Market Transformation:
Substantial Progress from a Decade of Work

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EXECUTIVE SUMMARY

The term "market transformation" was first coined in 1992 to describe the process that substantially increases the energy efficiency of all new appliances, buildings, vehicles, or other technologies over time. In the subsequent decade, dozens of market transformation initiatives have operated in the United States, including national, regional, and local ones. This report looks at 28 of the major initiatives, how they have fared in the market, and the lessons each initiative teaches. We conclude with a summary of lessons learned that should be kept in mind when developing and refining market transformation initiatives in the future.

Results

Overall, the 28 initiatives have varied in level of effort and success in transforming markets. Of the 28 initiatives, 10 had a high level of effort, 11 = medium, and 7 = low. On progress towards market transformation, the breakdown is as follows:

- Two are rated as “largely transformed” (residential clothes washers and commercial exit signs);
- Seven and one-half are rated as “transformation likely” (condensing furnaces in cold climates, residential central air conditioners and heat pumps, residential appliances, packaged air conditioners, commercial clothes washers, building operator training and certification, dry-type transformers, and traffic signals);
- Ten are rated as “substantial progress” (residential windows, residential new construction, compact fluorescent lamp [CFL] bulbs and fixtures, home electronics, packaged commercial refrigeration, commercial new construction, real estate, schools, premium-efficiency motors, and compressed air system improvements);
- Seven and one-half are rated as “some progress” (furnace fan motors, central air conditioner installation and maintenance practices, residential duct sealing, ground source heat pumps, cool roofs, retrocommissioning, commercial lighting design, and motor management practices); and
- One is rated as “little progress” (heat pump water heaters).

Lessons Learned

In general, the measures that have made significant progress over the past five or so years share one or more of the following attributes.

- The measures have low incremental cost (e.g., home electronics and dishwashers).
- The measures have rapid paybacks (e.g., LED exit signs and traffic signals, and CFLs).
- The measures have substantial other benefits besides energy savings (e.g., LED exit signs and traffic lights have long lives, efficient clothes washers provide improved cleaning performance, and efficient new homes can be more comfortable).
- The measures generally are improvements in the efficiency of an existing technology, rather than a totally new technology or changes in practices or design methods (i.e., most

of the energy-saving practices have a progress rating of 2, with a few at 3 and only one—the Building Operator Training and Certification Program—at 4).
- The measures are incorporated into new codes and standards (e.g., residential and commercial clothes washers, residential and commercial air conditioners, transformers, LED traffic lights and exit signs, and packaged commercial refrigeration equipment).

Furthermore, unsurprisingly, there is a correlation between level of effort and progress towards market transformation, with measures with a high level of effort averaging 3.5 on progress, measures with a medium level of effort averaging 3.1, and measures with a low level of effort averaging 2.6.

The initiative-by-initiative reviews included here also provide many other examples of what has worked, what has not, and why. Among the lessons that are illustrated by multiple initiatives are the following:

- It is important to work with the major players in the market, to enlist their input, participation, and support.
- The target for the initiative needs to be achievable, but it also needs to be aggressive enough to attract the interest of program operators.
- In developing programs, some attention needs to be paid to the efficiency metrics that are used, since manufacturers will tend to focus on the metric to the exclusion of other parameters.
- Success in the market often happens when efficient products and services can be successfully differentiated in the eyes of purchasers from conventional products and services. Generally, differentiation will depend not just on efficiency, but also on related parameters.
- Promotion (e.g., advertising and educational materials) is a key component of most initiatives. Promotion raises awareness among potential purchasers as well as those who sell equipment and services. Promotion should emphasize the full range of benefits and not just energy savings. In undertaking promotion activities, the clearer the message the better.
- Training of service providers and equipment salespersons and installers can also be an important part of a market transformation initiative.
- Incentives can be an important part of an initiative, particularly in the initial stages. Incentives attract attention and help address the higher initial costs of many efficient products and services, costs that are often high when a technology or practice is first introduced to the market. As consumer awareness, local stocking, and salesperson and installer experience improve, costs often come down, permitting incentives to be reduced, and in quite a few cases to be ended entirely.
- Most of the successful market transformation initiatives are multi-pronged efforts that involve several different market interventions (e.g., training, incentives, and promotion) and multiple organizations, and that evolve over time.
- While programs may be multi-pronged and complicated from the perspective of program implementers, for program participants, the programs should be kept simple.
- Ultimately, an initiative can succeed only if the product or service is valuable and works well. Broad market transformation initiatives should probably not be undertaken until

products are ready (for products in earlier stages of market development, research and demonstration efforts will generally be more suitable).

Conclusion and Discussion

In the past decade, market transformation initiatives have generally made good progress in the United States. Several initiatives have largely transformed markets and most have made substantial progress. But not all market transformation initiatives have succeeded, indicating that the market transformation approach is not a cure-all for all of society's energy efficiency problems.

So far, efforts to promote more efficient equipment have been more successful than efforts to promote more efficient practices. Efforts to promote efficient equipment should continue, because chances of success are relatively high. But more efficient practices can offer very large opportunities for savings and deserve increased attention. Some of the practice-based initiatives profiled here provide a model that can and should be employed for other practices.

Based on the success of market transformation initiatives in many regions of the United States, we would recommend that other regions and countries seriously consider expanding their use of the market transformation approach to program design. However, funding will be needed to help these programs succeed—including funding for training, promotion, and incentives. Minimum-efficiency standards and building codes have also been very useful for completing the transformation process for many technologies. Market transformation initiatives can advance technologies to the point where codes and standards are not controversial. By working in tandem, voluntary market transformation initiatives and mandatory codes and standards can achieve greater savings than either approach can achieve alone.

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INTRODUCTION

Market transformation generally means a strategic effort "by utility and other organizations to intervene in the market, causing beneficial, lasting changes in the structure or function of the market…, leading to increases in the adoption of energy-efficient products, services and/or practices" (Schlegel et al. 1997).

Market transformation is typically pursued through *initiatives* that employ multiple activities designed to address market barriers that impede use of particular energy-saving technologies or practices. Often, more than one organization will be involved in implementing an initiative, and activities will evolve as the market development of a measure progresses.

In general terms, a market transformation initiative for a specific technology or practice will often involve:

- A careful analysis of the overall market, including an identification of the particular barriers that are hindering the development, introduction, purchase, and use of the targeted measure;
- A clear statement of the overall goal of the initiative as well as the specific objectives that will be accomplished along the way by the different initiative activities;
- The development of a set of coordinated activities that will achieve the desired objectives and systematically address each of the identified barriers;
- Successful implementation of the individual activities, including periodic evaluations and adjustments designed to respond to actual experience; and
- Development and execution of a plan for transitioning from extensive market intervention activities toward a largely self-sustaining market, i.e., an "exit strategy."

Market transformation efforts are different from most traditional demand-side management (DSM) programs in several respects. The primary difference is that the fundamental goal of market transformation is to change markets and thereby save substantial amounts of energy in the long term. For the most part, the focus is not on short-term energy savings (although some programs with a need for short-term savings will use strategies to maximize both short- and long-term savings). As a result of this market focus, market transformation activities are generally devised in direct response to identified market barriers.[1] In fact, understanding the particular market barriers for a measure is very helpful for developing and implementing successful market transformation activities. In addition, market transformation initiatives generally are broader and longer-term than typical DSM programs. A market transformation initiative may have several phases, many players, and a variety of activities. Coordination among the relevant players is thus necessary to ensure that a market transformation initiative or strategy is effective and the broad goals are accomplished.

