United States Environmental Protection Agency

EPA 430-R-08-014

September 2008

Clean Energy Options for Addressing High Electric Demand Days

Report

Prepared for
U.S. Environmental Protection Agency
Climate Protection Partnerships Division
State and Local Programs
http://www.epa.gov/cleanenergy/stateandlocal/

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Executive Summary

Objective

Nitrogen oxide (NOx) emissions from electrical generating units (EGUs) are a key contributor to ground-level ozone formation and other regional air quality problems such as acid rain and smog. Hot summer days are particularly conducive to ground-level ozone formation, and air conditioning loads on such days are often a major contributor to electricity demand spikes. At the same time, some EGUs called "peaking units" only operate during periods of peak demand when the electric grid requires maximum generating capacity, and could be high-emitting sources. Peaking units might lack NOx controls because they have low emissions on a seasonal basis, even if hourly emissions are high during periods when they are in use. In addition, these EGUs are often less economical sources of electric power supply.

As currently designed, emissions standards and air pollution trading programs have limited success in reducing emissions from EGUs that predominantly operate on high electric demand days (HEDDs). Existing emissions models and inventories are designed for typical summer days, not the extreme conditions that occur on HEDDs. Regulatory standards could be designed for larger EGUs that meet baseload demand, rather than EGUs that are only called on to meet demand spikes. Using a cap and trade mechanism to promote the cleanup of HEDD units could require high NOx retirement ratios and might not be an economically viable approach.

Clean energy policies and initiatives promoting increased energy efficiency, demand response, and low-emitting distributed generation (DG) technologies offer cost-effective opportunities for reducing peak electric demand and associated NOx emissions. In addition to air quality benefits, ancillary benefits of deploying clean energy strategies to reduce peak electric demand include increased grid reliability while reducing the need to construct new electricity generating capacity or additional transmission and distribution infrastructure.

Recent EPA analysis in support of an Ozone Transport Commission (OTC) stakeholder process estimates that implementation of a portfolio of enhanced energy efficiency, DG, and demand response initiatives could reduce peak day NOx emissions by 4 to 8 percent across the OTC states in two years of implementation (by 2010), and by 13 to 20 percent within seven years of implementation (by 2015). Emissions reductions could be even greater with appropriate provisions to address increased emissions from the use of high-emitting back-up generators associated with many demand response programs. At the modeled penetration of energy efficiency, combined heat and power installation, solar photovoltaic installations and demand response activities, energy efficiency and combined heat and power provided the largest emissions benefits on HEDDs. Demand response activities did reduce emissions from grid connected electric generators, but also were estimated to increase emissions at on-site behind-the-meter diesel generators. The estimated net effect in this modeling exercise was a slight increase of NOx emissions. The new OTC wide solar PV installations were estimated at 56 to 168 Megawatts (MW) OTC wide; at that penetration rate, they would affect a small decrease in NOx emissions.

The report summarizes best practices for cross-cutting policies that promote the adoption of clean energy technologies and provides detailed information on targeted policies and programs that promote energy efficiency, demand response, and clean DG technologies that could be employed to deliver significant reductions in peak NOx emissions.

Scope

The clean energy opportunities addressed in this report include:

- Policies that that promote broader deployment of clean energy technologies by addressing existing market and regulatory barriers to clean energy investment, and/or establishing incentives to promote such investment.
- Energy efficiency initiatives targeting the leading drivers of summer peak electric demand such as residential air conditioning, commercial heating, ventilation and air conditioning (HVAC), and commercial lighting.
- Demand response programs that reduce purchased electricity consumption during periods of peak demand, provided such programs are structured to avoid a net emissions increase through the use of emissions-intensive sources of backup power generation.
- Clean DG technologies such as CHP and solar photovoltaic (PV) applications that offset grid-supplied electricity.

Clean Energy Best Practices

Cross-Cutting Policy Support

Despite the environmental and grid reliability benefits associated with energy efficiency, demand response and DG technologies, as well as the success of clean energy initiatives at the federal, state, and local level across the country, the clean energy opportunities discussed in this analysis remain underutilized as an energy resource and as an emissions reduction strategy. Cross-cutting state policies that support clean energy development include:

- Establishing quantitative and enforceable goals for energy efficiency, renewable energy, and/or CHP through energy portfolio standards.
- Leading by example by establishing guidelines for government agencies to follow. Example guidelines include building energy performance standards, energy efficiency procurement policies, and renewable energy purchase requirements.
- Offering tax incentives to promote clean energy investment through personal or corporate income tax credits, tax reductions or exemptions, or tax deductions.
- Creating clean energy funding mechanisms such as public benefits funds that entail a small per-kWh charge on customer electric bills to fund grants, loans, rebates, technical assistance, and other strategies for enhancing clean energy investment, where cost effective.
- Developing regulatory incentive structures to promote utility investment in clean energy programs, such as mechanisms for program cost recovery, revenue stability, and performance-based incentives.

- Promoting utility rate structures that are more advantageous for the investment and installation of clean DG (e.g., addressing electric rates for supplying backup power, high standby connection charges, and exit fees) while ensuring appropriate cost recovery for utilities.
- Establishing uniform (across multiple utility service territories) rules, processes, and technical requirements for connecting DG applications to the grid and ensuring that such requirements are commensurate with the size, nature, and scope of the DG project.
- Facilitating deployment of advanced metering infrastructure to support dynamic pricing for retail electric customers.
- Incorporating energy efficiency as an important resource into utility resource planning, along with supply-side resources.
- Including evaluation measurement and verification (EM&V) as an essential part of energy efficiency program design that documents the results, benefits, and lessons learned from an energy efficiency program. EM&V can be used for planning future programs, for determining the value and potential of energy efficiency, and for retrospectively determining the performance (and payments, incentives, and/or penalties) of those responsible for implementing efficiency programs.
- Conducting energy efficiency potential studies as an effective tool for building the policy case for energy efficiency and other clean energy technologies as an alternative to supply side resources.

It is also important to leverage the relationships that exist between the clean energy opportunities addressed in this analysis. For example, greater environmental benefits can be captured through demand response initiatives if grid power is offset with low-emissions onsite power generating technologies such as CHP and PV, rather than fossil fuel-fired backup generators. An effective clean energy strategy might employ multiple policy-level best practice approaches, and require coordinated action on the part of state governors, legislatures, state energy offices, air and utility regulators, and support from a variety of stakeholders.

Energy Efficiency

Energy efficiency programs can do more than just target and secure energy savings measured on a kilowatt hour (kWh) basis; they can also achieve peak demand reductions which are measured on a kilowatt (kW) basis. For energy efficiency programs to address emissions on HEDDs, it is important to focus programs on loads that are highly coincident with peak demand. Quantifying the peak demand impacts of energy efficiency programs presents a greater technical challenge than evaluating energy savings impacts. While electric bills provide energy use data for all customer classes on a kWh basis, time of use (TOU) meters and demand meters are not widely distributed across all customer classes. In particular, residential and small commercial customers typically lack electric demand and TOU meters, making quantification of peak demand impacts of energy efficiency measures more challenging.

However, there is growing interest in the peak demand impacts associated with energy efficiency initiatives, in part due to grid congestion and electric supply reliability issues that are facing some areas of the country.

The leading drivers of summer peak electricity demand are residential cooling, commercial heating, ventilation and air conditioning (HVAC), and commercial lighting. Inefficient home appliances, commercial refrigeration, and office plug loads represent additional opportunities for energy efficiency improvement. This report reviews a number of proven energy efficiency program strategies for addressing these peak demand reduction opportunities, providing information on program design best practices, strategies for overcoming program barriers, peak demand impacts, and cost-effectiveness. This report also provides information on successful program models from around the country.

Table ES-1. Energy Efficiency Program Models Addressed in this Report

Program	Peak Savings	Cost
Residential Sector		
ENERGY STAR New Homes: Promotes energy-efficient new home construction.	1 kW per home	$0.01 - $0.08/kWh
Home Performance with ENERGY STAR: Provides comprehensive energy efficiency improvement for existing homes.	Approx 1.6 kW per home	$0.05/kWh
Quality HVAC Installation & Maintenance: Promotes proper sizing, installation, and maintenance practices for residential AC.	0.2-0.7 kW per home	$0.03 - 0.04/kWh
Appliance Recycling: Facilitates removal and recycling of inefficient home appliances.	0.16-0.4 kW per unit	$0.03 - 0.05/kWh
Commercial Sector		
PC Power Management: Promotes activation of energy-saving features to reduce office plug load.	1 kW per 150 PCs	$0.01 - 0.02/kWh
Commercial Lighting, Cooling, and Refrigeration: Offers incentives for energy-efficient commercial equipment.	0.6 – 200kW per participant	$0.005 - 0.06/kWh
Whole Building Performance: Provides comprehensive energy efficiency improvement for commercial buildings.	16 – 600 kW per participant	$0.01 - 0.04/kWh
Cool Roofs: Promotes roofing materials with high reflectance and surface emittance.		

Demand Response

"Demand response" is a broad term encompassing a range of program types designed to reduce electricity use during periods of peak electric demand. Demand response initiatives range from programs that provide customer incentives for voluntary (nonfirm) or mandatory (firm) load curtailment based on contractual arrangements, to dynamic pricing structures that charge higher rates during peak periods, employing a market-based approach to achieving peak demand reduction. Some program administrators are finding that a portfolio of demand response programs comprised of voluntary and mandatory reduction commitments is the most cost-effective demand response strategy to accommodate the different technologies and customer preferences in different market sectors. This approach also offers customers increased flexibility in terms of selecting the demand response option that is best suited to their risk tolerance.

In order to serve as an effective strategy for reducing HEDD emissions, it is essential that demand response initiatives be structured to avoid a net emissions increase through the use of emissions-intensive sources of backup power generation. Combining demand response with efforts to promote clean DG can be an effective strategy for achieving this objective. Some program administrators have addressed this issue by including requirements for the types of load reductions that are eligible for demand response incentives. In addition, policies that support the deployment of enabling technologies such as advanced metering and communications infrastructure, sophisticated load control devices, and energy management devices that provide customers with real time energy usage data help to maximize the impacts of demand response initiatives.

Distributed Generation

Where energy efficiency and demand response initiatives represent demand-side approaches to reducing peak electric demand and associated HEDD emissions, CHP and solar PV represent opportunities for supplanting grid-supplied power with clean, DG alternatives.

CHP refers to the simultaneous production of electricity and heat from a single fuel source. CHP is not a single technology, but an integrated energy system that can be modified depending upon the needs of the energy user. CHP technology is best-suited for energy-intensive facilities with substantial electric and thermal energy loads such as industrial manufacturing plants and large commercial and institutional facilities. CHP systems require less fuel to produce a given energy output, and as systems are located onsite where the energy is used, they eliminate the transmission and distribution losses associated with grid-supplied electricity.

PV systems generate electricity from solar energy and are another form of clean DG that displaces grid-supplied power. As the solar resource is greatest on hot summer days when peak electric demand is typically high, PV systems produce air quality benefits and reduce strain on the electric transmission and distribution system. Due to the modular configuration of PV systems, solar electric technology can be utilized in a diverse range of settings, from urban to rural and from small-scale residential to large-scale commercial applications.

Some of the cross-cutting policy supports for clean energy development discussed above represent key strategies for reducing barriers to clean DG technologies, namely ensuring equitable utility rate structures and developing standardized interconnection requirements. DG applications are typically grid-connected as they supply only a portion of a facility's total energy requirements. Utility rate structures that disadvantage clean DG applications include high rates for providing standby service to meet demand when onsite generating capacity is offline. In addition to requirements prohibiting such practices, a supportive regulatory environment for clean DG will also establish standardized technical and procedural requirements for connecting a DG application to the grid, ensuring that requirements are commensurate with the size of the DG application. Other strategies that have been successful in promoting clean DG include incentive programs and DG procurement processes.

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1. Introduction

1.1. Objective

Periods of peak electricity demand on hot summer days correlate closely with high levels of NOx emissions from electrical generating units (EGUs), and with meteorological conditions that contribute to ground-level ozone formation. As currently designed, emissions standards and air pollution trading programs have limited success in reducing emissions from EGUs that predominantly operate on high electric demand days (HEDDs). Clean energy opportunities such as enhanced energy efficiency, demand response initiatives, and clean forms of distributed generation (DG) such as combined heat and power (CHP) and solar energy can be cost-effective strategies for reducing peak electric demand, achieving air quality benefits, and contributing to electric supply reliability.

This report summarizes best practices for clean energy policies and initiatives that address summer peak electricity demand. Clean energy strategies addressed in this report include:

- Policies that address existing market and regulatory barriers to clean energy investment and/or establish incentives to promote clean energy investment.
- Energy efficiency initiatives targeting the leading drivers of summer peak electric demand such as residential air conditioning, commercial heating, ventilation and air conditioning (HVAC), and commercial lighting.
- Demand response programs that reduce purchased electricity consumption during periods of peak demand without increasing the use of emissions-intensive backup generation.
- "Clean" DG technologies such as CHP and solar photovoltaic (PV) that offset grid-supplied electricity.

The U.S. Environmental Protection Agency (EPA) has developed this analysis to support states and air quality planning agencies in their efforts to evaluate clean energy policy and program opportunities for addressing HEDD emissions.

1.2. Approach

The clean energy best practices discussed in this report were initially compiled by EPA to support the Ozone Transport Commission's (OTC) HEDD Initiative. In 2006, a group of OTC states launched a stakeholder process to evaluate opportunities for reducing HEDD emissions through a variety of approaches, including performance standards and emissions caps for HEDD units, state/generator HEDD partnership agreements, adjustment of NOx retirement ratios to provide for HEDD reductions, energy efficiency programs, demand response programs, and clean DG technologies. Stakeholders included representatives from regional transmission organizations (RTOs), public utility commissions (PUCs), electric generating companies, and EPA.

In March 2007, several OTC states signed a Memorandum of Understanding (MOU) to address HEDD emissions.[1] Beginning with the 2009 ozone season, six states are committed to pursue reductions of NOx emissions associated with HEDDs during the ozone season, with reduction targets ranging from 20-32 percent. These OTC states are in discussions with individual EGU companies and stakeholders regarding tailored strategies for achieving these emissions reduction targets. Strategies for HEDD emissions reductions could include, but are not limited to, equipment replacement, fuel switching, and control technologies. Further reductions can be achieved through clean energy initiatives that reduce peak electric demand.

EPA support for the HEDD Initiative included a modeling exercise to estimate NOx emission reductions that could be achieved through a portfolio of enhanced energy efficiency, demand response, CHP, and solar energy initiatives. EPA also developed a set of clean energy policy and program best practices to support the attainment of HEDD emissions reductions goals. This document updates the initial clean energy best practice report as a more general guide to other states and regions interested in addressing HEDD emissions.

OTC High Electric Demand Day Initiative: NOx Emissions Reduction Potential

- A 2006 EPA analysis estimated that a implementing a portfolio of enhanced energy efficiency, CHP, solar energy, and demand response initiatives could reduce peak day NOx emissions by 4 to 8 percent across the OTC states in two years (by 2010), and by 13 to 20 percent by 2015.
- Emissions reductions could be even greater with appropriate provisions to address increased emissions from the use of high-emitting back-up generators associated with many demand response programs.

1.3. Organization of the Report

The major sections of this report are organized as follows:

- Chapter 2, *Clean Energy Policy Best Practices*, discusses cross-cutting barriers to clean energy opportunities for addressing HEDD emissions and policy measures that have been successfully deployed to address those barriers.
- Chapter 3, *Energy Efficiency*, discusses successful program models targeting peak-coincident electric loads, program design and implementation, challenges, and examples of successful programs.
- Chapter 4, *Demand Response*, discusses programs that employ dynamic pricing to reduce electric demand during peak periods, or offer customer incentives for shifting or reducing electric use during peak periods. This chapter includes a discussion of strategies for ensuring that demand response programs do not contribute to a net increase in emissions due to the use of emissions-intensive forms of backup power generation and a discussion of supporting technologies such as advanced metering infrastructure and devices that automate demand response.
- Chapter 5, *Distributed Generation*, discusses initiatives that promote clean DG applications such as CHP and solar energy by reducing barriers to investment and enabling clean DG technologies to compete on a level playing field with traditional supply-side resources.

2. Clean Energy Policy Best Practices

2.1. Barriers to Clean Energy Opportunities

Despite the benefits of clean energy and the success of programs in many states across the country, clean energy remains underutilized as an energy resource and as an emissions reduction strategy. Promoting the portfolio of clean energy opportunities discussed in this report—enhanced energy efficiency, demand response, and clean DG—requires a combination of policy refinements and/or changes, including efforts to address existing market and regulatory barriers and to establish appropriate financing mechanisms. These efforts will likely require action on the part of state governors, legislatures, energy offices and/or utility regulatory agencies, in addition to efforts by air regulatory agencies and input from a variety of stakeholders.

