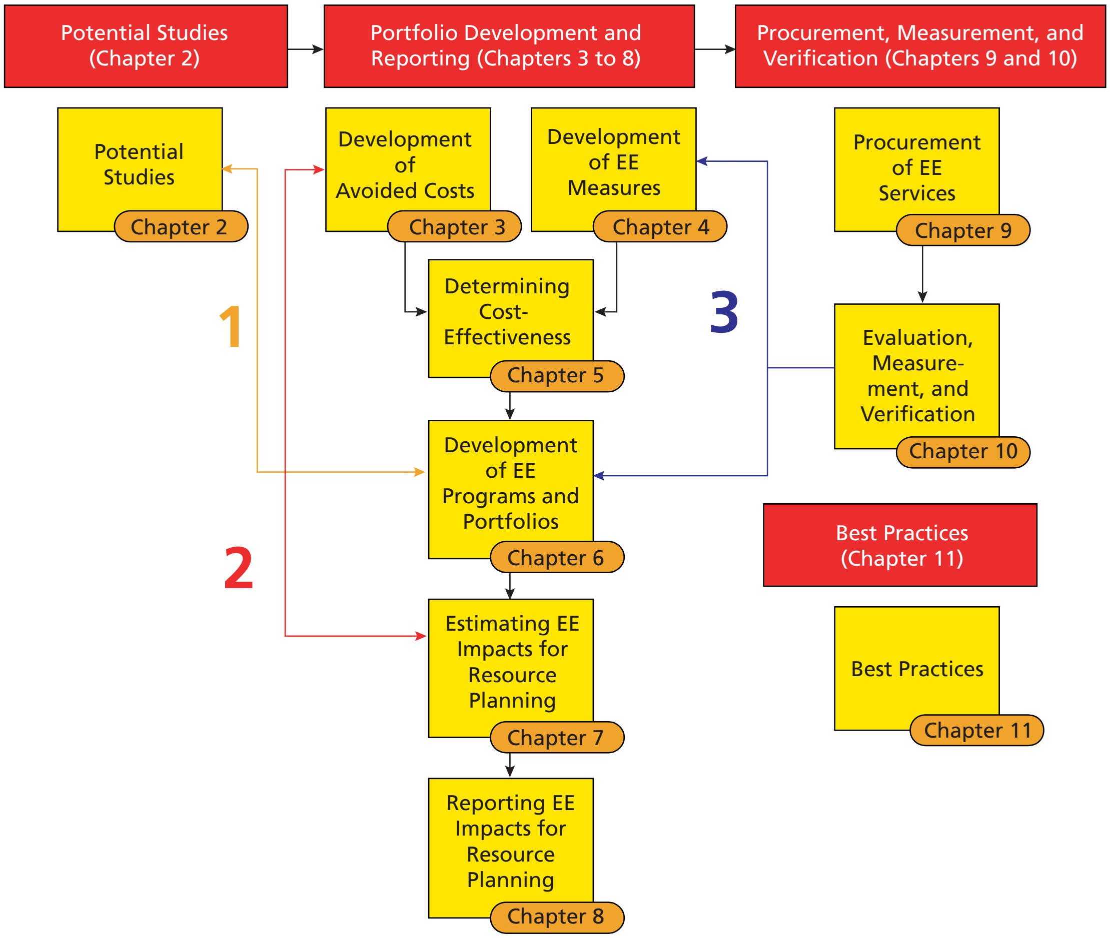
11.1 Overview

As energy efficiency becomes integrated in resource planning, there are a number of areas where coordination of different activities can improve the accuracy of the energy efficiency forecast and overall effectiveness of energy efficiency in resource planning. Improved coordination can also increase the confidence of energy efficiency administrators, supply-side planners, and policy-makers that the projected impact of energy efficiency contained in the resource plans will be achieved.