[1] For purposes of this report, under the term "market barriers" we include what economists refer to as market failures (e.g., split incentives, asymmetric information, and distorted market power) as well as other market barriers that economists consider to be non-market failures (e.g., existing preferences and uncertainty). The distinction between these different types of market barriers is beyond the scope of this report but is discussed more extensively by Golove and Eto (1996).

Since the primary goal of market transformation is to change markets, evaluation of market transformation initiatives emphasizes progress made in addressing market barriers and not precise measurements of program energy savings.

While many traditional DSM programs include some of these attributes, few include all of the attributes that typify market transformation initiatives. However, market transformation is not a label that uniquely identifies certain energy efficiency program designs to the exclusion of others. It is instead an objective that all energy efficiency programs have at least a theoretical potential to achieve, although some programs are clearly more effective at achieving this objective than others. For more information on the market transformation approach to program design, please see Nadel and Latham (1998) and Sebold et al. (2001).

The term "market transformation" was first coined in 1992 in a paper presented at the ACEEE Summer Study on Energy Efficiency in Buildings (Eckman, Benner, and Gordon 1992). In the subsequent decade, dozens of market transformation initiatives were operated in the United States, including national, regional and local ones. Since that time, ACEEE has periodically conducted reviews of the major initiatives, to assess how they are faring and the lessons each initiative teaches that can be of use to the design and implementation of these and future initiatives. Such reviews were conducted in 1996 (Suozzo and Nadel) and 1999 (Suozzo and Thorne). It has now been four years since our last review, and much has happened in this period. Thus, in 2003, ACEEE conducted a new review and this report summarizes the results.

For this review, we looked at market transformation initiatives around the country, and decided to focus on those initiatives that are now operating in multiple regions of the country and thus can be considered somewhat national in scope. We did not include several historical initiatives that achieved success in the 1990s (e.g., ENERGY STAR® computers, the Super Efficient Refrigerator Program, and the Northwest Model Conservation Standards)—these initiatives are discussed in the earlier ACEEE market transformation reviews.

Overall, we identified 28 initiatives that met our criteria for this new study. For each initiative, we examined what participants are active, what they are doing, initiative accomplishments, and lessons learned. In discussing initiative accomplishments, where data and estimates are available, we consider accomplishments relative to what would have happened without market intervention. But in some cases we discuss accomplishments relative to the pre-program base period because data or estimates are not available on likely trends in the absence of market intervention. We also evaluated each initiative on two scales—one for level of effort (rated "low," "medium," or "high"), and one for progress towards market transformation where:

1 = little progress,
2 = some progress,
3 = substantial progress,
4 = transformation likely, and
5 = largely transformed.

MARKET TRANSFORMATION INITIATIVES, THEIR ACCOMPLISHMENTS, AND LESSONS

This section summarizes our findings for each of the 28 initiatives examined. First we discuss residential initiatives, then those for the commercial and industrial sectors.

Residential

Residential New Construction

Target: New home construction

Who's Doing What: A wide range of residential new construction energy efficiency programs has been conducted in the United States over the last two decades. In the past five years, most of the program activity, while often initiated and managed at the state or local level, has been consolidated under the U.S. Environmental Protection Agency/Department of Energy (EPA/DOE) ENERGY STAR Homes program. Market transformation programs at the state and regional levels typically now fully coordinate their standards and brand identity with the ENERGY STAR program. Among the most active programs are those in Arizona, Nevada, Texas, and the Northeastern states. In some areas, EPA and its contractors and partner organizations manage ENERGY STAR programs directly. ENERGY STAR works increasingly closely with DOE's Building America program, which takes a broader building performance perspective, addressing basic building science, moisture control, and other issues. Building America has helped ENERGY STAR builders develop total design and construction solutions that also meet ENERGY STAR's narrower energy performance criteria.

Overall Level of Effort: Medium (high in some states, low to medium in others)

Accomplishments: The ENERGY STAR program has grown rapidly since its inception in the mid-1990s. In 2002, total homes certified under the program reached 37,000, up from 1,700 in 1997. The 2002 number represents about 3% of the total national market for single-family homes. On a state basis, Alaska builds 25% of its homes under the ENERGY STAR program, Vermont about 14%, Arizona and Nevada about 8%, and Massachusetts and Texas about 5%. In some large metro area markets, especially in Arizona and Texas, ENERGY STAR is reported to have market shares of 20% or more (Faesey et al. 2002; Rashkin 2003).

Rating on Progress Towards MT: 3 (substantial progress). The new homes market, because it is so larger and diverse, involving more than 100,000 construction companies across a wide range of climates and building traditions, is slow to transform in any respect. For ENERGY STAR to achieve a 3% market share in just five years is a remarkable success in this context, and thus a rating of "substantial progress" is warranted. Programs in leading states point the way for further growth.

Lessons Learned: Given the diversity of new home markets, construction techniques, and the fragmented and technically unsophisticated nature of the mainstream homebuilding industry,

ENERGY STAR has had to learn how to engage builders on terms they understand. Approaches that have helped recruit builders include: (1) ENERGY STAR as a mark of quality, which addresses a major consumer-backlash issue related to poor quality home construction; (2) ENERGY STAR as a profit-increasing program, in that it differentiates builders from competitors and creates increased perceived value in the market; and (3) ENERGY STAR as a problem-solver, in that many builders are looking for new, practical solutions to building design and performance, and ENERGY STAR's partnership with Building America has given it an enhanced image in that regard. ENERGY STAR has also learned to tailor the administration of its program to the local level by creating state and local partnerships with homebuilder associations, energy rating professionals, utilities, and market transformation organizations. Moreover, ENERGY STAR has shown flexibility in adapting the program's requirements for local codes (e.g., eligibility levels were recently strengthened in California).

Residential Windows

Target: New home construction and window replacement markets

Who's Doing What: High-efficiency windows have been available in the U.S. market since the 1980s. During the 1990s, several organizations arose to help promote this technology. The National Fenestration Rating Council, empowered by federal legislation in 1992, developed the first independent energy-performance rating and labeling system for window products. It is required by building codes in many states, and is the basis for DOE's ENERGY STAR Windows program, which launched in 1998. Around that same time, the Efficient Windows Collaborative was organized by the Alliance to Save Energy, Lawrence Berkeley National Laboratory, and manufacturers, some of whom have actively marketed high-efficiency windows for years. Regional and state windows programs have developed in the Northeast under Northeast Energy Efficiency Partnerships (NEEP), the Northwest under the Northwest Energy Efficiency Alliance (NW Alliance), and in California, Texas, Wisconsin, and Florida.