Highlights: Clean Energy Policy Best Practices

Cross-cutting policy best practices include:

- Promoting coordinated planning between air regulators and energy regulators.
- Establishing clean energy goals.
- Removing regulatory barriers to clean energy investment.
- Creating funding mechanisms to support clean energy opportunities.

The following table lists common cross-cutting barriers to investment in clean energy opportunities. A more detailed discussion of barriers specific to the clean energy opportunities is addressed in the relevant chapters.

Table 2-1. Barriers to Investment in Clean Energy Opportunities

Type of Barrier	Description
Market barriers	Includes fundamental market characteristics that inhibit investment in clean energy opportunities. Common examples include the **split incentive barrie**r, where the economic benefits of increased energy efficiency do not accrue to the decision-maker (e.g., the home builder or commercial developer who is not responsible for paying the ongoing energy bill), and the **transaction cost barrier,** where the costs associated with making the investment (acquiring information, evaluating risks, etc.) inhibit investment. Transaction cost barriers chronically affect individual and small business decision-making regarding investment in clean energy opportunities.
Customer barriers	Includes lack of information about clean energy opportunities, lack of awareness of how existing clean energy programs make investments easier, lack of time and attention to evaluating and implementing clean energy opportunities, and lack of funding to invest in clean energy opportunities.
Public policy barriers	Includes existing policy and regulatory conditions that discourage clean energy investment by utilities, retail electric service providers, power producers, and transmission and distribution companies. Historically these organizations have been rewarded more for building infrastructure (e.g., power plants, transmission lines, pipelines) and increasing energy sales than for helping their customers use energy wisely, even when the clean energy opportunities might cost less than building infrastructure.
Utility, state, and regional planning barriers	Includes energy supply planning structures/processes which do not allow clean energy opportunities to compete equitably with traditional supply-side resources.
Program barriers	Includes sub-optimal clean energy program design and implementation due to lack of knowledge about the most effective and cost-effective means of promoting clean energy opportunities in the target market, how best to address common market barriers, and available technologies.

2.2. Clean Energy Policy Best Practices

A variety of clean energy policy measures can be used to address one or more of these barriers at the state level and could be adapted for use in other states and regions as shown in the following table. The table also notes relevant sections of two recent reports (the EPA's *Clean Energy-Environment Guide to Action: Policies, Best Practices and Action Steps for States* and the *National Action Plan for Energy Efficiency*) that contain more detailed information on these policies and programs, including descriptions on the roles of key players including state governors, legislatures, environmental officials, energy offices, utility regulatory agencies, and stakeholders.

Table 2-2. Clean Energy Policy Best Practices

Policy Best Practice	Description	Relevant Section in Guide to Action or National Action Plan
Energy planning provisions	Institute energy planning processes that evaluate clean energy as a resource, set clean energy goals, consider how best to meet long-term needs, and fully realize the costs and benefits of different energy resources. Create mechanisms to promote coordinated planning between air regulators and energy regulators that serves the dual objectives of ensuring air quality and grid reliability.	• *Guide to Action*: 3.2 (State and Regional Energy Planning) and 6.1 (Portfolio Management Strategies). • *National Action Plan*: 3 (Energy Resource Planning Processes).
Energy portfolio standards	Establish quantitative and enforceable goals for energy efficiency, renewable energy, and/or CHP through energy portfolio standards.	• *Guide to Action:* 4.1 (Energy Efficiency Portfolio Standards); 5.1 (Renewable Portfolio Standards).
Demonstrate government leadership	Demonstrate clean energy leadership by promoting clean energy opportunities for public facilities through mechanisms such as executive orders that support building energy performance standards, energy efficiency procurement policies, and renewable energy purchases.	• *Guide to Action:* 3.1 (Lead by Example).
Tax incentives	Provide state tax incentives to promote clean energy investment such as personal or corporate income tax credits, tax reductions or exemptions, or tax deductions.	• *Guide to Action*: 3.4 (Funding and Incentives).
Public benefit funds	Create clean energy funding mechanisms, such as public benefits funds that entail a small per-kWh charge on customer electric bills to fund grants, loans, rebates, technical assistance, and other strategies for enhancing clean energy investment.	• *Guide to Action:* 4.2 (Public Benefit Funds for Energy Efficiency); 5.2 (Public Benefit Funds for State Clean Energy Supply).
Utility incentives for demand-side resources	Develop appropriate regulatory incentive structures to promote utility investment in clean energy programs, such as mechanisms for program cost recovery, revenue stability, and performance incentives.	• *Guide to Action*: 6.2 (Utility Incentives for Demand-Side Resources) and 6.3 (Emerging Approaches: Removing Unintended Utility Rate Barriers to Distributed Generation • *National Action Plan*: 2 (Utility Ratemaking & Revenue Requirements), 5 (Rate Design) and Appendix A (Additional Guidance on Removing the Throughput Incentive).

Policy Best Practice	Description	Relevant Section in Guide to Action or National Action Plan
Standby rates	Develop standby rate structures that ensure appropriate cost recovery for utilities but do not inhibit investment in clean DG (CHP and renewable energy) by charging excessive rates for supplying backup power, high standby connection charges, and exit fees.	• *Guide to Action*: 6.3 (Emerging Approaches: Removing Unintended Utility Rate Barriers to Distributed Generation)
Interconnection standards	Establish uniform rules, processes, and technical requirements across utility service territories for connecting DG applications to the grid, ensuring that such requirements are commensurate with the size, nature, and scope of the DG project.	• *Guide to Action*: 5.4 (Interconnection Standards)
Infrastructure investment	Facilitate deployment of advanced metering infrastructure to support dynamic pricing for retail electric customers.	

Resources for Additional Information on Clean Energy Policy Best Practices

- EPA's *Clean Energy-Environment Guide to Action: Policies, Best Practices and Action Steps for States*.
  - Identifies and describes 16 clean energy policies and strategies that states have used to meet their clean energy objectives.
  - Web site: http://www.epa.gov/cleanenergy/stateandlocal/guidetoaction.htm.

- *National Action Plan for Energy Efficiency,* facilitated by EPA and DOE.
  - A plan developed by more than 50 leading organizations in pursuit of energy savings and environmental benefits through electric and natural gas energy efficiency.
  - Web site: http://www.epa.gov/cleanenergy/actionplan/eeactionplan.htm.

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3. Energy Efficiency

3.1. Introduction

Energy Efficiency, which refers to using less energy to provide the same or improved level of service to the energy consumer, can be an effective way to provide peak demand savings in addition to overall energy savings, depending on the types of equipment and loads that are targeted. For energy efficiency programs that address emissions on HEDDs, it is important to focus programs on loads that are coincident with peak demand. There is growing information on the potential to reduce peak demand through energy efficiency programs. The impacts of energy efficiency initiatives can be assessed in terms reduced electricity consumption, typically measured in terms of kilowatt hours (kWh) of electricity saved, or in terms of the reduction in peak demand for electricity, typically measured in terms of kilowatts (kW) of peak demand reduction. The primary objective of most energy efficiency programs is to produce energy savings (kWh) rather than peak demand reduction (kW). Historically there have been limited resources devoted to assessing the peak demand impacts of energy efficiency programs. While electric bills provide energy use (kWh) data for all customer classes, time of use (TOU) meters and demand meters are not widely distributed across all customer classes. In particular, residential and small commercial customers typically lack electric demand and TOU meters, making quantification of peak demand impacts of energy efficiency measures more challenging. Even with advanced metering infrastructure, it may still be difficult to isolate the peak demand impacts associated with individual energy efficiency measures, and primary data collection efforts are costly. Typical approaches for assessing peak demand impacts involve applying load shapes or load factors to energy savings data. In order to meet short-term operating requirements and in connection with long term electric demand forecasting, utilities have developed comprehensive load shape data for their customer base. Individual load shapes have even been developed down to the level of market sub-segments such as single family homes and small commercial facilities.[2]

The American Council for an Energy Efficient Economy (ACEEE) recently completed an assessment of the peak demand impacts of energy efficiency programs nationwide.[3] The data presented in this assessment demonstrate how much the relationship between overall energy savings (kWh) and peak demand reduction (kW) can vary based on the end use characteristics of each individual measure. Climate-sensitive measures such as heating and cooling applications show particular variability. Table 3-1 presents peak demand savings (in watts) per unit of energy savings (kWh) for a number of common energy efficiency measures that have substantial effect on peak demand. The ACEEE study also developed a database of program-reported peak demand impacts at the measure level for a variety of residential, commercial, and industrial energy efficiency measures. Minimum, maximum, and medium kW impacts for a variety of measures, as compiled by ACEEE, are reported in tables 3-2 through 3-4 below.[a]

The tables demonstrate that energy efficiency measures offer the potential for peak demand reduction across all sectors (residential, commercial, and industrial) with residential and commercial heating and cooling applications, commercial lighting, HVAC, and refrigeration representing key areas of peak demand reduction opportunity. The remaining sections in Chapter 3 discuss a number of energy efficiency program models that have a proven record of achieving peak demand reduction. Information is provided on the following program areas:

- ENERGY STAR New Homes

[a] The full set of measure-level data compiled by ACEEE is available at: http://www.aceee.org/pubs/u073.pdf.

- Home performance with ENERGY STAR
- Quality HVAC Installation and Maintenance
- Appliance Retirement and Recycling
- PC Power Management
- Commercial Lighting, Cooling, and Refrigeration
- Whole Building Energy Performance for the C&I Market
- Cool Roofs

Table 3-1. Peak Demand Savings Per Unit of Energy Savings for Selected Measures[4]

Energy Efficiency Measure	W/kWh (Median Value)
ENERGY STAR room A/C	1.59
Refrigerator recycling[b]	1.54
Energy-efficient central A/C	1.29
Energy-efficient packaged rooftop HVAC (5-12 tons)	0.74
Energy-efficient chiller (150-300 tons centrifugal)	0.59
T-8 fluorescent lamp with electronic ballast	0.31
Premium efficiency motor (25 hp)	0.26
Premium efficiency motor (200 hp)	0.18
ENERGY STAR refrigerator	0.14
Compact fluorescent light bulb	0.10

Table 3-2. Peak Demand Savings of Residential Measures[5]

Energy Efficiency Measure	Coincident Summer Peak Demand Savings			
	Min (kW)	Max (kW)	Median (kW)	Data Points
ENERGY STAR room A/C	0.058	0.067	0.063	3
Energy-efficient central A/C	0.435	0.864	0.742	4
ENERGY STAR refrigerator	0.006	0.011	0.009	4
ENERGY STAR freezer	0.005	0.005	0.005	1
ENERGY STAR clothes washer	0.009	0.193	0.051	4

[b] Ratio of demand reduction to energy savings for refrigerator recycling is derived from data in the *Final Report Impact Evaluation of the Spare Refrigerator Recycling Program*, CEC Study #537, completed by Xenergy for Southern California Edison.

Energy Efficiency Measure	Coincident Summer Peak Demand Savings			
	Min (kW)	Max (kW)	Median (kW)	Data Points
Compact fluorescent light bulb	0.004	0.009	0.006	4
Fluorescent torchiere	0.020	0.028	0.025	3
ECM furnace fan	0.147	0.147	0.147	1

Table 3-3. Peak Demand Savings of Commercial Measures[6]

Energy Efficiency Measure	Coincident Summer Peak Demand Savings			
	Min (kW)	Max (kW)	Median (kW)	Data Points
Energy-efficient packaged rooftop HVAC (5-12 tons)	0.020 kW/ton	0.232 kW/ton	0.083 kW/ton	4
Energy-efficient chiller (150-300 tons centrifugal)	0.067 kW/ton	0.102 kW/ton	0.085 kW/ton	2
Variable speed motor drive	0.071 kW/hp	0.252 kW/hp	0.203 kW/hp	3
Compact fluorescent light bulb	0.006	0.039	0.026	4
Premium efficiency motor (5 hp)	0.056	0.070	0.063	2
Premium efficiency motor (10 hp)	0.117	0.148	0.133	2
Premium efficiency motor (25 hp)	0.151	0.191	0.171	2
T-8 fluorescent lamp with electronic ballast	0.006	0.008	0.008	3
Commercial packaged refrigeration	0.112	0.112	0.112	1
Commercial vending machine control	0	0.114	0.057	2
High efficiency copier	0.041	0.041	0.041	1

Table 3-4. Peak Demand Savings of Industrial Measures[7]

Energy Efficiency Measure	Coincident Summer Peak Demand Savings			
	Min (kW)	Max (kW)	Median (kW)	Data Points
Premium efficiency motor (40-50 hp)	0.219	0.471	0.345	2
Premium efficiency motor (75 hp)	0.474	0.551	0.513	2
Premium efficiency motor (150 hp)	0.575	0.728	0.652	2
Premium efficiency motor (200 hp)	1.146	1.450	1.298	2

3.2. ENERGY STAR New Homes

3.2.1. Overview

> ***Highlights: ENERGY STAR New Homes***
>
> - **Demand reduction**: 1 kW per home.
> - **Technologies**: Effective insulation, high-performance windows, tight construction and ducts, efficient heating and cooling equipment, efficient lighting, and appliances.
> - **Cost effectiveness:** $0.01-0.08/kWh.
> - **ENERGY STAR information at**: www.energystar.gov/homes.

Residential energy use accounts for 21 percent of U.S. primary energy consumption.[8] New home construction is an important segment of the housing market in which energy efficient design and construction techniques can lock in energy savings for decades. Energy-efficient new home construction offers a cost-effective approach to reducing peak demand and improving comfort. Each ENERGY STAR qualified home is at least 15 percent more efficient than homes built to the 2004 International Residential Code, and depending on the geographic area covered by the program, can be as much as 20-30 percent more efficient than prevailing local code.

EPA works with builders and energy efficiency program sponsors nationwide to adopt energy efficient technologies and “on-the-shelf” building practices that enable their homes to qualify for ENERGY STAR. EPA also works with the U.S. Department of Energy (DOE) Building America Research Program to promote new techniques and products to improve the overall energy efficiency of new homes to reach the ENERGY STAR specification or higher.

Currently, over 5,000 builder partners voluntarily label their homes, including over half of the nation’s top 100 largest builders. In 2005, over 160,000 homes earned the ENERGY STAR label or approximately 10 percent of all new home construction nationwide. Cumulatively, there are over 840,000 labeled homes and a growing number of regional and local markets with 20 to 50 percent or more market penetration. Together, these homes are saving American homeowners nearly a half-billion dollars on their utility bills while reducing peak demand by 600 MW.

3.2.2. Best Practices

Technical requirements for achieving the ENERGY STAR label are developed by EPA based on extensive interaction with the nation’s home building industry, detailed technical analyses, and public review process with the home building industry stakeholders and Home Energy Rating System (HERS) industry. A home can qualify using a performance path based on a maximum HERS Index Score, or a prescriptive path using an EPA-developed Builder Option Package (BOP). EPA has developed separate program requirements for manufactured homes built to U.S. Department of Housing and Urban Development (HUD) requirements. This includes a unique verification protocol incorporating quality control processes already included in HUD code homes manufacturing plants.

In some areas, a utility, state or local government agency, or energy efficiency program administrator serves as the program sponsor, providing education and training, incentives, and marketing assistance to builders that construct homes meeting the ENERGY STAR specification. Though ENERGY STAR homes are being built in areas without an active program sponsor, active program sponsors can play an essential role in increasing market penetration of homes that meet the standard. ENERGY STAR homes programs are designed to increase the effectiveness of key market actors including builders, HERS providers and raters, and realtors, as well as to stimulate consumer demand through marketing efforts.

Program design starts with an assessment of the local/regional market for new homes including the following market factors: predominant type of builder, level of housing dispersion, rigor of prevailing energy code and enforcement, availability of energy efficient technologies and construction practices, health and durability issues in new home construction, and relevant marketing messages for the target market.

EPA recommends a number of critical program elements. First, it is essential to ensure the presence of a HERS verification infrastructure and to develop and nurture it where not fully mature. Second, providing builder sales training is critical. Lastly, investments in effective marketing stimulate market demand and are crucial for success. In addition to building consumer awareness, program support for builder sales and marketing efforts help secure builder confidence in the program.

3.2.3. Barriers

Barriers to the adoption of energy efficiency technologies in the home building industry include: industry resistance to change and concerns with risk; first cost decision making which ignores utility cost savings and improved comfort, durability and indoor air quality; lack of skills selling energy efficient homes; lack of consumer awareness; and lack of technical infrastructure for construction and verification. An effective ENERGY STAR homes program addresses these key market barriers through marketing, outreach, and training efforts, and presents a strong business case for builders.

3.2.4. Peak Demand Impacts

EPA has developed national peak demand reduction and energy savings estimates for ENERGY STAR qualified homes based on current specifications. EPA estimates peak demand reduction of 1kW per home.[c] EPA estimates annual energy savings of approximately 3,500 kWh for an all-electric home and approximately 2,030 kWh and 131 therms for a home with electric cooling and gas heating.