The three main areas where coordination can improve are shown with arrows between different functions of the resource plan in Figure 11-1:

1. Coordination between the development of the potential studies and the development of the actual energy efficiency programs and portfolios.
2. Linking the forecasted peak load reductions to account for deferral in supply-side requirements when developing avoided costs.

Figure 11-1. Areas to Increase Coordination to Improve Energy Efficiency in Resource Planning



3. Incorporating results from the EM&V when developing measures and estimating penetration and impacts of energy efficiency programs and portfolios.

11.2 Coordinate Potential Studies and Actual Energy Efficiency Programs and Portfolios

The process of developing potential studies can be removed from the actual implementation of energy efficiency and the programs that are ultimately offered to customers, and vice versa. The Action Plan identifies three types of potential studies; policy-level, planning-level, and program-design studies (see Chapter 2 of this report, as well as the Action Plan's Guuide for Conducting Energy Efficiency Potential Studies [National Action Plan for Energy Efficiency, 2007a]). Both policy-level and planning-level studies are typically done independently of the development of actual programs offered to customers.

While there is value in estimating how much energy efficiency is possible without many constraints, estimates of achievable potential can be improved by incorporating historical results of actual programs. For example, evaluating adoption rates and impacts achieved by programs in the field can improve understanding of what is actually achievable, and what constraints are in place. Since potential studies should be informed by data from the field, it is important that these studies be updated every few years to reflect the most current understanding of consumer behavior and program impacts.

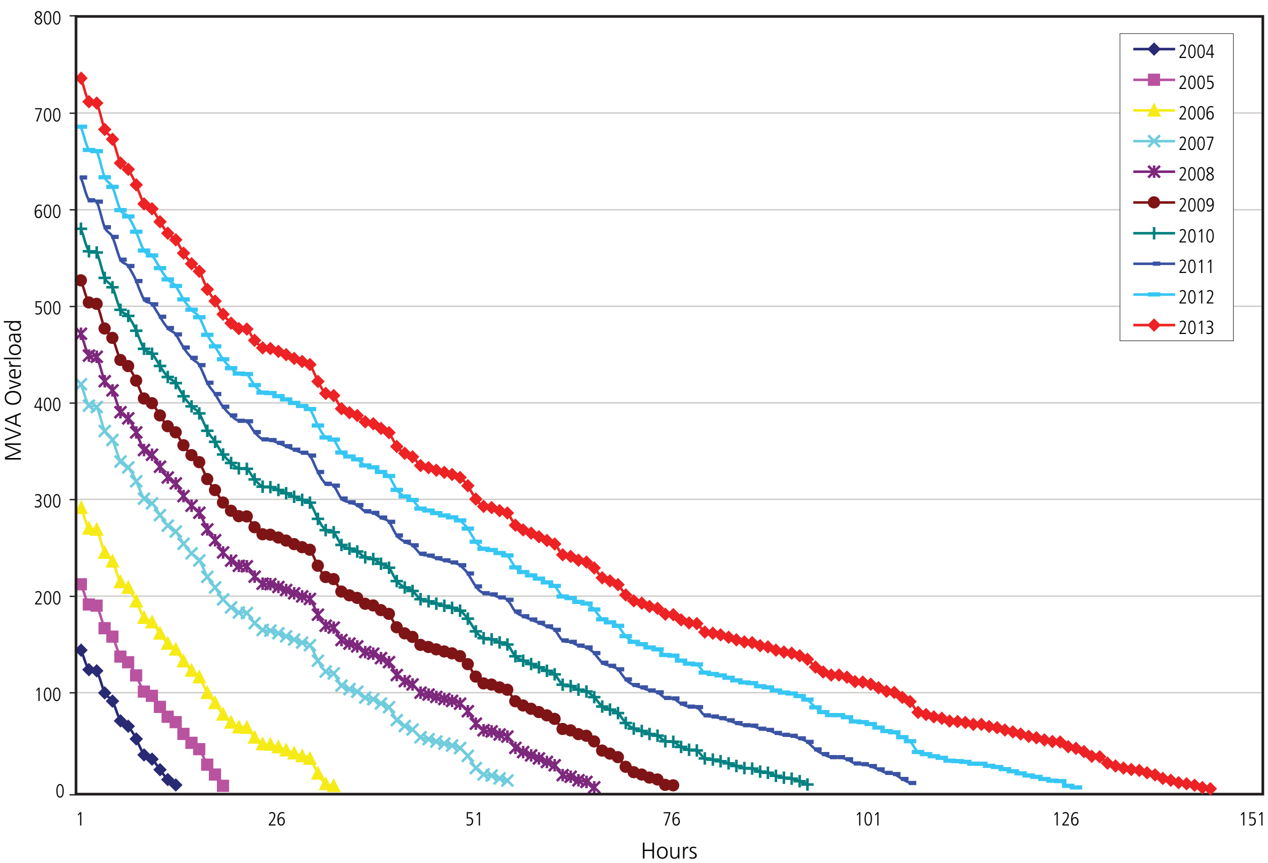
At the same time, development of the energy efficiency program actually offered to customers can be done without reference to prior policy- and planning-level potential studies. Thus, this kind of program development may not exploit the detailed information in these studies that evaluate a wide range of energy efficiency options based on a "bottom-up" approach. Therefore, the broad scope of policy- and planning-level energy efficiency studies can help bring new ideas to the development of the energy efficiency program ultimately offered to customers.