Overall Level of Effort: Medium to high (medium level of effort nationally, higher levels of effort in some regions)

Accomplishments: High-efficiency windows have achieved significant market penetration since the 1980s. A Lawrence Berkeley National Laboratory study in 1997 showed that nationwide, about 34% of the residential windows market was rated efficient, using the presence of low-emissivity (low-e) glass as a threshold for efficiency (Ducker Research Company 1997). The ENERGY STAR Windows program applied stricter criteria beginning in 1998, dividing the United States into cold, moderate, and warm climate zones with different standards for each region. While market penetration data to date is limited, NEEP conducted a study in 2002 of eight northeastern states (NJ, NY, CT, RI, MA, VT, NH, and ME), finding an overall market share of 43% for ENERGY STAR Windows. Market shares ranged from 25% in New Jersey to 54% in Massachusetts (Quantec LLC 2002). In the Northwest, NW Alliance staff reported an overall 75% market penetration after a strategic campaign that worked with window manufacturers to promote efficient windows at retail

stores (Degens 2003). Market shares are typically much lower in the warmer states; the 1997 study found less than 10% market share in the South for low-e products, let alone those meeting ENERGY STAR criteria. However, the new International Energy Conservation Code (IECC) contains strict window standards, equal to or more stringent than ENERGY STAR criteria in several states. Texas, for example, adopted the IECC in 2001; a recent utility market study in the Dallas area indicated that ENERGY STAR windows have more than 80% of the market, and code compliance is inferred as the primary driver for this finding (RLW Analytics 2002).

Rating on Progress Towards MT: 3 (substantial progress). Regional efforts, the ENERGY STAR program, and updates to state and local building codes are rapidly changing residential windows. In regions with strong traditions of energy efficiency like the Northeast and Northwest, high-efficiency windows appear to be gaining a dominant share of the market. In the warmer climates, where market penetration has historically been much lower, building code requirements are having dramatic effects.

Lessons Learned: Windows are an interesting case study in the interaction between voluntary and regulatory program strategies. A common market transformation strategy is to use voluntary programs to gain substantial market share for a technology or practice, and then to make it mandatory via a building code or appliance standard. In the case of residential windows, national building code requirements in the IECC are in many regions very close to, or even more stringent than, ENERGY STAR criteria. This is particularly true in the warmest climates. In these states, such as Texas, the adoption of the IECC code is apparently creating a very rapid market shift, more dramatic than a voluntary program could have achieved.

Another lesson from this market is the value of understanding the structure and motivating forces within the industry. In the windows business, there are over 4,000 window product manufacturers, but only five major glass manufacturers. The glass companies are the most motivated to sell high-performance glass, because it is a value-added item in what otherwise is a very homogeneous commodity market. They are also large corporations often willing to commit resources to programs that will promote their products. Engaging the glass companies in a collaborative effort to educate and advocate for both ENERGY STAR and codes programs as appropriate has proven very effective.

CFL Bulbs and Fixtures

Target: Compact fluorescent lamps (CFLs) and lighting fixtures for residential use

Who's Doing What: CFLs have been the focus of market transformation programs targeting residential customers for many years. ENERGY STAR specifications for CFLs and fixtures have been widely adopted by market transformation programs at the state and regional level as the basis for their program activities. During 2002, ENERGY STAR worked with manufacturers, retailers, utilities, and other regional organizations to promote efficient CFL bulbs and fixtures through a special campaign including marketing, education, and promotions. Utilities and other market transformation organizations around the country ran customer promotions using instant-off coupons, rebates, and other special offers. Through an

innovative effort in Wisconsin, students have been selling CFLs as a school fundraiser. As part of the unprecedented efforts to address the energy crisis in California, the state's three investor-owned utilities built on previous efforts and offered a program of incentives paid directly to participating retailers and manufacturers. These incentives were passed on to consumers through reduced prices, eliminating the need for coupons or mail-in rebates. An extensive advertising campaign alerted customers to the benefits of CFLs and the opportunities to purchase them at low cost. Other notable programs have been offered by NEEP and its partners, NW Alliance, Wisconsin Focus on Energy, and Efficiency Vermont, among others (Efficiency Vermont 2003; Focus on Energy 2002; York and Kushler 2003).

Overall Level of Effort: High

Accomplishments: The market for CFL lamps and fixtures has grown rapidly over the past three years as the number of manufacturers and variety of products available continues to improve. For example, a wider range of bulb sizes and configurations as well as new dimmable CFLs has been introduced, and the number and types of retailers offering CFLs continues to grow. Prices for CFLs continue to drop; lamps can be purchased for $10 or less without incentives in many parts of the country. As of January 2003, participation in the ENERGY STAR program has grown to more than 120 CFL lamp manufacturers and approximately 40 fixture manufacturers (with more than 2,000 qualified fixtures) (EPA 2003d, e). Sales of CFL lamps are growing in many regions as sales of incandescent bulbs declines. Nationwide, sales of CFLs grew from less than 6 million in 1999 to more than 21.6 million in 2001 and almost 12 million in the first half of 2002 for a market share of 1.6%. In California, sales increased four-fold from 2000 to 2001 and market share increased from approximately 1% in 2000 to a high of 8.6% during the peak of the energy crisis in mid-2001, settling to an average of almost 5% during late 2001 and early 2002 (RER 2002). The Pacific Northwest has seen similar growth—sales of CFLs grew roughly 10 times from 2000 to 2001 (to 6 million units in 2001) (Calwell et al. 2002; York and Kushler 2003). Sales figures for CFL fixtures are less readily available, but the estimated 1.1 to 1.4 million ENERGY STAR fixtures sold in 1999 accounted for less than 1% of the residential fixture market (Opinion Dynamics 2000). Among the products sold, interest in CFL torchieres has been particularly high and continues to grow as the product continues to be the target of numerous education campaigns and turn-in events, and as safety concerns reduce the demand for halogen torchieres.

Rating on Progress Towards MT: 3 (substantial progress). Over the past few years, the number and variety of CFL bulbs and fixtures available has grown considerably. Manufacturer and retailer interest in the products has led to greater involvement and support for production and promotion. Customer awareness has grown and customer willingness to purchase the products has led to increasing market share, particularly in those regions where electricity reliability has been a big issue or where significant promotions have reduced the price differential between CFLs and incandescent bulbs. Additional effort is needed in regions where program activity has been minimal.

Lessons Learned: The success of resource acquisition programs offered to address acute reliability concerns in California and the Pacific Northwest relied on the foundation built by

years of ongoing market transformation activity. Through this activity, the utilities were able to build on their knowledge and relationships with manufacturers and retailers to pull off a program with unprecedented success in a very short time. Experience from these regions demonstrates the benefits of working with manufacturers and retailers to develop customer-friendly programs and the important role of advertising and education in building customer awareness and interest. The successful efforts to increase the market for CFL torchieres highlights the importance of promoting non-energy benefits and effective alternatives to conventional technologies that have proven problematic. Problems with the quality of a number of ENERGY STAR-qualified CFLs has led to de-listing of a significant number of models (as many as 10% of listed models). In response, DOE has stepped up its product testing practices and is currently working on a more stringent specification to address product testing and many of the quality concerns.