Programs employ a number of key metrics to track and ensure savings and peak load reduction targets are being met. HERS raters report the number of labeled homes for a given geographic area, and this total can be multiplied by the above savings numbers to provide a general estimate total program impacts. More detailed assessments of peak demand impacts involve field evaluations of the HERS verification process, assessments of actual utility bills for labeled and control homes, and measurements of peak energy use for labeled and control homes. When planning measurement and evaluation activities, the HERS certification process includes oversight by the Residential Energy Services Network (RESNET). RESNET can be contacted to explore how to leverage their quality assurance efforts.

3.2.5. Cost Effectiveness

Consistently strong cost-effectiveness performance has been documented by many of the more than 50 regional sponsors implementing ENERGY STAR homes. Some program administrators

[c] This is a national number used by EPA for planning purposes; more climate-specific energy savings per home can be readily generated through a number of software programs.

are implementing ENERGY STAR homes programs at approximately $0.06/kWh.[d e] However, the cost effectiveness is highly dependent on climate, with greater cost effectiveness in regions having higher cooling loads.[f] Other variables that affect cost effectiveness include incentive levels, program maturity, market maturity, geographic concentration of builders, and access to an established home energy rating infrastructure. Additional cost savings can come into play where there are both electricity and heating fuel savings. Non-energy benefits such as improved comfort, indoor air quality, and durability also add value to homebuyers.

3.2.6. Program Examples

The following programs demonstrate how effective regional solutions for implementing ENERGY STAR homes programs have helped transform residential construction markets.

- **New York State Energy Research and Development Authority (NYSERDA), New York**: Transforming the home building industry in upstate New York presented substantial challenges for NYSERDA. The industry was dominated by widely dispersed, hard to reach small and mid-size regional builders. NYSERDA responded by first developing a strong HERS industry across the region. NYSERDA then provided extensive training to home builders, offered substantial rebates, and implemented an effective regional marketing campaign conveying the benefits of energy efficiency. Since the inception of the ENERGY STAR homes program five years ago, market penetration is over 10 percent and ENERGY STAR for homes is positioned for strong continued growth. Program web site: http://www.getenergysmart.org/SingleFamilyHomes/NewConstruction/HomeOwner.aspx.
- **CenterPoint Energy and Oncor/TXU, Texas**: Joining forces in Houston and Dallas, these two utilities realized that their markets were dominated by large production builders. It was critical in their markets to expand the HERS verification infrastructure and effectively market the benefits of energy efficiency to consumers. Both utilities implemented ENERGY STAR homes programs with extensive efforts to recruit HERS providers in their respective markets, a minimal rebate to builders, and a strong advertising campaign educating local home buyers. As a result, during a five year period, Houston and Dallas have achieved a respective 35 and 45 percent market penetration for ENERGY STAR qualified homes. Program web sites: http://centerpointefficiency.com/energystar/h_verify.htm and http://www.oncorgroup.com/electricity/teem/services/starhomes/default.aspx.
- **Las Vegas ENERGY STAR Partners, Nevada:** A strong group of builders, HERS raters and local home building marketing professionals formed an alliance to promote ENERGY STAR qualified homes. This group effectively implemented outreach campaigns advertising the benefits of ENERGY STAR to homebuyers, and worked together to develop and disseminate on-site marketing materials. They also provided technical and marketing training, and promoted the results of their efforts at local

[d] Levelized cost of $0.06/kWh sourced from http://www.energystar.gov/ia/partners/downloads/meetings/NewHomesHPwES.pdf

[e] Program data from NYSERDA in 2004 shows levelized CCE of $0.04/kWh, and Long Island Power Authority data from 2003 shows levelized CCE of $0.08/kWh.

[f] Program data from TX, CenterPoint Energy, Oncor/TXU, and Entergy Gulf States show levelized CCE in the range of $0.01 to $0.02/kWh (calculated levelized cost of conserved energy using first year savings (kWh), a discount rate of 6%, and a lifetime of 16 years).

industry conferences. As a result, after five years, nearly 60 percent of all homes in Las Vegas are labeled ENERGY STAR without any monetary incentives, and home buyer ENERGY STAR awareness exceeds 95 percent. Other programs have succeeded without rebates in markets such as Phoenix (over 30 percent market penetration) and Indianapolis (nearly 20 percent market penetration) where a strong champion, individual or group, effectively promoted ENERGY STAR qualified homes.

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3.3. Home Performance with ENERGY STAR

3.3.1. Overview

> ***Highlights: Home Performance with ENERGY STAR***
>
> - **Demand reduction**: Approx. 1.6 kW per home.
> - **Technologies**: Central HVAC equipment replacement/tune-ups, insulation, air sealing, and duct sealing, high-performance windows, efficient lighting, and appliance recycling/replacement.
> - **Cost effectiveness:** $0.05/kWh.
> - **ENERGY STAR information at**: www.energystar.gov/homeperformance.

For the existing residential market, Home Performance with ENERGY STAR represents a proven strategy for promoting comprehensive home energy efficiency improvements that capture significant energy savings potential. The program, which generates savings through improving heating and cooling systems, windows, insulation, and reducing air leakage, is especially timely as increasing product standards mean less savings potential from program strategies that focus on single end uses such as lighting or HVAC. The greatest peak demand impacts are associated with improving home heating and cooling efficiency, particularly in regions with substantial cooling loads.

After more than 20 years of energy efficiency programs in existence in some parts of the country, there is still enormous potential to reduce energy consumption and peak demand, especially from older homes. Typical home performance improvements will deliver electricity savings as well as heating fuel savings. Non-energy benefits like comfort also help as they convince homeowners to make improvements and make a lasting, positive impression.

3.3.2. Best Practices

A whole-house energy audit is a good first step toward energy efficiency improvement, but recommendations are seldom implemented if the homeowner does not know who to trust to complete the work or is unable to easily finance improvements. Through Home Performance with ENERGY STAR, the contractor who completes the home assessment is also prepared to complete the needed renovations or work closely with participating contractors who can do so. Programs that offer homeowners a quick and easy way to finance improvements see even better results.

A local or regional program administrator is crucial to the implementation and operation of Home Performance with ENERGY STAR. Organizations such as a utility, state energy agency or non-profit energy efficiency organization are typical program administrators who understand local market conditions and can provide third-party oversight of home improvement contractors.

Measurement and verification of results is another important element of a successful program. Program administrators typically track the number of contractors participating, projects completed, and average energy saved per project based on information submitted by the contractor as a condition of program participation, rebates processed, and/or financing information. Making contractor training and incentive offerings contingent upon the submission of documentation is an early program design consideration.

ENERGY STAR provides program sponsors with assistance in program planning, promotion and contractor participation. To do this, EPA and DOE have established a national network of experienced program implementers, building scientists, marketing and ad firms, and contractors that can serve to advise and assist in program start-up and delivery.

3.3.3. Barriers

Program implementers need to consider local market conditions in their planning process, as there are several common barriers to address in program design and implementation. Common barriers and strategies for overcoming them include:

- **Contractor participation**: In many markets there is a limited supply of qualified contractors with the skills to diagnose and market whole-house energy efficiency improvements. A key strategy to overcome this barrier is to help develop a local network of qualified professionals. Offering technical training to participating home improvement trade contractors is one place to start. Many program sponsors offer sales and business process training to help contractors succeed in selling and delivering home performance services.

- **Financing home improvements**: The up-front cost to the homeowner of whole-house energy efficiency improvements is another common barrier. Several programs offer financing for home improvements. Cash rebates can also help generate consumer interest in the program and offset some costs, especially when the rebates are contingent on the purchase of a comprehensive package of improvements from participating contractors.

- **Consumer awareness**: Many homeowners are not aware that a whole-house assessment can uncover their home's performance problems and identify improvements that, when made together, can greatly improve their home's energy efficiency and comfort. Program administrators can use a variety of marketing and media activities to overcome this barrier.

- **Quality assurance**: Quality assurance reassures homeowners that participating contractors will be held accountable for the work they perform. Following a quality assurance plan will help streamline delivery and avoid problems associated with contractor reporting. This plan will determine how and what information contractors will submit and how it will be reviewed, and these data will become the basis for the evaluation of program impacts (demand reduction, etc.).

3.3.4. Peak Demand Impacts

EPA estimates a summer peak electricity demand saving of 1.6 kW per home, with the greatest impacts experienced in areas with substantial cooling loads. Existing home performance programs have achieved even better results. Austin Energy's 2005 results estimated a deemed savings per participant of more than 2,500 kWh of electricity and 2 kW in peak demand. As home improvements are verified through a quality assurance process, there is relatively little risk that program investments will not produce savings.

3.3.5. Cost-Effectiveness

Building a network of qualified professionals to deliver whole-house services requires substantial resources, particularly during the first year of implementation. This is one reason many program administrators choose to start with a pilot program in a target market. A pilot program allows for flexibility to work out the details of efficient program design and delivery. Once the infrastructure is established in the pilot market, the investment to maintain and expand the program decreases and the cumulative savings increase. For mature programs, cost effectiveness estimates show that Home Performance with ENERGY STAR has a levelized cost of conserved energy of about 0.05 $/kWh. For programs with integrated gas and electric savings, the cost effectiveness will be even higher.

3.3.6. Program Examples

Over the past five years, EPA and DOE have worked with states, utilities, and others to develop and pilot Home Performance with ENERGY STAR in a dozen markets with good results. Program pioneers, like those noted below, have collectively improved the efficiency of nearly 36,000 existing homes and saved their customers an estimated $400 per year in energy costs.

- **NYSERDA, New York:** From 2001 through middle of 2007, over 150 contractors participating in NYSERDA's Home Performance with ENERGY STAR program helped New Yorkers invest over $110 million to improve the energy efficiency of more than 15,000 homes, saving over 16,000 MWh of electricity and over 600,000 MMBtu of fossil fuels.[9] As of 2005, the net verified summer peak demand reductions attributable to the program were 1.7 MW, based on installations at over 9,500 homes.[10] Program web site: http://www.getenergysmart.org/WhereYouLive/HomePerformance/overview.asp.
- **Focus on Energy, Wisconsin**: The statewide energy efficiency program in Wisconsin, Focus on Energy, has run a successful Home Performance with ENERGY STAR program since 2003, and also provides subsidized home performance services to income-eligible customers. Over 5,000 homes have received home performance assessments since 2003, with nearly 40 percent of homes installing at least one major building performance-related measure within the year that the home assessment was conducted. From July 2006 to June 2007, over 2,000 homes received an assessment and over 700 homes implemented improvements, achieving a net verified peak demand reduction of 222 kW.[11] During the same year, the program produced electric savings of over 325,000 kWh and natural gas savings of almost 300,000 therms. Program web site: http://www.focusonenergy.com/page.jsp?pageId=34.
- **Austin Energy, Texas**: In 2005, Austin Energy had over 70 contractors participating in its Home Performance with ENERGY STAR program, completing 1,400 projects with a peak demand savings of over 3,000 kW. Program Web site: http://www.austinenergy.com/Energy%20Efficiency/Programs/Rebates/Residential/Home%20Performance%20with%20Energy%20Star/index.htm.

3.4. Quality HVAC Installation and Maintenance

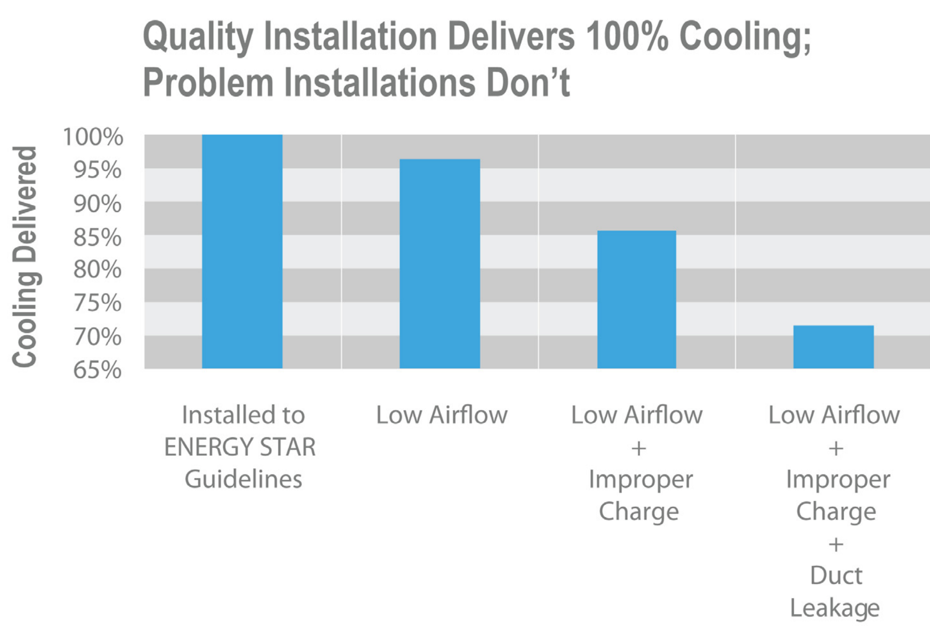
3.4.1. Overview

Air conditioning accounts for about 14 percent of residential electricity use in the United States.[12] More than 53 percent of existing homes have central air conditioning, with this percentage on the rise as four out of five new homes are constructed with central AC. Central air conditioners and heat pumps rank as the third largest end use of energy in the home, behind space and water heating.[13]

> ***Highlights: Residential HVAC Quality Installation & Maintenance***
> - **Demand reduction**: 0.2 - 0.7 kW per home.
> - **Technologies**: Proper sizing and installation of residential HVAC systems; corrections to refrigerant charge and airflow; duct sealing.
> - **Cost effectiveness:** $0.03 - 0.04/kWh.

There are substantial energy efficiency and peak demand reduction opportunities associated both with the sizing and installation of new central AC systems, as well as with ensuring proper maintenance of existing systems. Common problems that reduce AC efficiency include improper sizing, improper refrigerant charge, improper airflow over the indoor coil, and air duct leakage. When all of these issues occur, the efficiency of AC equipment could be reduced by 30 percent.

Figure 3-1. Impact of Quality Installation on AC System Cooling Delivery



Approximately 5 percent of air conditioners are replaced each year, and getting the installation right represents a good opportunity to reduce electric demand. For existing equipment, some estimates showing that as many as 78 percent of central AC units are improperly charged and up to 70 percent have improper airflow. Adopting a regular diagnostic and maintenance program can improve the efficiency and performance of existing equipment.

3.4.2. Best Practices

Many programs have promoted high efficiency AC equipment to reduce peak demand in the past. This approach continues, but is less effective since the minimum energy efficiency standard for residential central air conditioners increased to a Seasonal Energy Efficiency Ratio (SEER) of 13. Best practice for energy efficiency programs is rapidly evolving toward a focus on proper sizing, installation, charge and airflow for both new and existing systems. It is expected that this program approach will become increasingly common as standards and protocols are established.[g]

Successful programs typically adopt best practice standards for installation and train contractors to meet them. A trade association, such as the Air Conditioning Contractors of America (ACCA), can help to identify contractors interested in participating. The best time to engage contractors is during the fall or spring when business is slower and they are more receptive to new business opportunities. Training is essential to explain program incentives, standards, and expectations.

Contractors are typically required to document the installation or tune-up on forms that must be submitted to the program before an incentive is issued to the consumer or contractor. Some form of verification procedure or quality assurance inspection is used to ensure compliance with program standards. Some programs contract with a third party verification service that works with contractors and remotely verifies installation criteria such as air flow and refrigerant charge. The most successful programs to date are operated by utilities or state energy agencies. For example, utilities in NJ, MA, NY and RI have offered programs with incentives for high efficiency residential central air conditioners or heat pumps and for quality installation.

In addition to a quality installation there are other home improvements that can reduce cooling demand. Improvements to a home's thermal envelope, such as air sealing, adding insulation, and installing ENERGY STAR qualified windows will also reduce the amount of time the air conditioner runs to keep the home comfortable. ENERGY STAR's DIY Guide to Home Sealing is an excellent resource to encourage homeowners to make improvements to their home's thermal envelope.

EPA is developing the ENERGY STAR HVAC Quality Installation Program that will build on the efforts of the Air Conditioning Contractors of America and other industry stakeholders to develop a quality installation specification. EPA is dedicating resources to develop the right tools and consumer messages to grow the program. EPA will work closely with program administrators and develop customized materials for the promotion of proper installation of HVAC equipment.

3.4.3. Barriers

Implementing a quality installation and maintenance program requires a commitment to work with HVAC trade contractors and play a role in technician training and mentoring. To maintain the credibility of the program, it is essential to verify that contractors are meeting program standards. When standards are not enforced, the program does not achieve the expected savings, and the business of contractors following program standards is damaged. Some programs use an independent organization, called a verification service provider, to verify that

[g] Though this section focuses on the residential market, AC installation and tune-up programs are also a successful strategy for achieving peak demand savings in the commercial market.

air flow and refrigerant charge are correct. Programs have also used on-site inspections to verify that program standards are met.