11.3 Adjust Capacity Value Based on Expected Load Reductions

Another area where coordination can improve the resource planning process is integration of energy efficiency and supply-side resource planning. Capacity savings are not captured unless the supply-side planner defers or eliminates an investment, either because energy efficiency offsets growth or the planner has enough confidence in the projections of energy efficiency to delay an investment. At the same time, the energy efficiency planners may under-invest in energy efficiency, if they do not know the kW impact required to defer the need for new investments.

One example of integration of demand- and supply-side planning is BPA's non-wires alternative studies. In these evaluations, non-wires alternatives including energy efficiency are evaluated for new transmission projects to determine whether there is a feasible alternative. For example, in the BPA Kangley-Echo Lake Transmission Line non-wires study, transmission planning provided energy efficiency planners with specific levels of load reductions that were required to keep within the system's established limits (shown in Figure 11-2).

Figure 11-2. Transmission Alternative Targets, 2004–2013



Source: Bonneville Power Administration [BPA] 2007. (In references section)

In 2004, approximately 10 hours were expected to be overloaded, with the peak hour expected to exceed ratings by approximately 120 MW, and the fifth highest hour to exceed ratings by 60 MW. Therefore, in order to provide a reliable alternative, energy efficiency had to provide sufficient load reduction in these hours. Over time, as load in the Seattle/Tacoma area increased, more and more reductions were necessary to keep within reliability ratings. In this case, BPA moved ahead with the transmission line, which was energized in late 2003 (BPA, 2007).

11.4 Use EM&V Results in the Development of Measures and Energy Efficiency Programs

A final area where coordination can improve the accuracy of energy efficiency forecasts is in using the EM&V results to update assumptions in two main areas:

- Specific measure assumptions such as the achieved energy savings, the expected useful life of the measures, and the number of installations that are completed properly. Incorporating this information from the field makes the forecasts of future energy efficiency savings more accurate, and provides information to improve program delivery.
- Program-level EM&V results can provide information on how to market and target new programs. For example, discovery of poor NTGR in a program, which means that customers are not delivering much net savings, indicates that the program budget would be better spent in a different area. This information can be used to eliminate this program and allocate the budget to a better use when doing the program design.

Appendix A: National Action Plan for Energy Efficiency Leadership Group

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President, National Association of Regulatory Utility Commissioners

James E. Rogers
Chairman, President, and C.E.O.
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Seattle City Light

Lonnie Carter
President and C.E.O.
Santee Cooper

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American Council for an Energy-Efficient Economy

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Mark Wolfe
Executive Director
Energy Programs Consortium

Facilitators

U.S. Department of Energy

U.S. Environmental Protection Agency

Appendix B: Glossary

Achievable potential: The result of estimating how much market barriers and program uptake limits will reduce the economic potential.