Residential Clothes Washers

Target: Resource-efficient, ENERGY STAR-qualified residential clothes washers

Who's Doing What: The ENERGY STAR specification for clothes washers has been adopted by many market transformation programs around the country as a common platform for their programs. Through its Super-Efficient Home Appliance Initiative, CEE coordinates its base energy efficiency tier with the ENERGY STAR program. CEE's program also specifies a series of more stringent tiers that utilities can adopt for promotions including incentives, retailer outreach, and education. All of the CEE tiers include specifications for water efficiency as well as energy use. More than 240 energy and water utilities and energy organizations around the country participate in CEE's Residential Clothes Washer Initiative (CEE 2003e). Leading programs include those operated by NW Alliance and NEEP and its partners (York and Kushler 2003). Common program features are retail field support including labeling and training; marketing campaigns including paid media advertising; and incentives including rebates, targeted coupons, and various tax incentives. Several programs are increasingly targeting independent retailers, retail buying groups, owners of apartment buildings, and condominium managers. In addition, some sponsors are beginning to leverage efforts by coordinating washer programs with their other appliance, lighting, and new home programs.

Overall Level of Effort: High

Accomplishments: In the mid-1990s, manufacturers began to introduce new, resource-efficient residential clothes washers in response to programs and requests by energy and water utilities, energy efficiency organizations, and others concerned about the high water and energy use of existing top-loading washer designs. Since that time, consumer interest and the market share of resource-efficient designs have grown. Due in part to the success of market transformation programs in increasing the availability and reducing the price of resource-efficient washers, appliance manufacturers and efficiency supporters were able to reach a consensus agreement on new clothes washer efficiency standards that DOE adopted in 2001. The new standard takes effect in two stages—a modest efficiency increase in 2004 and 35% savings relative to the previous DOE standard in 2007 (DOE 2001). At the same

time, the ENERGY STAR specification was amended in January 2001 to the 2007 standard level. In 2004, the ENERGY STAR target will again increase. As of January 2003, 114 washers models from 20 participating manufacturers qualified for ENERGY STAR (EPA 2003f). Manufacturers continue to introduce innovative products including new top-loading designs. The market share of ENERGY STAR clothes washers surpassed 16% nationwide as of the second quarter of 2002. Regions with active market transformation programs enjoyed even higher sales levels; by mid-2002 ENERGY STAR sales reached 26% in Wisconsin, 32% in the Pacific Northwest, 27% in New England, and 25% in California (EPA 2003g).

Rating on Progress Towards MT: 5 (largely transformed). The current ENERGY STAR level will become the federal minimum standard in 2007. Manufacturers and a growing number of retailers have demonstrated their support for ENERGY STAR. Manufacturers continue to introduce models that exceed the 2004 ENERGY STAR level. Increased market share has persisted in areas where incentives have been lowered substantially. Progress has also been made on increasing the market share of water-efficient machines, but further work is needed.

Lessons Learned: Manufacturer commitment to resource-efficient machines and the ENERGY STAR program has motivated development of a variety of washers to meet different consumer needs. This motivation has grown as market transformation programs have increasingly adopted the ENERGY STAR platform. Non-energy benefits including water savings, improved cleaning performance, and improved washer designs are important in engaging retailers and attracting consumer interest in ENERGY STAR washers. The use of ENERGY STAR marketing and promotional materials can increase consumer awareness and sales of efficient washers. Regional campaigns that tie into ENERGY STAR, but include customized messages for local audiences, have been effective in increasing sales. Strong relationships with retailers (including national and regional chains, independents, and retail buying groups) are important for ensuring support and promotion of ENERGY STAR clothes washers by stores and sales staff. Staff in some regions have built these relationships through training programs on ways to best sell ENERGY STAR products. In some regions, these relationships can be more effective than expensive TV advertising campaigns. Standards are helping to complete the market transformation process and were also a significant factor contributing toward manufacturer and program-implementer interest in resource-efficient washers (Suozzo and Nadel 1996).

Other Residential Appliances (Refrigerators, Dishwashers, and Room Air Conditioners)

Target: ENERGY STAR-qualified refrigerators, dishwashers, and room air conditioners

Who's Doing What: The ENERGY STAR platform has been adopted by most large utilities and other program implementers as the foundation for their appliance efficiency programs. As of January 2003, the ENERGY STAR program has been expanded to include all sizes of refrigerators including compact models. The California Energy Commission (CEC) encourages its members to promote ENERGY STAR as the base level for "efficient" appliances. In its Super-Efficient Home Appliance initiative, CEE promotes "super-efficient" appliances that exceed ENERGY STAR through a series of more stringent efficiency tiers

that members can adopt for promotions including incentives, retailer outreach, and education (CEE 2003f). Local and regional programs promote efficient appliances through education and promotional outreach to retailers, consumer marketing, and incentives including rebates and tax incentives. The products targeted and incentive levels used vary to meet the needs of each region. For example, New York State Energy Research and Development Authority (NYSERDA) has run an aggressive program to promote room air conditioners to apartment dwellers and building owners as part of its effort to reduce peak demand on the hottest days. In addition, several utilities are offering cash rewards to consumers that turn in old operating refrigerators and room air conditioners. Newer program directions include building relationships with retail buying groups, remodelers, owners of apartment buildings, and condominium managers, and the coordination of appliance programs with efforts targeting lighting improvements and new homes.

Overall Level of Effort: High

Accomplishments: ENERGY STAR has continued to build support among manufacturers and retailers leading to increasing availability of qualified products and enhanced retailer promotion. As of January 2003, ENERGY STAR listed 407 qualified dishwashers (from 13 manufacturers), 478 refrigerators (from 12 manufacturers), and 224 room air conditioners (from 15 manufacturers) (EPA 2003h). The market share of ENERGY STAR appliances has also continued to grow; over the first half of 2002, national market share for dishwashers approached 30%, for room air conditioners 25%, and for refrigerators almost 17%. Market share for refrigerators increased from less than 1% in the first quarter of 2001 (due to the limited number of available models in light of the increase in ENERGY STAR levels prior to the effective date of the new federal standard) to more than 17% in the second quarter of 2002. Regions with active market transformation programs (e.g., California, the Northwest, the Northeast, and parts of the Upper Midwest) report higher market shares for ENERGY STAR appliances than less active parts of the country. In these regions, sales of dishwashers ranged from 25 to 33%, room air conditioners 26 to 43%, and refrigerators 17 to 22% (EPA 2003g).

Rating on Progress Towards MT: 4 (transformation likely). ENERGY STAR has a growing market share in each appliance category. Based on discussions with key parties involved in the DOE standard-setting process, it is likely that the ENERGY STAR levels will eventually be adopted as federal standards. With agreement on a new dishwasher test procedure, the dishwasher standard may be up for a long-awaited revision. The refrigerator and room air conditioner standards are not likely to be revised until around 2010.

Lessons Learned: Independent retailers are particularly important partners for market transformation. In California, independent retailers (including regional chains) represent 44% of appliance storefronts, but they represent a majority of ENERGY STAR appliance sales in the state. Regional programs that coordinate incentive levels can more effectively reap the benefits from state- or region-wide marketing campaigns. Programs must be ready to adjust activities and incentive levels as changes in the market influence the availability and mix of qualified products. For example, changes in the federal standard and ENERGY STAR levels of refrigerators led to more than six months with limited product availability. During this

time, many programs shifted their emphasis to other appliances. Refrigerator pick-up and room air conditioners turn-in programs can garner substantial energy savings and are attractive to customers. This may play an important role in countering the increasing trend toward multiple refrigerators.

Home Electronics

Target: Low standby-power consumer electronics products including televisions, VCRs, DVDs, home audio equipment, cable boxes, and telephony products.