3.4.4. Peak Demand Impacts

Program-reported demand reductions range from 0.2 kW per home to around 1 kW per home, with the greatest impacts experienced in areas with substantial cooling loads.[h]

Programs employ a number of key metrics to track key savings and ensure that peak load reduction targets are being met. Use of a third party verification service provides a built-in system for verifying the activities of participating contractors, although program implementers have found that random spot checks of contractors are necessary to ensure accurate reporting.

3.4.5. Cost-Effectiveness

Central AC installation and maintenance programs report a levelized cost of conserved energy (CCE) between $0.03 and $0.04/kWh.[i] Programs are most cost-effective in warm climates where high equipment usage produces larger energy savings and where there is a high market saturation of central AC systems.

3.4.6. Program Examples

- **Long Island Power Authority (LIPA), New York:** LIPA has offered financial incentives for the installation of high efficiency HVAC equipment with documentation of proper installation for several years. In 2006, third-party verification of charge and air flow was instituted into the program. Similar programs in Massachusetts and Rhode Island are also using third-party verification of air flow and refrigerant charge. LIPA estimates a per-unit savings of 1,364 kWh/year and peak demand savings of 1.75 kW when an old 10.2 SEER unit is replaced with a new 15 SEER unit that is installed correctly. Program Web site: http://www.lipower.org/cei/coolhomes.html.

- **New Jersey Clean Energy Program, New Jersey**: The COOLAdvantage Program, funded by a systems benefit charge, offers financial incentives for proper installation of high efficiency HVAC equipment. In 2005, over 600 HVAC technicians received sales and technical training, and over 17,000 central air conditioning units or heat pumps were installed achieving an estimated savings of 15,012 MWh of electricity and 12.7 MW of demand reduction.[14] Program Web site: http://www.njcleanenergy.com/residential/programs/cooladvantage/cooladvantage-program.

- **Oncor, Texas**: Through the Air Conditioning Installer Program, Oncor provides technician training on proper installation practices for air conditioning and duct systems. An independent verification confirms that the installations meet program specifications, and the homeowner receives a “High Performance Installation” certificate. Small installer incentives are offered to offset additional labor and materials costs associated with a quality installation project. In 2003, the program achieved a peak demand reduction of nearly 1,800 kW and electricity savings of over 2,600 MWh. In 2004, the

[h] Based on reported results from Great River Energy, the New Jersey Clean Energy Program, and Proctor Engineering’s CheckMe! program.

[i] EPA estimates levelized CCE based on data from PG&E.

program achieved a peak demand reduction of over 9,000 kW and electricity savings of over 12,000 MWh, while distributing fewer incentive dollars to participating contractors. An evaluation of the 2003-2004 programs concluded that these results indicate the program is achieving its market transformation objectives.[15] Program Web site: http://www.oncor.com/electricity/teem/consumer/ac_installer/default.aspx.

- **Northeast Energy Efficiency Partnership (NEEP)**: NEEP facilitates information exchange to increase sales of high efficiency AC systems using quality installation practices. NEEP is working to change the northeast residential HVAC market to one in which most consumers choose efficient equipment and systems, and most service providers use quality installation practices when installing and servicing HVAC equipment and systems. In 2006 NEEP completed a research project on behalf of the NJ Board of Public Utilities and the New York State Energy Research and Development Authority (NYSERDA) with State Technologies Advancement Collaborative (STAC) funding from DOE to inform the development of common regional quality installation protocols. As an outcome of this effort, NEEP published a regional market transformation strategy residential HVAC. Program Web site: http://www.neep.org/initiatives/Res_HVAC.html.

3.5. Appliance Retirement and Recycling

3.5.1. Overview

> ***Highlights: Appliance Recycling***
>
> - **Demand reduction**: 0.16 - 0.4 kW per unit.
> - **Technologies**: Retirement and recycling of inefficient working refrigerators, freezers, and room AC.
> - **Cost effectiveness:** $0.03-0.05/kWh.

For new appliances such as refrigerators, freezers and room air conditioners, tightening efficiency standards means the incremental peak demand savings between premium efficiency equipment and standard equipment is smaller, but there is still a large amount of inefficient old equipment on the grid. For example, of the existing stock of refrigerators in U.S. homes, approximately 25 percent (31 million) were manufactured before minimum efficiency standards took effect in 1993.[16] By implementing an appliance retirement and recycling program, energy efficiency program sponsors are able to reduce energy consumption and peak demand by removing high-energy consuming refrigerators, freezers, and room air-conditioners from the grid and by ensuring that they are not put back on the secondary market. As an additional benefit, programs are also able to reduce emissions of ozone-depleting substances (ODS) and greenhouse gases by ensuring that the refrigerants and foams contained in appliances are properly removed and recycled/destroyed.

3.5.2. Best Practices

Promoting the retirement and recycling of old, inefficient refrigerators or freezers through a turn-in incentive program is a straightforward model for achieving cost-effective energy savings. Programs typically offer a turn-in incentive and cost-free pickup of the functioning older appliance. The average incentive is around $35 per appliance, though some programs have offered an incentive as high as $50.

Appliance recycling programs are a common program model for utilities, with many utilities simplifying program administration by contracting with a national or regional appliance recycling company to implement the program. These companies provide turnkey implementation services including eligibility verification, appointment scheduling, appliance pickup, recycling and disposal, and incentive processing. Some programs stipulate disposal requirement, specifying that recycling contractors incinerate foam insulation to prevent the release of chlorofluorocarbons (CFCs).

To ensure a high net-to-gross ratio (the ratio that adjusts gross energy savings to determine the net energy savings for which the recycling program should actually be credited) programs often specify key eligibility criteria such as appliance size, age (for example, some programs specify that refrigerators must be models produced before 1993 efficiency standards took effect), and requirements that units are functioning at the time of pick up. Consumers should be informed that they will be charged a fee to recycle equipment that is not functioning.

Most programs include a strong marketing and consumer education component emphasizing the cost of keeping a second refrigerator or freezer in the basement or garage, as well as education on the savings associated with replacing primary refrigerators that were manufactured before 1993.

In addition, some programs work with major appliance retailers to offer an incentive for retirement and recycling of refrigerators when new appliances are delivered to ensure that older refrigerators do not become second refrigerators or are not sold through resale markets.

3.5.3. Barriers

In general, appliance recycling programs show declining cost effectiveness and peak demand impacts with time as the market is depleted. A recent review of refrigerator recycling programs suggests that in the early years of a program, most participants will retire (and not replace) secondary models, while in later years of implementation a higher percentage of participants will replace primary equipment.[17] Thus, education and incentives to promote the purchase of ENERGY STAR qualifying new equipment might be beneficial for long-standing programs—new ENERGY STAR qualifying refrigerators use less energy than a 75-watt light bulb.

3.5.4. Peak Demand Impacts

The energy benefits attributed to the program are the product of the energy consumption of collected appliances, the remaining life of those appliances, and the net-to-gross ratio. Typical peak demand impacts per unit for refrigerator retirement programs range between 0.16 kW and 0.28 kW.[j] Programs that included room air-conditioners in their evaluation estimated summer peak demand savings between 0.34 and 0.41 kW.[18] While air-conditioners consume less energy annually, they achieve the greatest savings in summer peak demand when compared with refrigerators and freezers.

3.5.5. Cost Effectiveness

According to the Appliance Recycling Centers of America Inc. (ARCA), the cost of an appliance recycling program is roughly the same regardless of its location throughout the country—about $90 to $110 per unit, not including advertising and the incentive. According to ARCA, transportation costs vary only by about $10 to $20 per unit from any location in the continental U.S.

Refrigerator recycling programs can be administered for a levelized cost of conserved energy (CCE) between $0.03 and $0.05/kWh.[k] In general, levelized CCE is lower in the early years of program implementation when there is a higher percentage of retired secondary units that are not replaced. Long-running programs like Southern California Edison's have shown a gradual decline in cost-effectiveness as the average age of collected refrigerators decreases and the percentage of units being replaced increases.[19]

3.5.6. Program Examples

- **Connecticut Light & Power (CL&P) and United Illuminating (UI), Connecticut**: CL&P and UI ran a successful joint appliance recycling program from 2004 through 2006. The demand reduction attributable to the program was over 4 MW.[20]
- **Southern California Edison (SCE), California**: SCE has run appliance recycling programs since 1994. From a residential customer base of 4 million, SCE achieves an annual recycling volume of around 50,000 units per year.[21] In 2002, the program recycled 43,000 units, reducing peak demand by over 12 MW.[22] Program Web site: http://www.sce.com/RebatesandSavings/Residential/_Appliances/RefrigeratorandFreezerRecycling/.

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[j] Peak demand impacts based on evaluation data from AmerenUE, CL&P/UI, SCE, PG&E, SDG&E, SMUD, Nevada Power, and Sierra Pacific Power.

[k] eSource estimates are based on data from Fort Collins Utilities, Nevada Power, Sacramento Municipal Utility District, Southern California Edison, and Utah Power.

3.6. PC Power Management

3.6.1. Overview

> ***Highlights: PC Power Management***
> - **Demand reduction**: Approx. 1 kW per 150 PCs.
> - **Technologies**: Software that reduces monitor and computer power use when inactive.
> - **Cost effectiveness:** $0.01-0.02/kWh.
> - **ENERGY STAR information at**: www.energystar.gov/powermanagement.

Computers account for over 1 percent of the nation's commercial electricity usage, and EPA estimates that half of all energy used to power personal computers (PCs) is wasted. In a typical building, office equipment accounts for about 18 percent of electricity use, with PCs accounting for more than half of that equipment plug load.[23] Computers (CPU, hard drive, etc.) use roughly 60 to 70 watts when active. Flat panel LCD monitors use around half the power of computers when active. Power management, a feature available on all computers and monitors, automatically places inactive PCs into a low-power sleep mode—where the monitor and computer will draw only 1 to 3 watts each. PCs quickly wake up from sleep with a wiggle of the mouse or touch of the keyboard.

Roughly 80% of monitors have power management settings already activated. However, only 5 to 10 percent of computers are power managed. Since computers use twice the power of LCD monitors and are rarely power managed, EPA recommends activating power management on both the computer and monitor—and not just the monitor only—to maximize your savings. Overall, EPA estimates that if all office computers and monitors in the U.S. used their power management feature, the country could save more than 44 billion kWh of electricity, equivalent to the greenhouse gas emissions of 5 million cars each year.

In areas with large numbers of commercial office buildings, programs can achieve peak demand reductions by helping businesses manage the way they operate their computers. Savings can often be accomplished at low to moderate cost through network tools that can activate power management settings simultaneously on every computer in a network. PC power management also offers real cost-savings opportunities for businesses. Monitor power management (MPM) saves $10-30 per monitor annually, and computer power management (CPM) saves an additional $15-45 per desktop computer annually. Reducing PC energy use also helps to reduce the internal heat load in commercial offices, creating additional savings from cooling load reductions. Providing businesses with additional information on purchasing options for a host of other ENERGY STAR qualifying products for the office (including computers, monitors, printers, copiers, televisions and electronics) provides an additional value-added service and helps avoid lost opportunities for peak demand reduction.

3.6.2. Best Practices

At a minimum, energy efficiency programs promoting PC power management entail targeted outreach and education efforts. Programs can be education-only, informing customers about the benefits of PC power management and referring them to ENERGY STAR tools and resources. Programs can also provide a higher level of technical support and incentives for implementing power management protocols where appropriate.

Programs must have the capacity to discuss energy savings opportunities at a top level with business managers as well as the technical knowledge to communicate options and opportunities to IT managers. Technical expertise that contribute to successful power management efforts include: 1) Making available solutions to accommodate waking up sleeping computers at night for updates, and 2) Advising network administrators on the appropriate network tool option to activate power management on their specific network environment. Targeting sites with more than 500 computers increases cost-effectiveness of outreach efforts, although direct mail and online tools have been used successfully for smaller businesses and residential customers. Other elements of success include management support for energy efficiency improvement, a well-managed and proactive IT department, and the capacity and motivation to effectively communicate the benefits of PC power management to computer users.

3.6.3. Barriers

IT departments regularly deactivate power management features when setting up new PCs because they update computers at night or had bad experiences when CPM was much more unstable. IT departments must be convinced that power management is a sound technology and be presented with solutions to ensure that sleeping computers do not interfere with the nighttime distribution of administrative software updates. For these reasons, it is important for energy efficiency programs to have a high level of technical capability so they can communicate effectively with IT staff and change standard practice.

3.6.4. Peak Demand Impacts

Though savings (kWh) per computer are relatively well-documented, there are fewer data on the peak demand impacts (kW) attributable to PC power management programs. (A study is currently underway at a Seattle utility to quantify the peak demand impacts of PC power management.) Key factors affecting savings include how computers are currently used—nighttime shut downs, work patterns, and whether monitor power management is already in use. For example, if each computer uses 70 watts and 10 percent of them enter low-power sleep mode (a conservative estimate) during peak demand periods, then power managing around 150 computers saves 1 kW of peak demand.

3.6.5. Cost-Effectiveness

PC power management programs can be implemented within a short time horizon. Businesses need to simply activate existing features on their PCs. Power management programs offer a good opportunity to reduce load during peak times on relatively short notice. In the past, programs that promoted and implemented power management of only the monitor typically achieve a levelized CEE of $0.01 to $0.02/kWh.[l] Outreach and education-only programs are the lowest-cost, but it is more difficult to verify the savings associated with these programs. Programs that provide a higher level of technical support services incur costs between $0.01 and $0.06/kWh, or $5-30 per computer. Monitoring and verification activities increase program costs. There are also some costs to the customer in terms of the time internal IT staff spend on power management projects.

3.6.6. Program Examples

- **Avista Utilities, Washington**: Avista provides an incentive of $10 per controlled PC for software that enables a centralized approach to power management and which meets utility-specified minimum criteria. Program Web site: http://www.avistautilities.com/saving/conservation/power_management.asp.

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[l] EPA estimates based on data from NYSERDA and PG&E.

- **Pacific Gas & Electric Company (PG&E) and the Association of Bay Area Governments (ABAG), California**: PG&E and ABAG partnered to promote CPM, providing free materials and information to ABAG member agencies. Technical consultants hosted conference calls to help agencies identify the best path to CPM giving their unique IT environments. PG&E offered an incentive of $10 per controlled PC to association members, regardless of the CPM solution implemented.

- **Northwest Energy Efficiency Alliance (NEEA)**: In 2001, NEEA formed a partnership with Verdiem, Inc. to commercialize the Surveyor Network Energy Manager software, which enables network operators to remotely turn off PCs and enable pre-installed power management software on networked computers. NEEA provided matching funds to support Verdiem's marketing efforts. A 2005 program evaluation verified savings of around 200 kWh per PC, but did not evaluate peak demand impacts. Program Web site: http://www.nwalliance.org/ourwork/projectsummary.aspx?ID=65.

3.7. Commercial Lighting, Cooling, and Refrigeration

3.7.1. Overview

> ***Highlights: Commercial Lighting, Cooling & Refrigeration***
>
> - **Demand reduction**:
>   - **Lighting:** 1-7 kW/participant for small commercial programs, and 20-35 kW/ participant for large C&I programs.
>   - **HVAC:** 0.6-1 kW/participant for small commercial programs, and ~200 kW/participant for large C&I programs.
> - **Technologies**: Efficient lighting, HVAC, and refrigeration equipment for commercial applications.
> - **Cost effectiveness:**
>   - **Lighting programs:** $0.005-$0.02/kWh.
>   - **HVAC programs:** $0.01-$0.06/kWh.

In the commercial sector, which comprises about 35 percent of all retail electricity sales in the U.S.[24], lighting and cooling represent key areas of opportunity for peak demand reduction. Lighting consumes approximately 23 percent of the electricity used in commercial buildings and is a primary source of heat gain and waste heat. On average, cooling accounts for about 26 percent of electricity use in commercial buildings and an even larger percentage in warm climates.[25] On a national basis, offices, retail spaces, warehouses, and schools are the largest consumers of electricity for commercial lighting and HVAC, and are likely to be strong initial targets for commercial retrofit programs. Refrigeration represents around 9 percent of commercial energy use, and programs have achieved peak demand reduction by promoting energy-efficient refrigeration in targeted segments of the commercial market such as grocery stores and food service establishments.

3.7.2. Best Practices

Prescriptive incentive programs are a proven strategy to capture savings from efficient lighting, cooling, and refrigeration measures across a range of non-residential sectors. Such programs offer pre-determined incentives for a range of common energy efficiency measures for which per-measure energy savings can be readily estimated. To maximize market impact, prescriptive programs are typically trade ally-driven, and might involve manufacturers, distributors, equipment vendors and installers, and energy service providers. Such programs minimize barriers to participation through simple application processes and rapid incentive processing. Due to their straightforward design and implementation approach, prescriptive incentive programs can also be ramped up quickly, and are the basic building blocks of virtually every energy efficiency program portfolio.