Avoided costs: The forecasted economic "benefits" of energy savings. These are the costs that would have been spent if the energy efficiency had not been put in place.

Carbon dioxide equivalent: A unit used to put all greenhouse gases on a common footing in terms of global warming potential.

Discount rate: A measure of the time value of money. The choice of discount rate can have a large impact on the cost-effectiveness results for energy efficiency. As each cost-effectiveness test compares the net present value of costs and benefits for a given stakeholder perspective, its computation requires a discount rate assumption.

Economic potential: The result of reducing the technical potential by applying cost-effectiveness and program eligibility criteria.

Energy efficiency: The use of less energy to provide the same or an improved level of service to the energy consumer in an economically efficient way. "Energy conservation" is a term that has also been used, but it has the connotation of doing without in order to save energy rather than using less energy to perform the same or better function.

Evaluation, measurement, and verification: The process of determining and documenting the results, benefits, and lessons learned from an energy efficiency program. The term "evaluation" refers to any real time and/or retrospective assessment of the performance and implementation of a program. "Measurement and verification" is a subset of evaluation that includes activities undertaken in the calculation of energy and demand savings from individual sites or projects.

Free driver: A non-participant who has adopted a particular efficiency measure or practice as a result of the evaluated program.

Free rider: A program participant who would have implemented the program measure or practice in the absence of the program.

Impact evaluation: Used to determine the actual savings achieved by different programs and specific measures.

Marginal emission rates: The emissions associated with the marginal generating unit in each hour of the day.

Market effects evaluation: Used to estimate a program's influence on encouraging future energy efficiency projects because of changes in the energy marketplace. All categories of programs can have market effects evaluations; however, these evaluations are primarily associated with market transformation programs that indirectly achieve impacts.

Market transformation: A reduction in market barriers resulting from a market intervention, as evidenced by a set of market effects, that lasts after the intervention has been withdrawn, reduced, or changed.

Measures: Installation of equipment, installation of subsystems or systems, or modification of equipment, subsystems, systems, or operations on the customer side of the meter, in order to improve energy efficiency.

Net resources for load: The load forecast net of all energy efficiency impacts. This is the amount of load that is expected to be met with supply-side resources (i.e., the load that actually materializes).

Net-to-gross ratio: A key requirement for program-level evaluation, measurement, and verification. This ratio accounts for only those energy efficiency gains that are attributed to, and the direct result of, the energy efficiency

program in question. It gives evaluators an estimate of savings that would have occurred even without program incentives.

Participant cost test: A cost-effectiveness test that measures the economic impact to the participating customer of adopting an energy efficiency measure.

Planning study: A study of energy efficiency potential used by demand-side planners within utilities to incorporate efficiency into an integrated resource planning process. The objective of a planning study is to identify energy efficiency opportunities that are cost-effective alternatives to supply-side resources in generation, transmission, or distribution.

Policy study: A study commissioned by a utility regulator or legislative body that would like more information on the benefits of establishing a program, or by third-party energy efficiency advocates who want to bring energy efficiency benefits to the attention of regulators and policy-makers.

Portfolio: Either (a) a collection of similar programs addressing the same market, technology, or mechanisms or (b) the set of all programs conducted by one organization.

Potential study: A study conducted to assess market baselines and energy efficiency savings potentials for different technologies and customer markets. Potential is typically defined in terms of technical, economic, achievable, and program potential.

Process evaluation: Used to verify whether the energy efficiency program was (or is being) correctly implemented, and to understand any problems or issues that arose (or may arise) in program implementation. All energy efficiency program categories can have process evaluations.

Program: A group of projects, with similar characteristics and installed in similar applications.