Who's Doing What: In response to growing recognition and concern over the magnitude of energy consumed by consumer electronics during their standby and off modes, EPA introduced the first of its ENERGY STAR home electronics programs in 1998. There are now four active home electronics programs covering TVs and VCRs, audio equipment and DVDs, set-top boxes, and telephony products. Each of the programs has different performance specifications, although all focus on standby power consumption. Product specifications for each program except for set-top boxes are scheduled to decline to one watt or less between 2003 and 2005. EPA has developed numerous marketing campaigns and promotional materials to educate the public about labeled home electronics products. The campaigns target holiday shoppers, college students, and other key audiences for electronics. The ENERGY STAR website also offers information on where to find qualified products. Several utilities and market transformation include home electronics in their work with retailers and in promotional activities designed to build consumer interest in ENERGY STAR products. A number of program operators have expressed an interest in pursuing opportunities to further promote home electronics to key customer segments (e.g., hotels, hospitals, schools, and cable and satellite television companies); options for working with original equipment manufacturers on procurement of higher-efficiency external power supplies for a broader range of electronics products; and expanding the ENERGY STAR program to address active mode as well as standby power consumption.

Overall Level of Effort: Medium (heavy EPA activity, more limited activity at local and regional level)

Accomplishments: More than 30 manufacturers participate in the ENERGY STAR Home Electronics program including all of the industry-leading firms. Several manufacturers have upgraded the vast majority of their products to meet the ENERGY STAR specifications and many products exceed these specifications. EPA estimates of the 1998 to 2001 market share of ENERGY STAR-qualified products show increases in market share for many product categories (EPA 2002b):[2]

- TVs—51%, up from 17%
- VCRs—95%, up from 33%
- TV/VCR combos—77%, up from 17%
- Cable boxes—14%, up from 1%

[2] Not all products that qualify for ENERGY STAR are labeled under the program.

Other products have experienced more modest growth or little change:

- Audio mini-systems—15%, up from 9%
- DVDs—45%, up from 33%
- Satellite receivers—76%, up from 74% (in 1999)

It is too early to report on telephony products as the program only began in January 2002.

Rating on Progress Towards MT: 3 (substantial progress). Market share has grown substantially for many of the major products.

Lessons Learned: Building positive relationships with industry and basing specifications on solid technical research have been important components of EPA's success to date with the ENERGY STAR Home Electronics program. Promotion of the program has contributed to overall consumer awareness of the ENERGY STAR brand, but it is not clear to what extent it has influenced consumer purchases. In the electronics market, where efficiency improvements are transparent to the consumer (i.e., there is no change in product performance, features, or price) and where several manufacturers upgrade the majority of their product lines to meet program specifications, the role of the program in driving manufacturing practice and raising overall consumer awareness of energy efficiency may be the key factors for measuring success. Recent experience with revisions to the TV/VCR program demonstrates the benefits of negotiating multi-tier program specifications from the outset. The other programs include a preliminary tier effective upon program launch and a second, more stringent efficiency tier scheduled to take effect two, three, or four years later, respectively, for telephony, set-top boxes, and audio/DVDs. The original TV/VCR program did not include a second tier and development of a revised specification has been a long and arduous process taking more than two years to complete.

Residential Central Air Conditioning Equipment

Target: Residential central air conditioners and heat pumps with efficiencies substantially higher than those required under federal efficiency standards

Who's Doing What: High-efficiency residential central air conditioner (and heat pump) rebates were among the first utility programs. CEE began its program of coordinated performance levels for rebates from its utility members in about 1994, and now lists 22 participating utilities (CEE 2002a, 2003d). Most of these programs now focus on units with a Seasonal Energy Efficiency Ratio (SEER) of 13 or higher. Some also have minimum EER levels (Energy Efficiency Ratio—a measure of efficiency under high temperature conditions) and require certification of sizing and proper installation. In 1995, ENERGY STAR began encouraging the purchase of high-efficiency air conditioners and heat pumps. Originally the program targeted units with a SEER of 12, but in October 2002, the ENERGY STAR level was raised to SEER 13 *and* EER 11 (EPA 2002a).

Overall Level of Effort: Medium

Accomplishments: The number of high-efficiency *models* available has increased dramatically. The table below gives the CEE efficiency level and the fraction of central air conditioner models available through time (Foster 2003). In 2002, 52% of models met or exceeded SEER 12 (up from 35% in 1997) and 28% met or exceeded SEER 13 (up from 12%).

	SEER	1997	1998	2000	2001	2002
Tier 1	12	35%	40%	48%	49%	52%
Tier 2	13	12%	16%	22%	23%	28%
Tier 3	14	3%	6%	7%	8%	12%
Advanced	15			2%	2%	4%

Shipment-weighted average efficiency has also advanced some, from 10.46 in 1992 when the federal central air conditioner efficiency standard took effect, to 11.07 in 2002 (Menzer 2003). As of 1997, the last year for which data are available, 18% of equipment sales met or exceeded SEER 12, and 3% met or exceeded SEER 13 (ARI 1998). There was likely some increase in market share since then, as the sales-weighted average efficiency rose 0.26 EER points in 1998 and an additional 0.15 points during the 1999–2002 period (ARI 2002). In areas with active promotion efforts, the market share is even higher. For example, in New Jersey, between 1998 and 2000, 28% of all central air conditioners had SEER 13 or higher; this rose to about 35% in 2002 (Neme 2003). Neme also suggested that a PEPCO program in Maryland reached over 50% penetration with SEER 13 and above air conditioners in the later 1990s.

In January 2001, DOE issued a new minimum-efficiency standard for residential central air conditioners, requiring SEER 13 as of January 2006. Following the transition from President Clinton to George W. Bush, DOE subsequently reconsidered this standard and ultimately elected to make the new standard SEER 12, but still effective in January 2006. This action is now being challenged in Court (Inside Energy 2003).

Rating on Progress Towards MT: 4 (transformation likely). A new federal efficiency standard will raise efficiency to at least SEER 12, completing transformation process for this level of efficiency and allowing programs to focus on higher-efficiency levels.

Lessons Learned: The long-running programs offered by utilities and others have been key to demonstrating the feasibility of more stringent standards. Indeed, in January 2000, DOE issued a new minimum-efficiency standard for this equipment, calling for a SEER 13 level effective in 2006. Regardless of whether the ultimate standard is SEER 12 or 13, long-running market transformation initiatives clearly demonstrated the feasibility of more stringent standards, illustrating the linkage between market transformation initiatives and new standards. Although moving the market toward higher-performance products has been a notable success, it has also revealed some shortcomings of the federal metric. SEER does not show good correlation between laboratory test results and field performance. SEER also puts little emphasis on high-temperature efficiency, which matters greatly to utilities trying to meet peak demands. Efficiency programs are now paying greater attention to these issues.

Residential Central Air Conditioner Installation and Maintenance Practices

Target: Good residential central air conditioner installation and maintenance practices, including proper sizing, correct refrigerant charge, and air flow within specifications

Who's Doing What: California utilities participate in the Residential Contractor Program (RCP). Over 13,000 CheckMe! diagnostic checks of residential and light commercial air conditioners have been conducted to assure correct refrigerant charge and air flow (Downey and Proctor 2002). New Jersey utilities tie incentives for efficient air conditioners and heat pumps to a documented load calculation, with certification of refrigerant charge and airflow. CEE has developed a *Specification of Energy-Efficient Installation and Maintenance Practices for Residential HVAC Systems,* and is working with the North American Technician Excellence (NATE) program for a technician's certification in energy efficiency.