Major program elements typically employed by energy efficiency program administrators include:

- Prescriptive incentives that cover a portion of the incremental cost of installing a higher efficiency technology, with many programs setting incentive levels to ensure payback in one to two years.
- Incentive structures linked to ENERGY STAR specifications and performance thresholds, when available.
- Program marketing via trade allies such as lighting and HVAC vendors and contractors. Regular communication with trade allies allows program administrators to address issues as they arise and ensures allies are actively engaged in promoting the program.

In some cases, trade ally incentives are offered to motivate sales of qualifying equipment.

- Additional marketing and outreach to end users conducted through business and industry trade associations, as well as direct solicitation by mail and telephone.
- Straightforward incentive application processes, with some utilities offering online rebate application and processing.
- Streamlined verification/quality control processes to facilitate ease of participation and minimize the time required for incentive payment.
- Simple tools and calculators to help customers understand the benefits of investing in energy efficient technologies and to help trade allies sell high efficiency products by clearly demonstrating payback period and lifetime savings benefits.

Although prescriptive programs are an excellent starting place for capturing peak demand reduction opportunities in the commercial sector, a multi-faceted program approach might be needed to capitalize on all opportunities for peak demand reduction. To capture a larger amount of energy efficiency potential and serve a broad range of end-users, a program administrator might choose to include prescriptive, custom, and targeted market program elements in the initial energy efficiency portfolio, or establish the necessary market presence with a prescriptive program before launching more complex program designs in subsequent years.

Lighting

To promote optimal efficiency in commercial lighting design, some best practice programs employ incentives based on energy savings or demand reduction (per kWh or kW). Though prescriptive per-fixture incentive programs are simple to administer, they are less effective in promoting optimal lighting design (for example, they do not address energy savings that could be achieved through delamping). Though savings-based incentives increase administrative complexity (particularly in terms of measurement and verification requirements), such approaches seek to optimize energy use in a given space, enabling customers to achieve the benefits of improved lighting quality as well as energy savings.

Cooling

In the case of HVAC systems where proper sizing and installation greatly improves performance, a quality assurance plan helps to ensure proper design and installation. Proof of proper sizing might be required as a condition of the rebate. For packaged HVAC units used in smaller commercial applications, programs have developed clear quality assurance standards and provided on-site verification using a sampling approach to verify performance. For larger units, some programs offer commissioning assistance and incentives to ensure proper function.

Refrigeration

A broad prescriptive program might not be an effective mechanism for reaching niche market segments such as grocery and food service establishments. Targeted market programs can employ financial value messaging and implementation strategies that are designed to have maximum efficacy in niche market segments. In addition, small businesses and other hard-to-reach market segments often face barriers to participation in efficiency programs that are more severe or complex than those addressed by mainstream program design. Some program administrators include specialized programs designed to target hard-to-reach customer segments where a specific delivery approach is needed to overcome market-specific participation barriers. Common approaches employed by such programs include grassroots outreach strategies, higher incentive levels, on-bill financing mechanisms to help customers finance costs not covered by incentives, and direct installation of low-cost measures such as refrigerator/freezer door gaskets, strip curtains for walk-ins, or anti-sweat heater (ASH) controls.

3.7.3. Barriers

Prescriptive incentive programs might fail to realize savings that are associated with more complex measures or with systems that include multiple technologies. For example, a facility that is evaluating equipment for a cooling system upgrade might not consider how implementing a lighting system upgrade would reduce cooling load and potentially allow for down-sizing of cooling equipment. A balanced energy efficiency portfolio will also include programs to promote more comprehensive assessments of facility energy use and cross-cutting energy efficiency opportunities (see Section 3.8 for a discussion of whole building energy performance programs for the commercial market). Proven models include custom incentive programs that offer a greater degree of technical assistance and incentives based on calculated energy savings and/or demand reduction. Design assistance programs offer similar mechanisms to promote energy efficient design and construction of commercial facilities (new construction or major renovations).

3.7.4. Peak Demand Impacts

Prescriptive incentive programs for the commercial market vary in terms of peak demand impacts per customer depending on the technologies promoted and market segments addressed. Section 3.1 presents measure-level demand reduction data compiled by ACEEE.

At the program level, lighting programs for the small commercial market have achieved demand reduction impacts ranging from 1 to 7 kW per participant, and lighting programs targeting large commercial and industrial (C&I) customers have achieved demand reduction impacts ranging from 20 kW to 35 kW.[26] HVAC programs targeting tuneups and small commercial applications have achieved demand reductions of 0.6 kW to 1 kW per participant. An HVAC program promoting energy efficient water-cooled chillers for the large C&I market implemented by the Los Angeles Department of Water & Power achieved demand reductions of over 200 kW per participant.[27] For refrigeration measures, a statewide program in California targeting efficient refrigeration and lighting for independent grocery stores achieved peak demand reductions of 10 kW per participant.[28]

3.7.5. Cost-Effectiveness

Prescriptive commercial lighting and HVAC programs have been market-tested and proven to be cost-effective across the country. Prescriptive programs targeting commercial lighting report a levelized CCE between $0.005 and $0.02/kWh.[29] Prescriptive programs targeting commercial HVAC systems report a levelized CCE between $0.01 and $0.06/kWh.[30] As savings associated with HVAC systems are highly dependent on base usage levels, HVAC programs are more cost effective in severe climates than in mild ones.

3.7.6. Program Examples

- **Xcel Energy, Minnesota**: Xcel's Lighting Efficiency Program offers prescriptive and custom incentives to promote energy-efficient lighting retrofits in existing commercial buildings and energy efficient lighting design in commercial new construction. The program employs higher incentive levels for small commercial customers. In 2006, the program completed nearly 300 lighting retrofits and achieved an average peak demand reduction of 12 kW per customer (program-reported gross savings).[31] Program Web site: http://www.xcelenergy.com/XLWEB/CDA/0,3080,1-1-3_4530_39021_40437-779-5_538_969-0,00.html.

- **Northeast Energy Efficiency Partnerships (NEEP)**: NEEP developed Cool Choice as a regional implementation model for energy efficiency program sponsors targeting retrofits of commercial HVAC equipment. Until the adoption of new federal efficiency standards (set to take effect in 2010) the program offered technical assistance and incentives for the installation of packaged HVAC units (up to 30 tons in capacity) that met CEE Tier 2 efficiency standards. Local program sponsors include the Long Island Power Authority (LIPA), NSTAR, Efficiency Vermont and Efficiency Maine. In 2002, the program served 3,200 customers and achieved 3.5 MW of peak demand reduction.[32] Program Web site: http://www.neep.org/initiatives/Comm_HVAC.html.

- **Pacific Gas & Electric Company (PG&E), California**: The EnergySmart Grocer program provides information, technical assistance, and incentives to promote energy efficient refrigeration, lighting, and HVAC equipment for independent food retailers. Program incentives include direct installation of low-cost measures as well as prescriptive rebates for more capital-intensive measures. Although at one point the program was jointly administered as a statewide program by the four major investor-owned utilities in California, it is now offered only by PG&E. An evaluation of the statewide program for 2004-2005 assessed annual peak demand impacts at 12.7 MW. With around 1,300 retrofits completed over that period, the program achieved peak demand reductions of almost 10 kW per customer.[33] Program Web site: http://www.energysmartgrocer.org/.

3.8. Whole Building Energy Performance for the C&I Market

3.8.1. Overview

> ***Highlights: Whole Building Performance***
>
> - **Demand reduction**: 16 - 600 kW per participant.
> - **Technologies**: Efficient lighting, HVAC, motors and drives, process retrofits, and commissioning services.
> - **Cost effectiveness:** $0.01 - 0.04/kWh.
> - **ENERGY STAR information at**: www.energystar.gov/buildings.

Commercial building energy use is a leading component of peak energy demand. Typical commercial building energy efficiency programs provide rebates to upgrade specific equipment. While these technology-specific incentives have an important role in building markets for energy efficiency, taking a more comprehensive approach—looking at interactions of energy end-uses and overall building performance—allows for energy efficiency programs to capture much greater savings. Over the past 25 years, the energy efficiency of building components such as windows and chillers has improved by more than 30 percent; yet, building energy efficiency has not improved by nearly as much. This result reflects the significant role that proper sizing of heating and cooling equipment, integrating individual technical components and controlling, operating and maintaining equipment can have in determining the energy performance of a building.

A whole building energy performance approach moves beyond traditional energy efficiency programs focused on individual measures or end uses. EPA estimates that the energy consumption of commercial and industrial buildings can be reduced by up to 30 percent through whole-building strategies that address improved operations, maintenance practices, and comprehensive upgrades to building equipment.

In the C&I sector, lack of knowledge about overall building energy performance is a key barrier to motivating building owners and operators to implement comprehensive energy efficiency improvement projects. To address this obstacle, EPA created an energy performance rating system that compares the energy use of an individual building against the national stock of similar buildings using a 1 to 100 point rating system. This rating enables building owners and managers to measure how well building systems are integrated, operated, and maintained. The EPA rating has a clear role to play in any comprehensive program design by providing a standardized metric for whole-building performance. Use of the performance rating also allows program administrators to establish a valuable link to the ENERGY STAR program platform for the commercial market.

3.8.2. Best Practices

There are two primary program strategies for capturing the peak demand reduction opportunities associated with whole building energy performance improvement. Each strategy is designed to take a comprehensive approach to assess energy savings opportunities in C&I buildings, although each has a different primary focus. One strategy focuses on operations, maintenance, and low cost equipment improvements through retrocommissioning (RCx) building systems. The other strategy employs comprehensive, customized approaches to target capital retrofit improvements.

- **RCx programs**: RCx is an emerging energy efficiency program design in the U.S. that improves the operating efficiency of buildings that do not require immediate capital improvements to replace or repair equipment. The RCx process ensures that building systems such as HVAC equipment and control systems are operating at optimal efficiency in accordance with design specifications. Demand and energy savings are realized through the systematic evaluation of building systems and the implementation of low-cost measures designed to improve system operations and, in many cases, improve occupant comfort.

- **Comprehensive retrofit programs**: These programs are designed to promote a comprehensive assessment of energy efficiency retrofit opportunities across multiple building systems. Common features include walk-through energy audits and a high level of technical assistance. Technical assistance is usually provided on a cost-share basis to ensure customer investment in the process, and might include training on benchmarking energy use with the EPA rating system, energy modeling, and financial feasibility studies of energy efficiency retrofit opportunities. Comprehensive retrofit programs employ a variety of incentive strategies, including custom incentives based on kW or kWh reductions, standard offer contracts, and bidding processes.

EPA's energy performance rating system supports both program strategies. In addition to increasing customer motivation to participate in existing energy efficiency programs and/or otherwise pursue improvements in energy efficiency, promoting the use of the EPA rating through early educational and informational efforts can help lay the foundation for more comprehensive improvement approaches. Program administrators have incorporated the EPA rating as their energy use intensity benchmark for retro-commissioning programs and whole-building benchmarking and upgrade programs.

3.8.3. Barriers

Whole building energy performance programs are generally more complex to administer than prescriptive rebate programs, and are most commonly implemented by program administrators with an established record of energy efficiency initiatives. Less experienced program administrators might begin with traditional prescriptive programs and gain experience with more comprehensive approaches on a small-scale pilot basis. In order to capture a larger amount of energy efficiency potential and serve a broad range of end-users, a mature energy efficiency portfolio will typically include a mixture of prescriptive and comprehensive program approaches for the C&I market.

Such programs may also encounter more substantial barriers to participation as they require a higher level of effort on the part of the customer/trade ally. In some markets, there may be few trade allies qualified to implement more comprehensive energy efficiency improvement projects. NYSERDA and National Grid have invested resources in developing networks of qualified trade allies through screening and training activities.

Lastly, whole building approaches typically require more measurement and verification (EM&V) M&V resources to verify peak demand impacts. Where prescriptive programs can employ deemed savings estimates due to the standardized nature of the energy savings measures they promote, custom programs often require a greater number of on-site assessments as well as some post-installation metering and verification because of the non-standard nature of the measures covered, interactive effects (e.g., between lighting and HVAC systems), and project size.

3.8.4. Peak Demand Impacts

There is a wide range in the peak demand impacts attributed to programs promoting whole building energy performance improvement. Comprehensive programs serving the large C&I market have achieved peak demand reductions of 16 to 300 kW per participant.[34] Retro-commissioning programs show a similar range in demand reduction impacts depending on the nature of targeted facilities and the extent of commissioning services provided, with programs reporting reductions between 17 and 600 kW per participant.[35]

3.8.5. Cost-Effectiveness

Programs leveraging the ENERGY STAR platform to promote comprehensive whole building energy performance are delivering substantial energy savings for a levelized CCE of $0.03 to $0.04/kWh.[m] A recent review of large comprehensive retrofit programs for the C&I market show levelized CCE between $0.01 and $0.04/kWh.[36]

3.8.6. Program Examples

- **NYSERDA, New York:** NYSERDA has been a leader in developing comprehensive approaches to whole building performance improvement and has integrated the EPA energy performance rating system rating into several of its programs—New York Energy $mart Schools, the Retro-Commissioning Pilot, Healthcare Facility Benchmarking, and the recently launched Enhance Commercial/Industrial Performance Program. Without investment in major capital equipment improvements, NYSERDA estimates that RCx projects can reduce building energy demand (kW) by 5 to 7 percent, with typical energy consumption savings (kWh) ranging from 5 to 20 percent. Program Web site: http://www.nyserda.org/Programs/Commercial_Industrial/cipp.asp.

- **CL&P, Connecticut:** CL&P has two programs that promote whole building energy performance in the C&I market. The Operations & Maintenance program provides incentives for RCx services and other O&M improvement opportunities, and also offers a Building Operator Certification training program to promote ongoing O&M best practices. In 2006, the program achieved demand reductions of 27 kW per participant. Energy Opportunities is a comprehensive program that provides prescriptive and custom incentives as well as technical assessments of energy efficiency retrofit opportunities in existing buildings. In 2006, the program achieved demand reductions of 30 kW per participant.
    - O&M Program Web site: http://www.cl-p.com/clmbus/target/OandM.asp.
    - Energy Opportunities Program Web site: http://www.cl-p.com/clmbus/target/custom.asp.

- **NSTAR, Massachusetts**: Since 2003, NSTAR has assessed whole building energy performance in over 70 buildings, totaling 16 million square feet of floor space. NSTAR uses the EPA performance rating system and other ENERGY STAR tools to educate customers about the overall performance of their buildings and to help them identify and prioritize energy efficiency upgrades. NSTAR also provides prescriptive and custom incentives through the Business Solutions Program. Approximately 50 percent of

[m] Estimates based on data from Northeast Utilities (CL&P and UI); NSTAR, and SCE.

customers that benchmark their buildings have taken action to improve energy performance, with many taking advantage of prescriptive and custom incentive offerings. Program Web site: http://www.nstaronline.com/business/energy_efficiency/electric_programs/benchmark.asp.

3.9. Cool Roofs

3.9.1. Overview

Energy-efficient roofing systems—also called "cool roofs"—can reduce roof temperature by as much as 100°F on hot summer afternoons, lowering cooling energy requirements and peak energy demand. Additional benefits associated with cool roofs include increased comfort for building occupants and greater durability as cool roofs are less subject to damage from ultraviolet radiation and daily temperature fluctuations. ENERGY STAR qualified roof products can help reduce the amount of air conditioning needed in buildings and can lower peak cooling demand by 10–15 percent.

Highlights: Cool Roofs

- **Demand reduction**: 0.19-0.4 kW per 1000 sq. ft.
- **Technologies**: Roofing materials with high reflectance and surface emittance.
- **Cost effectiveness:** $0.03-0.11/kWh.
- **ENERGY STAR information at**: http://www.energystar.gov/index.cfm?c=roof_prods.pr_roof_products.

The typical cost premium for a cool roof is less than $0.20 per square foot, and may be as low as zero.

3.9.2. Best Practices

There are two primary strategies to achieve the peak demand reductions associated with cool roofs: building codes that establish cool roof requirements and energy efficiency incentive programs.

Building codes

California is a leading example of the use of building codes to promote cool roofs, as the state incorporated cool roofs into its "Title 24" Building Energy Efficiency Standards in 2005.[n] These requirements apply to conditioned (heated or cooled) nonresidential buildings that have low-sloped roofs. This includes newly constructed buildings and re-roofing of existing buildings. Title 24 does not require that building owners replace or recover existing roofs that are not in need of re-roofing.

Title 24 offers builders the option of following a prescriptive or performance approach to complying with their energy budget. Title 24 standards are developed and promulgated by the California Energy Commission (CEC), but local building departments are responsible for enforcing the cool roof requirements. The CEC maintains a Title 24 Hotline, offers training at meetings of local building officials, and provides onsite training upon request. California's electric and gas utilities also sponsor training sessions for local building departments on compliance options. For a cool roof product to be eligible to qualify under the Title 24 standards, it must be tested and rated through the Cool Roof Rating Council (CRRC). Cool roof manufacturers offer products for both low-slope and sloped roofs.