Program administrators: Typically procure various types of energy efficiency services from contractors (e.g., consultants, vendors, engineering firms, architects, academic institutions, community-based organizations), as part of managing, implementing, and evaluating their portfolio of energy efficiency programs. Program administrators in many states are the utilities; in some states they are state energy agencies or third parties.

Program design potential study: Can be undertaken by a utility or third party for the purpose of developing specific measures for the energy efficiency portfolio.

Program potential: The efficiency savings that can be realistically realized from the achievable potential, given the budget, staffing, and time constraints for the efficiency program. Program potential establishes the total, or gross, savings expected from a program.

Project: An activity or course of action involving one or more energy efficiency measures, at a single facility or site.

Ratepayer impact measure: A cost-effectiveness test that measures the impact on utility operating margin and whether rates would have to increase to maintain the current levels of margin if a customer installed energy efficient measures.

Resource acquisition program: A program designed to directly achieve energy and or demand savings, and possibly avoided emissions.

Societal cost test: A cost-effectiveness test that measures the net economic benefit to the utility service territory, state, or region, as measured by the total resource cost test, plus indirect benefits such as environmental benefits.

Technical potential: An estimate of what energy and capacity savings would be achieved if all technically feasible efficiency measures were implemented for all customers. The technical potential is adjusted by applying a series of screens of real-world constraints.

Total resource cost test: A cost-effectiveness test that measures the net direct economic impact to the utility service territory, state, or region.

Total resource requirements: Represents total expected (energy or capacity) demand in the absence of any energy efficiency measures or strategies. It can also be thought of as the sum of all supply-side and demand-side resources in the utility's portfolio.

Utility cost test: A cost-effectiveness test that measures the change in the amount the utility must collect from the customers every year to meet earnings target, e.g. change in revenue requirement. In a number of states, this test is referred to as the program administrator's cost test. In those cases, the definition of the "utility" is expanded to program administrators (utility or third party).

Appendix C: ISO New England's Forward Capacity Market

This appendix illustrates a new approach to integrating demand resources into the wholesale market as a capacity resource comparable to traditional generation resources. In 2007, ISO New England received approval to advance this approach in their forward capacity market (FCM). This appendix describes the market design features, how the FCM addresses all resource types, measurement and verification for demand resources, and the strong initial response from demand resources.

C.1 Overview

ISO New England, New England's electricity system operator and wholesale market administrator, is implementing a forward capacity market (FCM) that will, for the first time, permit all demand resources to participate in the wholesale capacity market on a comparable basis with traditional generation resources. "Demand resources," as defined by ISO New England's market rules, includes energy efficiency, load management, real-time demand response, and distributed generation. Enabling demand resources to directly participate in the wholesale capacity market creates a predictable stream of revenue for the capacity savings produced by demand resources, gives demand resource providers access to capital to finance projects, and enables the implementation of "all-cost-effective" demand resources. The response to this path-breaking development will create many "lessons learned" opportunities for using demand resources as a capacity resource.

Developed through industry and regulatory consensus, the FCM provides an auction structure—called the forward capacity auction (FCA)—through which capacity resources compete to obtain a market-priced capacity payment, in exchange for a commitment to be available in the years ahead to meet the region's electricity needs. The Federal Energy Regulatory Commission (FERC) approved detailed market rules implementing the FCM in a series of Orders issued in April and June 2007. A pioneering element of the FCM is that demand resources can qualify as capacity resources along with conventional generation resources and be eligible to receive capacity payments. The time from December 2006 to May 31, 2010, has been established as a transition period; the first FCA will be conducted in February 2008, with the first commitment period—the period within which capacity must be delivered to the New England electricity system—beginning June 1, 2010.

C.2 Market Design Features

The objective of the FCM is to purchase sufficient capacity for reliable system operation over time. The FCM is designed to:

- Procure enough capacity to meet New England's installed capacity requirement (ICR)—i.e., forecasted demand and reserve requirements—3 years in advance.
- Use a competitive FCA process to select the most cost-effective portfolio of generation and demand resources to meet the ICR.
- Provide a long-term (up to 5-year) commitment to new generation and demand resources to encourage new investment.