As of April 2003, the Oregon residential code will require the use of mastic or UL-181 certified tape and mechanical fastening of duct components, and will outlaw the use of building cavities as ducts. This market transformation was based on extensive duct training and certification programs, and tax credits for certified ducts. Oregon also provides tax credits for high-efficiency heat pumps and air conditioners. In order to get this equipment credit, the customer must have the Proctor Engineering CheckMe! or Honeywell Enalasys system checks performed on the system (Stephens 2003a).

Overall Level of Effort: Low nationwide, medium in California, New Jersey and Oregon

Accomplishments: CheckMe! has done some 13,000 installation evaluations, predominantly in California. In 2002, the New Jersey program provided incentives for approximately 20% of air conditioners and heat pumps sold for use in existing homes (another program deals with new construction) (Neme 2003).

Rating on Progress Towards MT: 2 (some progress). Progress is most pronounced in California, New Jersey, and Oregon, but interest in these issues is starting to spread to other states.

Lessons Learned: Perhaps the most valuable lesson is the importance of contractor training, and making the program part of the contractor's business model. At this stage, it must help him differentiate his services from the dreaded low-cost provider. A second lesson, implicit in the New Jersey and California programs, is the need for quality control, such as the CheckMe! program.

Residential Furnaces

Target: Condensing furnaces that are much more efficient than units just meeting federal minimum-efficiency standards. Additional savings are possible with more efficient air handlers (furnace fans).

Who's Doing What: Market transformation efforts for condensing furnaces are widespread in that the ENERGY STAR recognition is available for all condensing furnaces (Annual Fuel Utilization Efficiency—AFUE—of 90 or more), and the program maintains a list of postal codes where rebates or other incentives are available (EPA 2003a). CEE extends this program, with two performance tiers beyond minimum condensing, at AFUE 92 and 94 (CEE 2002b). Massachusetts gas utilities are about to launch a program with incentives for both condensing and electrical efficiency. Through its System Benefits Charge, Wisconsin offers a "Cash Back Reward" of $150 for prequalified models of 90 plus AFUE furnaces with efficient fan motors. This program is restricted to existing homes (Focus on Energy 2003). Oregon has a program now operating based on state tax credits. It offers a tax credit of up to $350 for condensing furnaces with an electronically commutated variable speed motor (ECM) (Oregon Office of Energy 2003).

CEE reports on 22 separate furnace programs (CEE 2003a). There is a move toward base incentives at AFUE 92 rather than at AFUE 90. Active states and regions include the Northwest, New England, California, Iowa, Minnesota, New Jersey, New York, and Wisconsin. Incentive amounts range from $100 (90%) to $375 (94% with programmable thermostat). In Oregon, combining incentives from gas utilities, the state of Oregon, and manufacturers, the total incentive for a 90% AFUE furnace with programmable thermostat and efficient fan motor can reach $750.

Overall Level of Effort: Medium (high in some Northern states, generally low-medium elsewhere)

Accomplishments: According to the Gas Appliance Manufacturers Association, the fraction of condensing furnaces shipped has increased from about 18% in 1987 to 22% in 2000. However, this obscures the fact that 10 states have condensing furnace market shares of over 60% (Kendall 2002). Incremental costs for condensing furnaces have declined to the $400 range, which is generally cost-effective in cooler climates (ECW 1997). Much less attention has been paid to electrical efficiency. However, because of relatively generous state tax credits in Oregon ($350 for condensing furnace with electronically commutated fan motor), some distributors (wholesalers) have reportedly discontinued stocking units that are not eligible for the tax credit (Stephens 2003b).

Rating on Progress Towards MT: 4 (transformation likely) for condensing furnaces in cold climates); 2 (some progress) for fan motors

Lessons Learned: Condensing furnaces have good market penetration in many cold regions of the country. High market share was originally established in Wisconsin using a multi-pronged effort that included utility incentives and free installations through the low-income weatherization program. Together these programs increased stocking and installer familiarity with the equipment, leading to lower prices and a sustained market even when incentives ended (Suozzo and Nadel 1996). Other cold weather states have gradually caught up. One notable example is Massachusetts where the market share went from 46% in 1997 to 62% in 2000, primarily driven by a coordinated program involving all the state's gas utilities (Kendall 2002) However, even in Wisconsin, where condensing furnaces outsell non-

condensers by 2.7 to 1, they have lower penetration in the most urban area (Milwaukee). This most likely is due to the higher proportion of rental property and the "split incentive" problem (owners buy the equipment but tenants generally pay the energy bills). Together, these observations suggest that it would be appropriate to require condensing furnaces, at least in colder states. This may require that states petition for exemption from the federal minimum standard, which is much lower. Market transformation programs for more efficient electrical systems are just starting, but promise savings of several hundred kWh per year if implemented well.

Residential Duct Sealing

Target: Residential ductwork generally leaks a large fraction of the air carried into unconditioned spaces like attics (frequently 20–30%). Similarly, leaky return ducts can bring hot attic air into the air conditioning system. Duct sealing refers to any method for reducing these supply and return losses/gains. There are both proprietary (e.g., "Aeroseal") and "open" (e.g., mastic and tape) approaches.

Who's Doing What: NW Alliance began its Performance Tested Comfort Systems program in 1997. The program developed a service to diagnose and seal ducts. Seven utilities currently offer programs, and over 120 contractors have been trained and certified. Utility-sponsored incentives range up to about $400, paid either to the contractor or the customer (NW Alliance 2003). California utilities offer duct-sealing services through the Residential Contractor Program (SDG&E 2003) and they have also promoted duct sealing in new construction for many years. The city of Austin, Texas, awarded incentives for 370 duct sealing jobs in 2002, in a program that requires before-and-after testing of leakage (Thomas 2003). Oregon offers a basic income tax credit based on the efficiency of the system. In addition, Oregon offers a $150 "supplemental equipment tax credit" for installation protocols (such as Proctor Engineering's CheckMe! or Honeywell's Enalasys), and the duct system credit of one-quarter of the cost, up to $250 maximum (Stephens 2003b). Research by Lawrence Berkeley National Laboratory has been commercialized by Aeroseal as a new service and product. It comprises a specialized fan and controls to inject a latex material that solidifies at leakage points. The venture has been sold to a major HVAC equipment manufacturer that is franchising the system (Aeroseal 2003). At least one utility is working with the firm (SMUD 2003a).

Overall Level of Effort: Low, but growing

Accomplishments: Duct sealing is relatively new, and it is noteworthy that several groups are sponsoring programs to start market transformation. The Northwest Performance Tested Comfort Systems Program has tested and certified ductwork in over 2,400 houses (NW Alliance 2003). As of April 2003, the Oregon residential code requires the use of mastic or UL-181 certified tape and mechanical fastening of duct components, and will outlaw the use of building cavities as ducts (Oregon Office of Energy 2003). Recent amendments to the California Title 24 Building Code have added a certified low-leakage duct default; homes that are not so certified need to install additional energy-saving measures to make up for assumed losses from leaky ducts (Wilcox 2003). As a result, perhaps half of new California

homes are using duct sealing (Goldstein 2003). Also, the new Florida Building Code assumes that duct systems leak air. From this, those that are certified as essentially leak-free receive a 13% performance credit in code calculations. In the performance-based Florida Code, this relatively low-cost measure is "worth" almost as much as an expensive window upgrade, so it is expected to become common practice (Fairey 2003).