California has a long history of advancing cool roofs as a peak demand reduction measure. Related education and outreach programs are effective at reaching customers, retailers, and suppliers. The CEC's Consumer Energy Center offers a database of cool roof products, FAQs,

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[n] Additional details on California's cool roof requirements under Title 24 are available at: http://www.consumerenergycenter.org/coolroof/.

print material, videos, and a comprehensive Web site. Experts from the Lawrence Berkeley Lab (LBNL) and CEC frequently participate in peer exchange forums. Research by LBNL's Heat Island Program demonstrates that reductions in building cooling electricity use, peak power demand, and ambient air temperature are all possible from cool roofs in California. However, much of this research is location-specific, and other states may be interested in conducting their own analysis.

Incentive programs

Cool roof incentive programs have proven to be cost-effective strategies for achieving energy savings and peak demand reduction, particularly in regions with substantial cooling loads. Programs are typically trade ally-driven, providing incentives to roofing contractors for the installation of qualifying product in eligible facilities. Contractor outreach and training is recommended to develop a network of installers promoting qualified products to their customers. To maximize savings, programs typically establish requirements on the types of facilities that are eligible for incentives (e.g., commercial facilities with low- or no-slope roofs, etc.). Adequate roof insulation also plays an important role in reducing cooling-related building energy consumption, and some programs offer incentives for roofing and ceiling insulation as well as cool roofs.

3.9.3. Barriers

Cool roof incentive programs are not cost-effective in all areas. Building code requirements may be a more effective strategy in milder climate regions. Where cool roof programs are cost-effective, it is important to conduct verification of contractor work to ensure that program requirements are being met.

3.9.4. Peak Demand Impacts

DOE conducted building energy simulations to demonstrate the savings associated with the use of a cool roofing material on a prototypical California nonresidential building with a low-sloped roof. These simulations demonstrated significant electricity and gas savings on a unit-area basis, as shown in Table 3-5.

Table 3-5. Cool Roof Savings

Savings Category	Average Savings per 1000 sq. ft.
Annual electricity savings	297 kWh
Annual natural gas savings	4.9 therms
Annual source energy savings	2.6 MBtu
Peak demand reduction	0.19 kW
Cooling equipment cost savings	$94
Fifteen-year net present value (NPV) of energy savings	$451
Total cost savings (cooling equipment cost savings + 15-year NPV energy savings)	**$545**

Energy efficiency programs have achieved peak demand reductions of 5 kW per participant and 0.4 kW per thousand square feet.[o]

3.9.5. Cost-Effectiveness

Cool roof incentive programs will be most cost-effective in areas with substantial cooling loads. Cool roof programs reviewed in this assessment show a levelized CCE between $0.03 and $0.11/kWh.[p]

3.9.6. Program Examples

- **Austin Energy, Texas**: Austin Energy has offered a cool roof program since 2002, and currently provides commercial customers with incentives of $0.15 per square foot. From 2002 through 2005, the program achieved 680 kW of peak demand reduction by providing incentives for $1.6 million square feet of cool roofs.[37] Program Web site: http://www.austinenergy.com/Energy%20Efficiency/Programs/Rebates/Commercial/Commercial%20Energy/ceilingRoof.htm.
- **Sacramento Municipal Utility District (SMUD), California:** SMUD launched a successful cool roof incentive program in 2001 in an effort to increase market penetration of highly reflective and emissive roofing products in the commercial retrofit and new construction markets. The program was contractor-driven, providing roofing contractors with incentives on a square-foot basis for the installation of ENERGY STAR qualified roofing products. Cool roofs installed on commercial or multifamily residential buildings were eligible for incentives if the buildings were air conditioned and had no-slope roofs. Through 2002, the program achieved demand reductions of 5 kW per participant.[38] The program was discontinued at the end of 2005 once cool roofs became mandated by Title 24 standards. Program Web site: http://www.smud.org/rebates/cool%20roofs/.

[o] Based on program data from Austin Energy and SMUD.

[p] Based on program data from Austin Energy and SMUD.

4. Demand Response

4.1. Introduction

The broad term "Demand response" encompasses a range of program types designed to reduce electricity use during peak demand periods. Demand response programs are typically designed to increase system reliability and/or minimize the use of peaking units that are usually among the most expensive and most polluting sources of power. At the retail level, demand response programs are typically implemented by utilities or other load-serving entities (LSEs). At the wholesale level, independent system operators (ISOs) or regional transmission organizations (RTOs) might also provide incentives to LSEs for the aggregated demand reductions of retail customers. Demand response initiatives range from programs that provide customer incentives for voluntary (nonfirm) or mandatory (firm) load curtailment, to dynamic pricing structures that charge higher rates during peak periods, employing a market-based approach to achieving peak demand reduction.

Some administrators of demand response programs are finding that a portfolio of demand response programs comprised of voluntary and mandatory reduction commitments is the most cost-effective demand response strategy. This approach also offers customers increased flexibility in terms of selecting the demand response option that is best suited to their risk tolerance. A recent assessment of demand response programs by the Federal Energy Regulatory Commission (FERC) notes that multiple demand response offerings can serve complementary goals. For example, large-scale implementation of time-based rates reduces the severity or frequency of reserve shortages, which in turn reduces the need for mandatory curtailments. Reductions in the frequency of curtailment events may also boost participation in incentive-based mandatory curtailment programs by reducing the risks associated with frequent curtailment events.[39]

A variety of enabling technologies reinforce demand response objectives. Advanced metering and communications infrastructure transmits hourly (or even more frequent) data on customer energy use to the LSE, which is necessary to support dynamic pricing structures. Load control devices such as smart thermostats or switches might be located at a customer's home or business, permitting the LSE to remotely curtail their energy use. Smart thermostats and other energy management devices also provide the customer with more detailed information on their energy use, helping to motivate demand reductions when they are needed.

In order to serve as an effective strategy for reducing HEDD emissions, it is essential that demand response initiatives be structured to avoid a net emissions increase through the use of emissions-intensive sources of backup power generation. Some program administrators have addressed this issue by including requirements for the types of load reductions that are eligible for demand response incentives. Combining demand response with efforts to promote clean forms of distributed generation can be another effective strategy for achieving this objective. There is a growing appreciation of the complementary roles that demand response programs and energy efficiency programs play to reduce peak demand, and a balanced approach to demand-side management typically includes both types of initiatives. Moreover, these elements should, to the extent possible, be integrated conceptually and programmatically to extract maximum value from the demand-side resource.

The remaining sections in Chapter 4 discuss best practices for demand response incentive programs and dynamic pricing programs.

4.2. Incentive Programs

4.2.1. Overview

> ***Highlights: Demand Response Incentives***
> - **Demand reduction**: 0.6 kW to 1 kW per participant for direct load control programs.
> - **FERC Assessment of Demand Response & Advanced Metering**: http://www.ferc.gov/legal/staff-reports/demand-response.pdf.

Incentive-based demand response programs provide incentives to electricity users who voluntarily reduce consumption during periods of peak demand or allow their load to be directly curtailed by the LSE or system operator. With emergency demand response, curtailment is triggered when system generating or transmission/distribution capacity is not sufficient to meet demand. With economic demand response, curtailment is triggered by high wholesale prices for electricity. Participating customers typically reduce loads by switching to backup generation or flexing facility loads (e.g., adjusting HVAC or lighting set points) manually or through automated mechanisms controlled remotely by the program administrator. The net emissions reductions achieved by demand response programs depend on which of these load reduction options, or combination of options, is employed.

FERC estimates that the potential peak reductions from existing demand response incentive programs are roughly 37,500 MW nationally and range from 3 to 7 percent of peak demand in most regions.[40]

4.2.2. Best Practices

There are several common types of demand response incentive programs which differ by the end use sector they target (e.g., industrial, commercial, or residential) and the type of event that triggers their utilization (e.g., a system emergency or high wholesale prices). Common incentive program types include:[41]

- **Direct load control programs**: According to the FERC study, direct load control programs are one of the most common types of demand response programs. Direct load control programs typically target the residential or small commercial markets and employ switches or other technologies that allow the LSE or system operator to remotely switch off or cycle equipment such as air conditioners, water heaters, or pool pumps during peak demand periods. The customer usually receives an annual incentive payment or bill credit for participating in the program. Administrators of direct load control programs deploy increasingly sophisticated technologies to facilitate demand response, from smart thermostats to home climate control systems that can be programmed through a Web-based interface.

- **Interruptible/curtailable rates**: Interruptible/curtailable programs are a common program model for the large commercial and industrial market, and offer a rate discount or bill credit to customers that provide a specified amount of load reduction upon advance notice by the LSE. Failure to curtail could mean the customer is subject to a financial penalty, but the total number of curtailment hours that can be called upon during a year is usually capped. Such programs typically target large customers with demand of 200 kW or above, but are not well-suited for customers that operate 24 hours a day or employ continuous manufacturing processes.

- **Demand bidding/buyback programs**: Demand bidding programs also target large commercial and industrial customers and enable participants to specify how much load they would be willing to reduce at a given price or specify both the amount of load reduction and the price. If the customer bids are the least expensive way of meeting demand (e.g., costing less than the supply-side alternative), the load curtailment is called upon and the customers must achieve the specified demand reduction. Such programs are implemented both by LSEs and by system operators.

- **Emergency demand response programs**: Emergency demand response programs provide incentives to customers for reducing load during reliability-triggered events, but curtailment is voluntary. Though some LSEs implement emergency programs, they are most commonly implemented by system operators (ISOs or RTOs).

- **Capacity market programs**: Under capacity market programs, commercial and industrial customers commit to providing pre-specified load reductions during system emergencies. As participants are subject to penalties for failure to curtail usage when notified, capacity market programs represent firm load reduction commitments. Incentives are paid annually, whether or not curtailment events are called. Programs are typically administered by system operators (ISOs or RTOs).

4.2.3. Barriers

In order for demand response incentive programs to provide an effective strategy to reduce HEDD emissions, it is essential that such programs be structured to avoid a net emissions increase through the use of emissions-intensive sources of backup power generation. According to a recent ISO New England report, a significant fraction of incentive-based demand response came from the use of backup generation rather than curtailment.[42] Demand response programs that allow the use of backup generators to meet demand response obligations are likely to compromise the environmental benefits of the programs. Programs targeting residential and small commercial customers are unlikely to result in the use of backup generators, though such programs also have smaller peak demand impacts than programs targeting the large commercial and industrial market. Some program administrators have addressed this issue by including requirements for the types of load reductions that are eligible for demand response incentives. For example, New York Independent System Operator's Day Ahead Demand Response Program prohibits the use of backup generation. As economic programs are more likely to encourage load flexing, demand bidding initiatives could be a more appropriate candidate for inclusion in a HEDD strategy than emergency demand response programs.

As utility revenues from large C&I customers are typically based on a combination of energy consumption (kWh) and peak demand (kW) charges, addressing utility disincentives to providing demand response programs is another important issue that is best addressed at the regulatory policy level. States can ensure that utility incentives are aligned with well-functioning demand response programs using similar approaches as those used to address disincentives to energy efficiency investment, such as decoupling, cost recovery, and performance-based incentives (see Section 2.2). As many demand response programs either require or are significantly enhanced by advanced meters and/or devices that automate demand response (e.g., smart thermostats), allowing utility cost recovery for these investments and providing incentives to encourage such investments can be another important strategy.

Finally, demand response is best viewed as an important part of a portfolio approach to demand side management that also includes energy efficiency and technical assistance. Important synergies will likely exist between the programs (e.g., technical assistance can help customers identify appropriate load flexing opportunities).

4.2.4. Peak Demand Impacts

For direct load control programs serving the residential and small commercial market, the FERC assessment reports a typical demand reduction of around 1 kW for each air conditioner and around 0.6 kW for each water heater.[43] However, FERC notes that actual demand reductions vary by the size of the appliance controlled, customer energy usage patterns, and climate.

For demand response incentive programs targeting large C&I customers, there is substantial variability in per-participant impacts. A cross-cutting evaluation of the demand response programs offered by California IOUs showed that in 2005, participants in interruptible/curtailable programs reduced baseline load by 58-78 percent, and participants in bidding programs reduced baseline load by 9 percent.[44]

As estimates of demand response and subsequent payments are typically based on deviations from an established baseline, rigorous evaluation, measurement, and verification protocols are important to ensuring program effectiveness.

4.2.5. Cost-Effectiveness

The FERC assessment notes that one of the challenges facing broader deployment of demand response programs is the lack of any standard procedure for the definition and evaluation of cost-effectiveness. The cost-effectiveness tests used to evaluate energy efficiency programs focus on avoided generation costs, and there is no standardized procedure for valuing the market and reliability benefits that demand response programs entail. Though some ISOs and RTOs include cost-effectiveness analysis in their yearly evaluations, there is no consistency of approach to enable comparison.[45] [q]

4.2.6. Program Examples

- **Nevada Power Company Air Conditioning Load Management (ACLM) Project**: Nevada Power uses a variety of control devices in its direct load control program, including one-way switches and smart thermostats. In 2005, the company deployed an additional 5,000 switches and 1,000 thermostats, increasing the total number of active load control units in the Las Vegas region to about 18,000. Nevada Power achieved peak demand reductions of around 15 MW per curtailment event in 2005.[46]

- **New York Independent System Operator (NYISO), New York:** NYISO's incentive-based demand response programs include a capacity market program (SCR), a demand bidding program (DADRP), and an emergency demand response program (EDR). In the summer of 2003, 1,400 commercial, industrial, and multi-family residential customers reduced their peak consumption by 700 MW. In the summer of 2006, NYISO called on its EDR and SCR programs, which reduced peak demand by 1,100 MW. However, DADRP is the only program that precludes customers from transferring loads onto on-

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[q] On behalf of the Demand Response Resource Center, Energy and Environmental Economics conducted an analysis of challenges and data gaps that must be addressed in developing a standard practice for evaluation of demand response programs in California. The report, *Phase 1 Results: Establish the Value of Demand Response*, is available at: http://drrc.lbl.gov/pubs/60128.pdf.

site generation to meet load reduction requirements. Program Web site: http://www.nyiso.com/public/products/demand_response/index.jsp.

- **ISO New England (ISO-NE):** ISO New England's incentive programs include its real time demand response and capacity market (ICAP) programs. In order to participate, customers must have an approved Internet-based communication system installed. In 2005, ISO-NE had 472.5 MW ready to respond, 290 MW of which was in Connecticut. The program was called only once in 2005 and yielded 1,100 MWh, 870 MWh of which was met with backup generation. Program Web site: http://www.iso-ne.com/genrtion_resrcs/dr/index.html.

4.3. Dynamic Pricing

4.3.1. Overview

> ***Highlights: Dynamic Pricing***
>
> - **Demand reduction**: 5-15 percent in response to high peak prices; greatest response with enabling technology that automates demand response.
> - **FERC Assessment of Demand Response & Advanced Metering**: http://www.ferc.gov/legal/staff-reports/demand-response.pdf.

Dynamic pricing (also referred to as "time-based rates") encompasses a variety of rate structures where the price paid for electricity varies based on the time of day. As wholesale power costs fluctuate throughout the day based on time-specific and location-specific conditions, dynamic pricing structures promote demand response through price signals that reflect the underlying cost of production.[47] At the same time, dynamic pricing allows customers the flexibility to decide whether to reduce consumption at times when prices are higher. While time-based rates have commonly been used for large commercial and industrial customers, small commercial and residential customers have historically paid flat electric rates based on the average power production costs over time.

Where some kinds of demand response programs not well-suited to restructured (i.e., deregulated) electric markets, retail electric providers can successfully employ dynamic pricing in both regulated and deregulated electric markets. As with incentive-based demand response programs, participating customers can reduce loads during times of high prices by shifting loads to other time periods, foregoing electricity use without making it up at another time, or switching to backup generation. The elected option can have a significant impact on the resulting net emissions impact.

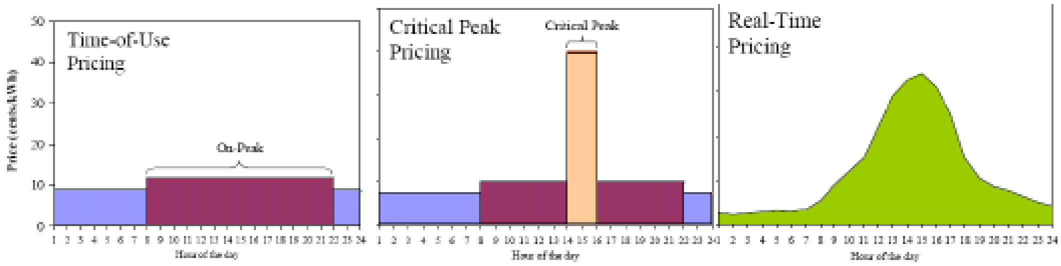
4.3.2. Best Practices

Dynamic pricing structures fall into three general categories:[48]

- **Time of Use (TOU) Pricing:** A TOU rate is a daily rate structure that employs different unit prices for electricity usage and/or demand during different blocks of time throughout a day (e.g., peak, shoulder, and off-peak periods). TOU rates reflect the average cost of generating and delivering power during those time periods.
- **Critical Peak Pricing (CPP):** CPP rates are designed to reduce energy use during extreme peaks in demand and can be structured as an overlay on TOU or flat rates. During a limited number of hours throughout the year, customers face a critical peak price that is three to five times higher than the normal peak price under a TOU rate structure. Customers receive notice of CPP events anywhere from a few hours or as long as one day in advance.
- **Real Time Pricing (RTP):** RTP rates fluctuate hourly to reflect changes in the wholesale price of electricity. RTP prices are typically known to customers on a day-ahead or hour-ahead basis.