An annual FCA would be held to procure capacity 3 years in advance of delivery.[1] This 3-year window gives developers enough time to construct/complete auction-clearing projects and to reduce the risk of developing new capacity. All capacity providers receive payments during the annual commitment period based upon a single clearing price set in the FCA. In return, the providers commit to providing capacity for the duration of the commitment period by producing power (if a generator) or by reducing demand (if a demand resource) during specific performance hours (typically peak load hours and shortage hours—hours in which reserves needed for reliable system operation are being

depleted). The quantity of capacity purchased through the auction is the ICR, which consists of the ISO's forecast of peak loads plus adjustments for reserves and other factors. Capacity projects that clear the auction, but are not constructed on time or are otherwise not available during performance hours, are subject to penalties.

The first commitment period begins June 1, 2010. Capacity prices and quantities for the first commitment period will be based on the results of the first FCA, expected to be held in February 2008. Prior to the 2010 commitment period, a transition period (December 1, 2006, through May 31, 2010) has been established to compensate capacity resources for meeting demand requirements. During the transition period, qualified capacity in New England will receive negotiated payments that start at $3.05/kW-month and increase to $4.10/kW-month.

C.3 Leveling the Playing Field Among All Competing Resources

To ensure that energy efficiency and other demand resources are effectively integrated into the capacity market, rules were established to provide fair competition with generation resources. One way the FCM achieves this is by guaranteeing a set market price determined under auction. This means that energy efficiency, load management, real-time demand response, and distributed generation resources receive the same price as fossil fuel, nuclear, hydropower, and renewable generation resources. The effect is to establish the economic value of demand-side initiatives and serve as an incentive for project developers.

Demand resources can participate in the FCM during both the transition period and the FCAs. Because demand resources have not historically competed in wholesale markets, ISO New England convened a stakeholder group—the Demand Resources Group (DRG)—to discuss critical issues and to provide recommendations. The DRG consisted of 40 active participants representing:

- State regulatory agencies (utility, environmental, energy policy).
- Utility companies (investor-owned and public power).
- Retail suppliers.
- Generators.
- Demand response providers.
- Energy service companies.
- Technology providers.
- Large customers.
- Advocacy groups (consumer, energy efficiency, environmental).

The DRG addressed:

- The transition period rules for demand resources.
- The treatment and integration of demand resources in the FCM.
- The integration of the current ISO New England Load Response Program resources into the FCM.
- Input to the ICR process, which sets the capacity resource needs for annual FCAs.
- Measurement and verification standards.

C.4 Measurement and Verification

To participate in the FCM (during the transition period or FCA), each demand resource project is required to demonstrate demand reduction performance during specific operating hours in a manner that provides electrical capacity to the New England Control Area. To demonstrate a demand resource's demand reduction value, the demand resource project sponsor must have a measurement and verification (M&V) plan that complies with ISO New England M&V standards. The measured and verified electrical energy reductions during performance hours are the basis of FCA payments

to demand resource project sponsors participating in the FCM.

To prepare for the first FCA, ISO New England and stakeholders from the DRG developed the *ISO New England Manual for Measurement and Verification of Demand Reduction Value from Demand Resources*. This document established the M&V standards on subjects including:

- Project information and general assumptions.
- Equipment, measure, and practice detail.
- M&V approach.
- Methodology for establishing baseline conditions.
- Statistical sampling plan.
- Demand reduction value calculations.
- Monitoring parameters and variables.
- Measurement equipment specifications.
- Monitoring frequency and duration.
- Data validation, retention, and management.
- Performance reporting.
- Independence and auditing.
- M&V supporting documents.
- Responsible parties.