Rating on Progress Towards MT: 2 (some progress). The concept has gotten some traction, particularly in the Northwest, California, and Florida.

Lessons Learned: First, there is now a technical basis for duct sealing programs, using either proprietary or public methods; either can be successful in many houses. Second, because duct sealing is fairly labor-intensive with both approaches, it is not inexpensive. Even more than duct "cleaning," it is an intangible service whose value is relatively difficult to demonstrate to consumers. More work is needed to document the links between duct sealing and attributes homeowners value, such as improved comfort. Third, there is very low consumer awareness. Thus, public education efforts need to increase. In addition, incentive or other "subsidy" programs will be required for the time being, either through utility incentives (perhaps focusing on retrofits), or as an optional compliance route in building codes (for new construction).

Ground Source Heat Pumps

Target: Residential ground source heat pumps (also promoted as geothermal and "GeoExchange" units) exchange heat with the ground or ground water. The high cost of the ground heat exchanger (generally comparable to the cost of the unit itself) is recovered by greater efficiency. In addition, since the compressor unit is generally indoors, it is easy to improve water heating efficiency with a supplemental desuperheater.

Who's Doing What: In 1995, utilities and manufacturers formed the Geothermal Heat Pump Consortium (GHPC) to promote the technology, sharing costs with the federal government. Considering all sources, about $1 million per year was invested in research and development (R&D) focused on improving the intangible infrastructure of drilling and groundwater regulations, contractor training, and developing materials for engineers doing commercial-scale installations.

According to GHPC, 13 states have some form of incentive program for the technology (GHPC 2003). There are 11 utility-sponsored programs, and six consumer-focused programs by state governments. Utilities offer nine rebate programs, two loan programs, and two lease programs. State programs include two each for rebates and low-interest loans, and one each for income tax credits and sales tax exemption.

Overall Level of Effort: Medium

Accomplishments: ACEEE analysis of ARI sales data suggests growth rates of at least 10% per year. Since the launch of a federal government, electricity utility, and manufacturer

program in the mid-1990s, the technology has become more visible, and annual sales have increased. Industry sources state that desuperheaters are installed in most residential systems.

Major efforts were undertaken to raise public awareness. Important investments in R&D advanced understanding of heat exchanger design, installation, and environmental protection. Other research strengthened design guidance, and there were major investments in training hundreds of design engineers and installation technicians. In the federal buildings sector, executive orders have greatly increased visibility by requiring explicit efficiency activities and highlighting Ground Source as a technology that can help meet expectations. Successful high-visibility installations (such as the Vice-President's official home and the President's ranch) may also have helped raise consciousness.

Rating on Progress Towards MT: 2 (some progress)—sales and awareness up somewhat

Lessons Learned: Progress has been spotty. Perhaps the most important lesson is that strong and sustained advocacy, backed by limited funding (for example, for exploratory drilling at commercial sites) is a key difference between states where market penetration has increased and those with flatter curves.

Heat Pump Water Heaters

Target: Residential heat pump water heaters (HPWHs) extract heat from basement ambient air (or ventilation exhaust air), and use a vapor compression (mechanical refrigeration) cycle to heat water in a conventional storage tank. The HPWH cost more than its primary competitor, resistance water heating, but reliable equipment would be highly cost-effective when compared to resistive water heating. In many situations, the basement dehumidification work done by the HPWH has additional customer value, and may offset the need for a separate dehumidifier that consumes hundreds of kilowatt-hours per season.

Who's Doing What: Building on prior work by the Bonneville Power Administration (BPA) and many others, the Electric Power Research Institute (EPRI) commissioned the development of a relatively low-cost, low-output residential HPWH. It was designed to be retrofitted on existing resistance storage water heaters, with a sealed refrigerant system, so that it was relatively easy to install where a condensate drain was available. This unit and its successors have been produced in modest quantities (certainly several thousand units cumulatively), but reports of field reliability problems moderated customer interest. One utility, Northeast Utilities, offered a sustained incentive program. Within the past five years, two additional firms (Nyle Special Products and ECR International) have entered the U.S. residential market. One, working with the most experienced utility, has put several hundred or more units in the field, and has provided appropriate support when problems were encountered (Johnson 2002, 2003). The other was developed with DOE support, and features a fully integrated design with the evaporator wrapped around the water tank, under its insulation. This design has undergone several years of continued development and field trials carried out by a federal laboratory. It is to be available in the near future, with a COP of 2.4 and savings of about $200 per year (standard DOE test cycle) at $0.08/kWh (ECR International 2003). At least one other new concept, an immersed-condenser retrofit package,

is being studied with DOE support (Vohra 2003). At present, there are few rebate or other incentive programs. In information programs, FEMP has developed an excellent "Federal Technology Alert" (FEMP 2002a). With NYSERDA support, ACEEE has put additional resources on the ACEEE website, including a review of the potential for commercial HPWH (Sachs 2002).

Overall Level of Effort: Low, but ramping up with significant federal investment in "getting it right this time"

Accomplishments: One investor-owned utility has offered large incentives over a sustained period. These have led to installations of perhaps 5,000 units from two different manufacturers, and important knowledge of ways to strengthen contractor capabilities and interest. However, despite promotion efforts such as these, discussions with manufacturers and utilities suggest that annual U.S. sales volume remains little more than a thousand units in an average year.

Rating on Progress Towards MT: 1 (little progress, albeit high potential). Older models were problem-plagued. Designs from manufacturers new to this industry are still being rigorously evaluated before large-scale rollout.

Lessons Learned: Although HPWHs have long been recognized as a major opportunity for very large energy savings (thousands of kWh per year for many families using resistance water heating), progress has been very slow. Early equipment that did not meet customer expectations for reliability hurt the technology's reputation and hampered utility promotion and incentive efforts. Requirements in some states for separate plumbing and electrical installation permits raised costs. The conclusions are plain: equipment must be highly reliable and fully backed by manufacturers and promoters. Simultaneously, costs must be reduced from the present $1,000 and up to make value clearer to consumers. Finally, a committed distribution channel is required. Only then will HPWHs grow from a few thousand units per year to a significant fraction of the U.S. market for about 3 million resistance water heaters per year.

Despite recent improvements in the technology, it is noteworthy that no major manufacturer of residential water heaters offers a HPWH model yet. New entrants will have to develop distribution and sales channels, even though they have overcome most of the barriers that required two trades for installation of a HPWH.

Commercial

Packaged Air Conditioning Systems

Target: Packaged commercial air conditioning systems generally contain both the evaporator and an air-cooled condenser section in a single unit and are commonly placed on rooftops (hence they are often called *rooftop air conditioners*). Frequently, they also have natural gas furnace sections, too, and are then called "year-rounds." Sizes are predominantly 3–15 ton but they extend to 60 ton or so. Rooftops are commonly used in schools, auditoriums, strip-

mall retail, etc. Many purchasers (landlords) are not the bill-payers (tenants), so most of the market values low purchase prices over efficiency. On the other hand, utilities recognize unitary equipment's large contribution to load peaks, so there is interest in programs to affect purchases.