Figure 4-1 compares the three primary dynamic pricing structures:

Figure 4-1. Comparison of Dynamic Pricing Structures[49]



In order for dynamic pricing structures to function effectively, the following conditions must be in place: (1) customers need timely access to information about rate changes; (2) customers must be capable of responding to price changes with automated load control systems facilitating demand response; and (3) customers must have an advanced meter installed so that hourly consumption data are available. Current estimates suggest that the market penetration of advanced meters is low nationally—around 6 percent. However, market penetration of advanced metering infrastructure is much higher in states such as Pennsylvania (52.5 percent) and Connecticut (21.4 percent).[50]

Section 1252 of EPAct (Smart Metering) creates several requirements of utilities and utility regulators with regard to time-based rates. By January 2008, each utility must offer time-based rates to each of its customer classes, provide time-based rates to individual customers upon request, and provide an advanced meter to each customer that requests time based rates. The statute also directs states and utilities to consider the costs and benefits of demand response programs and enabling technologies. Also by January 2008, in states that have not considered implementation and adoption of a smart metering standard, the state public utilities commission is required to issue a decision on whether to implement a standard for time-based rate schedules. [51]

4.3.3. Barriers

The type of customer response (e.g., shifting, foregoing, generating on site) to high peak prices is likely to impact the environmental benefits of time-based rates and is a key consideration for program design. In addition, dynamic pricing programs require advanced meters, are enhanced by enabling technologies such as smart thermostats that provide customers with timely information on electricity prices and consumption, and automate demand response by cycling equipment and/or changing set points. Allowing utility cost recovery for these investments and/or providing incentives to encourage such investments can be effective strategies to support the use of dynamic pricing. However, disseminating technology is not often sufficient to generate significant demand response. Providing technical assistance to help customers develop response strategies is also important.

Time-based rates are best viewed as an important part of a portfolio approach to demand side management that also includes energy efficiency, incentive-based demand response, customer education, and technical assistance. As discussed previously, there are important synergies between programs that can be leveraged to increase the effectiveness of the entire portfolio. For example, time-based rates can encourage investments in peak-targeted efficiency by providing the customer with a better signal of the true cost of electricity consumption during peak periods.

4.3.4. Peak Demand Impacts

The use of time-based rates, particularly CPP and RTP, is a relatively new development. Most studies have found modest demand response to high peak prices (e.g., 5-15 percent), but impacts vary significantly both within and between sectors. Preliminary results suggest that government and education customers are most likely to forgo use, while industrial customers are more likely to shift loads to off peak periods or utilize on-site generation. Commercial customers have been largely unresponsive to price.

4.3.5. Cost-Effectiveness

As noted in Section 4.2.5, there is a general lack of standardized process to evaluate the cost-effectiveness of demand response programs which makes comparisons between programs less meaningful.[52]

4.3.6. Program Examples

- **California IOUs:** California conducted a statewide CPP pilot from 2003-04 which included 2,500 customers from the industrial, commercial, and residential sectors. The pilot found that residential customers were more price-responsive than commercial or industrial customers, showing an average peak demand reduction of 12.5 percent. Another key finding from the pilot program was that the enabling technologies such as smart thermostats led to significantly higher levels of demand response. In 2005, the IOUs' voluntary CPP tariff reduced peak demand by an average of 11 MW across events. Load reductions were primarily achieved through process reductions and curtailing discretionary uses rather than through backup generation.[53]

- **Niagara Mohawk (now National Grid), New York**: Niagara Mohawk has imposed a mandatory RTP tariff for large customers (i.e., demand greater than 2 MW) since 1998. A recent case study found that although approximately half of all customers in this class were unable to adjust load, approximately one third of customers curtailed load without shifting it to other periods, and around ten percent of customers both curtailed load and shifted it to other time periods. The most common reduction strategy involved shutting off equipment despite the fact that over half of the customers had demand response enabling technologies that should have allowed for more sophisticated responses. Government and educational facilities were found to have the highest price-responsiveness, followed by industrial customers. Commercial customers were found to be least responsive to price. Overall, the program represents about 50 MW in peak demand reductions when the peak price is five times the off-peak price.[54]

5. Distributed Generation

5.1. Introduction

Where energy efficiency and demand response initiatives represent demand-side approaches to reducing peak electric demand and associated HEDD emissions, CHP and solar PV represent opportunities for supplanting grid-supplied power with clean distributed generation (DG) alternatives.

CHP (also known as "cogeneration") is the simultaneous production of electricity and heat from a single fuel source, such as natural gas, biomass, biogas, coal, waste heat, or oil. CHP is not a single technology, but an integrated energy system that can be modified depending upon the needs of the energy user. CHP is more efficient due to the dual use of thermal and electric energy, meaning that less fuel is required to produce a given energy output than if the heat and power were generated separately. In addition, CHP systems are located onsite where the energy is used, so they avoid the transmission and distribution losses that occur when electricity travels over power lines from a central generating unit. CHP technology is well-suited for energy-intensive facilities such as industrial plants; institutions such as colleges and universities, hospitals, prisons, and military bases; large commercial buildings; municipal facilities such as district energy systems and wastewater treatment plants; and multi-family housing or planned communities.

Benefits associated with CHP include:

- **Efficiency benefits**: CHP requires less fuel to produce a given energy output, and avoids transmission and distribution losses that occur when electricity travels over power lines.
- **Reliability benefits**: CHP can be designed to provide high-quality electricity and thermal energy to a site regardless of what might occur on the power grid, decreasing the impact of outages and improving power quality for sensitive equipment.
- **Environmental benefits**: Because less fuel is burned to produce each unit of energy output, CHP reduces air pollution and greenhouse gas emissions.
- **Economic benefits**: CHP systems can save facilities considerable money on their energy bills due to their high efficiency and can provide a hedge against unstable energy costs.

PV systems generate electricity from solar energy and are another form of clean DG that displaces grid-supplied power. The solar resource is greatest on hot summer days when peak electric demand is typically high, contributing to air quality benefits and also reducing strain on the electric transmission and distribution system. Due to the modular configuration of PV systems, solar electric technology can be utilized in a diverse range of settings, from urban to rural and from small-scale residential to large-scale commercial applications.

Clean DG technologies face a unique set of policy barriers that demand-side resources do not encounter. Sections 5.2 and 5.3 discuss policy best practices for addressing such barriers so that clean DG can compete on a level playing field with traditional supply-side resources. Sections 5.4 and 5.5 discuss incentive programs and other strategies that have been successfully deployed to promote CHP and solar PV development, respectively.

5.2. Standby Rates

5.2.1. Overview

> ***Resources: Standby Rates***
>
> - **EPA information on utility rates:** http://www.epa.gov/chp/state-policy/utility.html.
> - **New York Public Service Commission**: http://www.dps.state.ny.us/.
> - **Oregon Public Utility Commission**: http://www.puc.state.or.us/.
> - **California Energy Commission Distributed Energy Resource Guide**: http://www.energy.ca.gov/distgen/.

DG resources like CHP and solar PV usually supply only a portion of a facility's total electric demand, so facilities typically remain grid-connected. In addition, facilities that use renewables or CHP usually need to provide for standby power when onsite generation is unavailable during periods of maintenance, equipment failure, or other planned outages.

Some electric utilities assess standby charges on facilities with grid-connected DG in order to cover the costs the utility could incur in providing adequate generation, transmission, or distribution capacity for intermittent service. The rationale behind such charges is that the facility might require power at a time when electricity is scarce or at a premium cost and that the utility must be prepared to serve load during such extreme conditions. In some cases, such standby charges are excessive. Other rate practices that affect the financial viability of grid-connected DG include demand ratchets and other electric rates for backup power. Even in deregulated markets, sources must still pay demand charges to access competitively-supplied backup power, and transmission and distribution tariffs governing such charges might also employ rates that are unfavorable for DG.

The probability that all interconnected small-scale DG will need power at the same time is relatively low. Consequently, in recent years several states have begun to evaluate utility rate structures as part of their larger efforts to support cost-effective clean energy supply as an alternative to expansion of the electric grid.

5.2.2. Best Practices

Based on state experiences to date with developing rate structures that support CHP and renewable energy development, the following best practices can help other states implement similar policies:

- Ensure that public utility commissioners and staff have current and accurate information regarding rate issues for CHP and renewables, as well as the potential benefits that clean DG could provide. These issues may not have been considered in the development of rate structures that pre-date the more widespread application of renewable energy and CHP technologies.
- If electric rate structures for clean DG cannot be addressed under an existing open docket, utility commissions can open a generic docket to explore the actual costs and system benefits of onsite clean energy supply and develop rate structures that ensure cost recovery for utilities without creating undue financial obligations for onsite generators.
- Coordinate with other state agencies that can lend support. State energy offices, energy research and development offices, and economic development offices can be important sources of objective data on actual costs and benefits of onsite generation.

5.2.3. Best Practice Examples

Several notable examples of states with well-designed standby rate structures in place include Oregon, California, and New York. These states ensure that standby rates allow CHP and renewable forms of onsite generation to compete on a level playing field with traditional supply-side resources and recognize the benefits of developing clean forms of DG while ensuring grid reliability and providing adequate cost recovery for utilities.

Oregon

The Oregon Public Utilities Commission (PUC) outlined the following guidelines that should be used to implement standby rates:

- Utilities should offer both firm and interruptible standby service. Rates should be unbundled.
- There should be no inherent incentive for standby customers to idle their generators when natural gas and wholesale power prices are high.
- Customers that have reliable control equipment to reduce loads instantly when their generator goes off-line or reduces output should not have to pay for utility distribution and transmission facilities, or reserves charges, based simply on the nameplate capacity of the generator.
- Interruptible service should enable a customer to buy backup power on a short-term basis, optimizing the economic operation of the generator. Energy rates for the interruptible option should be market-based.
- Standby charges should not apply to customers with generating systems smaller than 1 MW. Variations in demand resulting from small systems going off-line at different times are not noticeable to the system.

In 2004, the Oregon PUC approved a settlement regarding Portland General Electric Company's (PGE) tariffs for customers that meet part of their energy requirements with onsite generation ("partial requirements" customers).[r] Under the settlement, the load served by onsite generation is treated in the same manner as any other load on the system, which under Oregon rules is obligated to have (or contract for) its share of contingency reserves. The onsite generation is, in effect, both contributing to and deriving benefits from the system's overall reserve margin. Under the new rates, the partial requirements customer must pay or contract for contingency reserves equal to 7.0 percent (3.5 percent each for spinning and supplemental reserves) of the "reserve capacity." Reserve capacity is defined as either the nameplate capacity of the onsite generating unit or the amount of load the customer does not want to lose in case of an unscheduled outage. If a customer is able to shed load when its onsite generating unit goes down, then it will be able to reduce the amount of contingency reserves it must carry. A similar standby pricing structure has been adopted by PacifiCorp.

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[r] An Oregon PUC staff report on distributed generation (February 2005) is available at: http://www.oregon.gov/PUC/meetings/pmemos/2005/030805/reg3.pdf.

California

California Senate Bill 28 1X passed in April 2001 and required the state's utilities to exempt DG customers from standby reservation charges. The exemptions apply for the following time periods:

- Through June 2011 for customers installing CHP-related generation between May 2001 and June 2004.
- Through June 2011 for "ultra-clean" and low-emission DG customers 5 MW and less installed between January 2003 and December 2005.
- Through June 2006 for customers installing non-CHP applications between May 2001 and September 2002.

California utilities submitted DG rate design applications in September 2001. A docket was opened to allow parties to file comments on the utilities' proposals in October and November 2001. After a year, the California Public Utilities Commission (CPUC) decided to incorporate the rate design proposals into utility rate design proceedings, which means that there is no uniform statewide standard. However, according to the California Energy Commission's recently-released *Distributed Generation and Cogeneration Policy Roadmap for California*, existing rules and regulations exempt most distributed renewable energy generating systems from standby charges and departing load charges. CHP and other forms of clean DG are exempt from standby charges and partially exempt from departing load charges.[55]

New York

In July 2003, the New York Public Service Commission (PSC) voted to approve new rates for utilities' standby electric delivery service to DG customers, as well as to independent wholesale electric generating plants that import electricity as "station power" to support their operations (NYPSC Case 99-E-1470). A key objective of the new rate structure was to provide customers with a clearer price signal for instances where onsite generation would provide a less expensive alternative to grid-supplied power.[56]

The new standby rate structure employs a cost-based approach which recognizes that the charges for providing delivery service to a standby customer should be based on the customer's peak load (kW) rather than energy consumption (kWh). This approach is consistent with the magnitude of transmission and distribution capacity needed to serve standby customers.

The New York PSC also established rules governing the transition of existing DG customers to the new standby rates. Because the new rates were designed to better align the customer's cost with the potential benefit of DG to the grid, in some cases it would be financially favorable for customers with existing onsite generation to opt in immediately to the new rates, which would also promote grid reliability. Recognizing the environmental benefits of certain forms of DG, three transition options were given to customers that began onsite generation between August 1, 2003, and May 31, 2006, with technologies such as small CHP applications (less than 1 MW) or "environmentally beneficial" technologies such as wind, solar, biomass, fuel cell technology, tidal, geothermal, and methane waste. Customers in this class could elect to remain on the current standard rate indefinitely, shift immediately to the new standby rate, or opt for a five-year phase-in period beginning on the effective date of the new standby rates. Other customers with preexisting onsite generation were offered two options: they could either shift immediately to the new standby rate or continue under the existing rate for four years and then phase into the standby rate over the next four years.

5.3. Interconnection Requirements

5.3.1. Overview

> ***Resources: Interconnection Requirements***
>
> - **EPA information on interconnection standards:** http://www.epa.gov/chp/state-policy/interconnection.html.
> - **EPA *Clean Energy-Environment Guide to Action***: http://www.epa.gov/cleanenergy/stateandlocal/guidetoaction.htm.
> - **IREC information on interconnection standards:** http://www.irecusa.org/index.php?id=30.

Interconnection requirements—the technical and procedural requirements associated with connecting a DG technology to the grid—could inhibit investment in clean DG technologies. Utility interconnection can be a critical component of a successful DG project. Connecting to the grid enables the facility to: purchase power from the grid to supply supplemental power as needed (e.g., during periods of planned system maintenance); sell excess power back to the grid; maintain grid frequency and voltage stability; and ensure utility worker safety. Standardized interconnection rules, which are generally developed and administered by a state's public utility commission, establish clear and uniform processes and technical requirements for connecting DG systems to the electric grid. Standardized interconnection rules encourage the use of renewable resources and CHP by establishing uniform processes and technical requirements that apply to all utility service territories within a state. Standardized interconnection requirements reduce uncertainty, delays, and costs that clean DG systems could encounter when obtaining approval for grid connection.
As of May 2007, 18 states have adopted standard interconnection rules for DG. An additional 14 states are in the process of developing their rules.

5.3.2. Best Practices

Standardized interconnection rules are generally developed and administered by a public utility commission. The policy objective is to establish clear, reasonable, and uniform requirements for connecting DG systems to the electric grid. These uniform interconnection requirements ensure that the costs of interconnection are the same throughout the state and are commensurate with the nature, size, and scope of the DG project. Standard interconnection rules can help reduce uncertainty and prevent excessive time delays and costs that DG systems could encounter when obtaining approval for grid connection. They also help DG project developers accurately predict the time and costs involved in the application process and the technical requirements for interconnection. Finally, standard rules ensure that the project interconnection meets the safety and reliability needs of both the energy end-user and the utility. By developing standard interconnection requirements, states make progress toward leveling the playing field for clean DG relative to centralized supply-side resources.

Successful interconnection standards address both the application process and technical requirements for interconnecting DG projects of a specified type and size with the electric grid. The application process for a well-designed interconnection rule will contain standard application forms, timelines, fees, dispute resolution processes, insurance requirements, and interconnection agreements. Another key element of interconnection rules is technical interconnect requirements. Rules generally specify the type of generation technology that may be interconnected, the required attributes of the electrical grids where the system will be connected, the types of equipment and protocols required for the physical interconnection, and the maximum system size that is eligible for the interconnection process. These requirements typically specify that DG must conform to industry or national standards (such as IEEE 1547 and UL 1741), and could include protection systems designed to minimize degradation of grid reliability and performance as well as maintain worker and public safety.