The development of common M&V standards applicable to all demand resources implemented throughout the multi-state New England region is a significant accomplishment, and is one of the first efforts in the country in which parties from different states worked together to develop a common set of M&V requirements. Formerly, individual states developed state-specific M&V standards for demand-side management programs implemented by state-regulated utility companies funded through retail rates. In New England, common M&V standards became necessary because of the creation of a multi-state capacity market in which demand resources implemented in any New England state were eligible to participate. As regional electricity markets and environmental policies such as carbon trading continue to develop, the need for common M&V standards applicable to all demand resources regardless of location will continue to grow.

C.5 Strong Initial Response to the Forward Capacity Market from Demand Resources

In order to participate in the competitive FCA process, capacity resources must first complete a qualification process, demonstrating that they can meet their commitment to provide capacity. The first step for a new resource is to submit a Show of Interest Application (existing resources are automatically entered into the auction, unless they specifically opt out under certain conditions set forth in the FCM rules). From these applications, ISO New England staff will evaluate the information and analyze the projects to determine if upgrades are needed to the power grid to support the proposed resources and if they could be completed by the start of the commitment period. ISO New England will conduct further intensive studies later in the process. For power plant proposals, ISO will conduct studies to ensure that resources can connect to the power grid without negatively impacting reliability. For demand resource proposals, ISO New England will ensure that the applicant's proposal for reducing electricity use and their M&V plan meet ISO New England's M&V standards.

As of the February 28, 2007, deadline, ISO New England has received over 250 Show of Interest Applications for new demand resource capacity, representing a total of 2,449 MW from resources such as energy efficiency, load management, real-time demand response, and distributed generation. A diverse pool of applications was received from municipalities, government agencies, electric utilities, retail customers, and competitive energy suppliers. Approximately 80% of the new demand resource capacity was proposed by non-utility, "merchant" providers such as energy service

Figure C-1. Demand Resource Show of Interest

State	Demand Resource Type (Total MW)					
	Real-Time Demand Response	Real-Time Emergency Response	Critical Peak	On Peak	Seasonal Peak	Grand Total
Massachusetts	346	279	286	282	29	1,222
Connecticutt	143	141	112	61	120	577
Maine	122	33	27	34	2	217
Rhode Island	68	74	9	36	4	192
New Hampshire	24	41	18	47	4	133
Vermont	17	22	8	61	1	109
Grand Total	**720**	**590**	**460**	**521**	**159**	**2,449**

Source: ISO-New England, 2007

Note: Demand resource type definitions:

a. **Real-time demand response resources—**designed for measures that can be dispatched (e.g., load management or distributed generation) by the ISO as needed.

b. **Real-time emergency generation resources—**designed for distributed generation measures whose state air quality permits limit their operation to limited "emergency" conditions.

c. **Critical peak demand resources—**designed for measures that can be "dispatched" by the project sponsor (e.g., load management or distributed generation) as needed.

d. **On-peak demand resources—**designed for non-weather-sensitive measures that reduce demand across a fixed set of on-peak hours, such as energy-efficient commercial lighting.

e. **Seasonal peak demand resources—**designed for weather-sensitive measures that reduce load during high-demand conditions, such as energy-efficient air conditioning.

companies, equipment vendors, competitive energy suppliers, and end-use customers, many of which have limited or no access to government funding for demand resource projects. Several of the merchant providers are planning to greatly expand their operations in New England. In order to serve New England with this new demand resource capacity, the interested providers still need to qualify to compete in the FCM auction, offer the needed amount of capacity, be priced at a level such that they will be selected in the auction, and actually perform as promised to fulfill their capacity supply obligation. If demand resources are selected in the auction, their contribution to meeting New England's capacity needs will signal an important milestone for the wholesale electricity markets in New England and may serve as a model for the rest of the country.

C.6 Notes

1. During the initial years of FCM implementation, FCAs will be held a little more frequently than once every 12 months and commitment periods for each FCA will commence in less than 3 years. However, once the process has matured, FCAs will occur once per year and commitment periods will start 3 years after the FCA.

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