Implementing successful interconnection standards requires collaboration between a variety of interested stakeholders to develop clear, concise rules that are applicable and appropriate to all potential DG technologies. The stakeholder process should include entities such as electric utilities, state public utility commissions, developers of clean energy systems, third-party technical organizations (e.g., the Institute of Electrical and Electronic Engineers (IEEE) and Underwriters Laboratory, Inc. (UL)), RTOs, and other governmental stakeholders such as environmental and public policy agencies.

Based on state experiences in developing standardized interconnection rules, the following best practices can help other states develop similar policies:

- Develop standards that cover the scope of the desired DG technologies, generator types, sizes, and distribution system types.
- Develop an application process that is streamlined with reasonable requirements and fees. Consider making the process and related fees commensurate with generator size. For example, develop a straightforward process for smaller or inverter-based systems and more detailed procedures for larger systems or those using rotating devices (such as synchronous or induction motors) to fully assess their potential impact on the electrical system.
- Create a streamlined process for generators that are certified compliant to IEEE and UL standards. UL Standard 1741 provides design standards for inverter-based systems under 10 kW. IEEE Standard 1547 establishes design specifications and provides technical and test specifications for systems rated up to 10 MW. These standards can be used to certify electrical protection capability.
- Consider adopting portions of national models such as those developed by the National Association of Regulatory Utility Commissioners (NARUC), MidAtlantic Distributed Resources Initiative (MADRI), and FERC, and successful programs in other states such as Maryland or Oregon. Consistency within a region increases the effectiveness of these standards. Developing consistency among states is also important in reducing compliance costs for the industry based on common practices.
- Try to maximize consistency between the RTO and the state standards for large generators.

Once developed, best practices for implementation of standardized interconnection requirements include:

- Working collaboratively to establish monitoring activities to evaluate the effectiveness of interconnection standards and application processes.
- Periodically reviewing and updating standards based on monitoring activities, including feedback from utilities and applicants.
- Working with groups such as IEEE to monitor industry activities and to stay up-to-date on standards developed and enacted by these organizations.

5.3.3. Best Practice Examples

- **Texas Public Utility Commission:** In November 1999, the Texas PUC adopted substantive rules that apply to interconnecting generation facilities of 10 MW or less. The rules require that Texas utilities evaluate applications based on pre-specified screening criteria, including equipment size and the relative size of the DG system to feeder load. These rules are intended to streamline the interconnection process for applicants. Texas' interconnection standards are available at: http://www.puc.state.tx.us/electric/business/dg/dgmanual.pdf.

- **New York Public Service Commission:** New York was one of the first states to issue standardized statewide interconnection requirements for DG systems. Enacted in December 1999, the initial requirements were limited to DG systems rated up to 300 kilowatts (kW) connected to radial distribution systems. In September 2005, New York modified these interconnection requirements to include interconnection to radial and secondary network distribution systems for DG with capacities up to 2 megawatts (MW). New York's interconnection requirements are available at: http://www.dps.state.ny.us/distgen.htm.

- **Oregon Public Utility Commission:** Oregon adopted the Standard Small Generator Interconnection Rule for DG sources in July 2007. The rule applies to small DG units of 10 MW or less and outlines a four-tiered application fee schedule, depending on the unit's generating capacity and if the unit plans to export power offsite. The rule also includes a provision for expedited review for "field approved" interconnection equipment in addition to "certified equipment." Oregon's proposed rule and accompanying documents are available at: www.puc.state.or.us/PUC/admin_rules/intercon.shtml.

5.4. Combined Heat and Power (CHP)

5.4.1. Overview

A CHP system is substantially more efficient than purchasing electricity from the grid and meeting thermal needs with a boiler or process heater. Typical fuel use efficiencies for CHP systems range between 60 percent and 75 percent. Additional pollution prevention benefits are achieved due to the elimination of energy transmission and distribution losses as CHP systems produce energy where it is used.

> ***Resources: CHP***
>
> - **EPA CHP Partnership:** http://www.epa.gov/chp/.
> - **CPUC SGIP Program:** http://www.cpuc.ca.gov/PUC/energy/sgip/.
> - **Connecticut Demand-Side RFP 2006:** http://www.connecticut2006rfp.com/context.php.
> - **ConEdison Demand-Side RFP 2007**: http://www.coned.com/sales/business/targetedRFP2007.asp.

Incentive programs are one way to promote CHP development. The California Self-Generation Incentive Program (SGIP) is one example of a successful program promoting CHP and other forms of clean DG. Another strategy to increase CHP capacity is to initiate a DG procurement process. In some areas, regional grid operators such as ISO-New England have been working with FERC to implement locational capacity and locational forward reserve markets as one mechanism to promote the development of required new capacity on the electric grid. However, such markets could potentially expose ratepayers to higher costs in part due to Federally Mandated Congestion Charges (FMCC) and other charges. As an alternative, some states have launched procurement processes for DG applications, including CHP, to meet capacity needs. The State of Connecticut and the New York utility, Consolidated Edison (ConEd), have both initiated such procurement efforts using a Request for Proposal (RFP) process. Both RFPs encourage the development of new DG by establishing long-term contracts and other financial incentives.

5.4.2. Best Practices

Best practices for supporting the development of clean DG opportunities such as CHP include:

- Institute forums for collaboration between state agencies, utilities, and regional grid operators to implement policies that encourage development of clean distributed energy resources (including CHP) to meet grid capacity requirements.
- Develop long-term financial incentives and/or procurement contracts to decrease the risks associated with investment in CHP and other clean DG applications, and support market development by assuring project developers of a viable revenue stream.
- Ensure that state PUC commissioners and staff have current and accurate information regarding the relevant rate issues and the potential benefits of clean DG in meeting grid capacity requirements.
- Open a generic PUC docket to explore the potential of targeted clean energy solutions to address grid congestion and utility-proposed grid upgrades and/or new power plants.

5.4.3. Best Practice Examples

California

As of November 2007, California had over 1,100 MW of distributed CHP capacity (systems of 20 MW in capacity or less).[57] The *Distributed Generation and Cogeneration Policy Roadmap for California* released by the CEC in 2007 establishes an aggressive statewide goal of 3,300 MW of CHP capacity by 2020.[58]

In addition to establishing a supportive regulatory framework for DG, (e.g. standardized interconnection rules, net metering, and exemptions from standby charges), California has run a statewide incentive program since 2001. Funding for the SGIP Program has been extended through 2011, and the program provides incentives to customers who offset their purchased electricity requirements with onsite microturbines, gas turbines, wind turbines, fuel cells, and internal combustion (IC) engines. Statewide program funding for 2007 is approximately $75 million. The program is administered by PG&E, SCE, and Southern California Gas Company in their service territories, and by the San Diego Regional Energy Office in San Diego Gas & Electric Company's service territory. The CPUC provides program oversight.

SGIP targets businesses and large institutional customers. In order to receive incentives, generation must be installed behind the customer meter and operate in parallel with the grid, meaning that sources of backup power generation are not eligible for SGIP incentives. Systems powered with fossil fuels must have an overall system efficiency of 60 percent and a NOx emissions rate less than or equal to 0.07lbs/MWh. Eligible equipment must be less than 5 MW in capacity, but there is no minimum capacity requirement.

Incentives are paid based on installed system capacity, and the program offers different incentive tiers for DG applications that employ renewable versus non-renewable fuels. The most recent impact evaluation of the SGIP program estimated that the program had a peak demand impact of 55 MW in 2004, based on a total installed capacity of 100 MW. The unit demand impact was estimated to be 0.39 $kW_{peak}/kW_{installed}$ for solar PV systems[s], 0.93 kW_p/kW_i for fuel cells, and 0.58 kW_p/kW_i for all other systems (IC engines, microturbines, and gas turbines). The evaluation notes that the peak demand impact of systems in the IC engine/microturbine/gas turbine category was strongly influenced by the fact that 26 percent of systems in this category were idle at the time of the 2004 CA ISO peak load.[59]

Connecticut

Connecticut's Public Act 05-01, An Act Concerning Energy Independence (EIA), authorized the Connecticut Department of Public Utility Control (DPUC) to launch a competitive procurement process focused on creating new supply-side and demand-side resources to reduce FMCCs. The DPUC issued a RFP in September 2006 for development of the following resources: "(1) customer-side distributed resources; (2) grid-side distributed resources; (3) new generation facilities, including expanded or re-powered generation; and (4) contracts for a term of no more than fifteen years between a person and an electric distribution company for the purchase of electric capacity rights." The targeted timeframe for FMCC reduction from new projects is for the period beginning May 1, 2006, and ending on December 31, 2010. Projects are evaluated based on their contribution towards lowering Connecticut ratepayer costs.

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[s] As of 2007, PV systems are no longer included in the SGIP program as they are now covered by the California Solar Initiative and the New Solar Homes Partnership (see Section 5.5.3).

DPUC's broad eligibility criteria include new generation facilities, additional investments in existing generation facilities that increase total grid capacity in Connecticut, conservation and other demand-side resources, and energy efficiency projects. DG projects are considered eligible to participate in this RFP. However, since DG has other opportunities under EIA, projects can choose to participate in this process or can participate in other programs, but not both.

The two local distribution companies, Connecticut Light and Power (CL&P) and United Illuminating (UI), will serve as the counterparty to contracts. Costs for the contracts entered into under the procurement process will be allocated equally on a load ratio basis to CL&P and UI resulting in a consistent $/kWh charge. There are three possible contract options under the RFP: one for generation, one for demand response, and one for other demand resources (including energy efficiency).

New York

There are a variety of financial incentives available to reduce electricity demand in the ConEd service territory, which is comprised of the five boroughs of New York City and a portion of Westchester County. Incentives are provided through statewide programs administered by NYSERDA and the Targeted Demand-Side Management Program (TP) administered by ConEd in its service territory. ConEd has issued multiple RFPs for demand-side projects under the TP. The most recent RFP was issued in August 2007 and calls for 158 MW of total demand reduction through clean DG and energy efficiency projects.[60]

Each qualifying project must produce at least 500 kW of demand reduction, be located in one of the geographic areas specified in the RFP, and deliver demand reductions according to the RFP schedule. Clean DG projects must reduce an existing electric load and should not include exports of power to the grid. Eligible DG technologies include natural gas-fired reciprocating engines, microturbines, combustion gas turbines and fuel cells. Eligible energy efficiency measures eligible for funding under the RFP include energy-efficient air conditioning, lighting, refrigeration, motors, and steam chillers.

5.5. Solar Energy

5.5.1. Overview

Solar energy—specifically solar electric power generated with photovoltaic technology—is an appealing renewable energy option for addressing high electric demand given that the resource is greatest when peak summer electric demand is highest. In addition to lowering peak demand and related emissions by offsetting grid-supplied power, solar energy systems can reduce strains on the electric transmission and distribution system.

> ***Resources: Solar PV***
>
> - **New Jersey Clean Energy Program**: http://www.njcleanenergy.com/renewable-energy.
> - **Go Solar California:** http://www.gosolarcalifornia.ca.gov/.

One of the greatest barriers to solar energy development is the high initial cost of installing a PV system. Analysis by Lawrence Berkeley National Laboratory (LBNL) determined that in 2004-2005, PV systems in California had an average installed cost of just under $9 per watt, declining at an annual rate of around 7 percent per year.[61] Other challenges include the complexity of the technology and associated informational and transaction cost barriers from the customer's perspective, and immature markets for solar system supply and installation. To address these barriers, supportive policies at the local, state, and federal level are essential to promoting solar energy development. Common forms of support include rebates based on the size of the system, production-based incentives, tax incentives, and renewable portfolio standards requiring the use of solar power to meet customer demand. Two states—New Jersey and California—are national leaders in promoting PV development.

5.5.2. Best Practices

To offset the high cost of solar PV installations, incentives and financing mechanisms provide essential support for solar energy development. To facilitate that development of a robust solar market, incentives should remain relatively stable over time, though incentives could be gradually reduced over time as the solar market becomes more robust and costs decline. Historically, solar rebates have been based on the rated system capacity (kW). However, incentives based on energy production (kWh) represent an emerging policy best practice. Production-based incentives are designed to promote optimal system performance as some studies have shown installed systems producing less electricity than expected. Typical problems resulting in poor performance include equipment shading, component failure, poor installation practices, and deviations from manufacturer specifications.[62] In addition, production-based incentives provide a revenue stream to offset ongoing system financing costs (e.g., loan and interest payments).

Consumer education and technical assistance are also important elements of programs that support solar energy development. Some programs train and certify networks of solar installers to ensure quality installations that maximize production. Consumer education and outreach is important to overcome informational barriers and risk perceptions.

5.5.3. Best Practice Examples

New Jersey

New Jersey's solar program is widely praised by the solar industry and renewable energy advocates. In addition to establishing an aggressive Renewable Portfolio Standard (RPS) in

April 2006 where 22.5 percent of the state's electric sales must come from renewable sources by 2021, the New Jersey Board of Public Utilities (NJBPU) has established a solar set-aside requiring that 2 percent of the RPS be met with solar electric power. At current electric consumption levels, New Jersey's solar set-aside is forecast to require 1,800 MW of solar capacity by 2021, making it the nation's largest solar commitment relative to population and electricity consumption.[63]

To achieve the state's aggressive solar goals, the New Jersey Office of Clean Energy (OCE) operates three integrated programs that encourage residents, building owners, and others to install solar technology:

- **Customer On-Site Renewable Energy (CORE) Program**: Under CORE, consumer rebates are available to residential and business customers to help reduce the up-front cost of PV systems. Rebates are based on system size (kW).
- **Solar Renewable Energy Rebates (SRECs):** The New Jersey SREC Program provides an additional mechanism for financing for clean, emissions-free solar electricity. The SREC program is an emerging market-based financing option for solar PV that offers a production-based revenue stream. Owners of solar arrays obtain an SREC each time they generate 1 MWh. The credits can then be sold to provide a revenue stream to offset ongoing financing costs. Recently the SREC program is compensating system owners at an average rate of $0.20 per kWh. The program is capitalized by funds generated from utility Alternative Compliance Payments (ACP), and the estimated impact on utility ratepayers is around $0.00002 per kWh.[64]
- **Clean Energy Financing Program**: Offers low-interest loans and grants to customers and is designed to help businesses, schools, and municipalities finance solar installations and other clean energy opportunities.

New Jersey is the fastest growing solar market in the country. In 2005, solar capacity increased by 157 percent. The state credits this rapid growth to the combination of rebates, financial incentives, and technical support offered by the OCE. New Jersey officials say that the programs have been so successful that the state has had problems meeting demand. Currently, in order to meet New Jersey's aggressive solar requirements more efficiently, the state is transitioning from up-front CORE rebates to an SREC-based financing program. In 2007 the OCE launched an SREC-only pilot program whereby customers can participate in the SREC market without participating in the CORE rebate program.

Since the inception of the state's solar incentive programs in 2001, over 2,300 New Jersey residential, commercial, public, and non-profit entities have installed solar electric systems. In total, CORE has paid out over $170 million in incentives, resulting in over 40 MW of program-induced solar capacity.[65] A joint state-federal analysis estimates that CORE reduced NOx emissions by 1.1 tons during the 2005 ozone season.

California

California's RPS was established in 2002, with the goal of meeting 20 percent of the state's electricity demand with renewable energy by 2017. As part of Governor Schwarzenegger's Million Solar Roofs Program, California has the goal of adding 3,000 MW of solar electric capacity by 2017, with total state funding of $3.3 billion. Solar incentive programs in California are administered by the California Energy Commission (CEC) and the California Public Utility Commission (CPUC).

- **California Solar Initiative (CSI):** Administered by the CPUC, CSI provides consumer incentives for solar installations. As of 2007, the program is transitioning from capacity-based (kW) to performance-based (kWh) incentives, offering different incentive tiers for residential, commercial, and nonprofit customers. Currently, all solar energy systems of 100 kW or larger receive monthly incentive payments based on actual energy production for a period of five years. Systems smaller than 100 kW receive an up-front incentive payment based on expected system performance, which is calculated based on equipment ratings and installation factors such as geographic location, tilt, and shading. Though smaller systems can opt in to performance-based incentives now, beginning in 2010 all systems larger than 30 kW will receive incentive payments based on actual energy production. Another key feature of the CSI is that incentive levels are automatically reduced over time based on the aggregate capacity of solar installations.[t]

- **New Solar Homes Partnership (NSHP):** CEC administers this 10-year, $400 million program to encourage the integration of solar technologies in new home construction. By 2017, the program has the goal of achieving 400 MW of installed solar electric capacity on new homes, with PV systems installed on 50 percent of all new homes built in California. The NSHP targets the single family, low income, and multifamily housing markets, and offers incentives to developers and builders for solar-integrated new construction projects. Incentives are based on expected system performance and homes must be at least 15 percent more energy-efficient than Title 24 building standards to qualify for incentives. As with the CSI program, incentive levels automatically decline based on the aggregate capacity of solar installations.

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