Who's Doing What: CEE made commercial packaged air conditioning systems one of its first program targets, developing Tier 1 and Tier 2 efficiency specifications in 1993. Twenty-nine utility and state programs are now part of the CEE initiative (CEE 2003c, 2003d). In 2001, ENERGY STAR began a packaged air conditioning system program, with the efficiency levels largely similar to CEE Tier 2 (EPA 2003b). Where they differ, the CEE specification is slightly more stringent. Twenty-five utilities participate in the CEE program (CEE 2003c). In New Jersey and New England, 14 utilities further cooperate in the "Cool Choice" program, which coordinates HVAC incentives at the CEE levels (Cool Choice 2003). Cool Choice rebates average about $80 per ton, and the program also offers incentives for dual enthalpy economizers. FEMP has developed an innovative program. With the Defense Logistics Agency, FEMP offered a procurement program that yielded fixed prices for two products (five models) with the lowest life-cycle costs; one at EER 11 and the other at EER 13 (FEMP 2002b).

Overall Level of Effort: Medium

Accomplishments: Since the CEE initiative began, the proportion of models on the market meeting CEE's Tier 2 have increased from just a few percent to 16% in 2001. Most major manufacturers offer a line of products meeting the Tier 2 specification (Foster 2003). A 1999 study for Massachusetts utilities found that 22% of the packaged unit sales were above standard efficiencies, with 13% in Tier 1 of the Cool Choice Program, and 9% in Tier 2 (RLW Analytics 1999). Since then, sales of Tier 2 units have increased, with Tier 2 incentives accounting for 51% of program participation in 2002 (NEEP 2003). In 1999, the American Society of Heating Refrigeration and Air-conditioning Engineers (ASHRAE) established Tier 1 as the recommended level in its model building code, a code that took effect in 2001 and has since been adopted as mandatory in many states. Due to the ASHRAE code, the transition to Tier 1 efficiency levels is largely complete, and program efforts are now primarily targeting Tier 2. DOE is considering Tiers 1 and 2 as minimum-efficiency standards in a current rulemaking proceeding. A decision is expected in late 2004. Work has also begun on higher-efficiency levels. As noted above, FEMP developed an exemplary procurement program that yielded fixed prices for two products with the lowest life-cycle costs. Both of these products exceed Tier 2, including one product whose efficiency is 15% above Tier 2 (FEMP 2002b). The FEMP effort was launched in late 2002, and is too new for its success to be gauged.

Rating on Progress Towards MT: 4 (transformation likely). Tier 1 efficiency levels are becoming standard practice and substantial progress is being made toward increasing availability and sales of Tier 2 units. The new DOE standard will complete the transformation process for Tier 1 and perhaps for Tier 2 as well.

Lessons Learned: The work on packaged air conditioners illustrates the importance of a long-term sustained effort, and the role of building codes and standards in completing the market transformation process. However, efforts have focused overwhelmingly on equipment efficiency and few programs address other aspects of system performance, such as ventilation effectiveness and efficiency, proper use of economizers, and installation and maintenance practices. These areas need increased attention in the future.

Packaged Commercial Refrigeration

Target: Efficient vending machines and reach-in refrigerators and freezers that reduce energy use by 30–50% relative to conventional new equipment; efficient ice-makers that reduce energy use by 10–30%

Who's Doing What: ENERGY STAR issued a specification for efficient reach-in refrigerators and freezers in September 2001 based on the efficiency of the top 25% of units then in the market. CEC adopted minimum-efficiency standards for reach-in refrigerators and freezers in November 2002, with the initial standard (which eliminates the 25% of current models that are least efficient) going into effect in March 2003. A second standard goes into effect in August 2004 (and is based on the average efficiency of models previously on the market) (CEC 2002). Over this same time period, DOE worked with Delfield, a major reach-in manufacturer, to develop a new set of reach-in models that use half the energy of previous Delfield models (ADL 2001). Delfield reports that they can sell the new units for the same price as their less-efficient older units (Sunderman 2002). In December 2002, CEE issued a 2-tier specification for this equipment, with Tier 1 the same as ENERGY STAR and Tier 2 based on the most efficient models that are commercially available (saving 30–40% relative to ENERGY STAR). CEE also issued specifications for ice-makers, with Tier 1 based on the top 20% of the market from an efficiency standpoint and Tier 2 20% more stringent (Nadel 2002a). ENERGY STAR issued a draft specification for vending machines in October 2002 that will result in about 30% energy savings relative to typical units then on the market (EPA 2003d). The specification is scheduled for finalization in the first half of 2003. Several energy efficiency program operators are offering programs based on these specifications including NYSERDA and several utilities in the Northwest. Additional programs are expected in 2003 and 2004 (Nadel 2002a).

Overall Level of Effort: Medium, with most of this activity in 2001–2002

Accomplishments: Since issuance of the ENERGY STAR specification for reach-in refrigerators and freezers, the number of units meeting this specification has soared. Shortly after the specification was published, EPA listed only eight complying models (EPA 2001). As of January 21, 2003, there are 284 complying models on EPA's list (EPA 2003c). The number of Tier 2 units is also increasing. Based on data compiled by CEC, in late 2000 there were no models on the market meeting the Tier 2 specification. As of January 2003, there were 35 models meeting this specification (CEE 2003b). These units also appear to be selling well. For example, Delfield reports that it is having difficulty keeping up with demand (Williams 2002).

With regards to ice-makers, as of January 2003, no models met Tier 2, but least two manufacturers have indicated they are now developing new models that should meet this specification. At least one of these manufacturers hopes to bring its first product to market in mid-2003 (Nadel 2002a). As for vending machines, the first model that meets the proposed ENERGY STAR specification reached market in 2001. The other two manufacturers plan to introduce complying models in the first half of 2003. Coke and Pepsi, whose distributors account for about 80% of vending machine sales (ADL 1996), have indicated that they are likely to purchase only or primarily ENERGY STAR units once the specification is finalized. In addition, in 2001–2002, the U.S. House of Representatives passed legislation calling for DOE to set vending machine efficiency standards, and the U.S. Senate passed legislation calling on DOE to set standards for both vending machines and reach-in refrigerators and freezers. As of this writing, this legislation is still pending, with enactment likely in fall 2003.

Rating on Progress Towards MT: 3 (substantial progress). Many high-efficiency units are being commercialized and these units appear to be selling well.

Lessons Learned: Initial market transformation work on packaged refrigeration systems can be traced back to 1993 when initial research on the opportunity for improving equipment efficiency was documented (Easton 1993). However, efforts to develop programs lagged for many years due to such problems as a lack of performance data on some products, lack of demand by purchasers for more efficient equipment, reluctance by manufacturers to re-engineer products, and concern by beverage companies that ENERGY STAR specifications would saddle them with demands to quickly replace the existing vending machine equipment stock. The logjam broke in 2001 when several initiatives occurred in tandem, leading to a perception among market participants that efforts to improve energy efficiency were possible and probably inevitable. The initiatives that broke the logjam included the ENERGY STAR specification for reach-ins, the California standards, and commercialization of new high-efficiency reach-ins and vending machines. The California and manufacturer efforts were spurred in part by the California electricity crisis. Since then, market transformation efforts have gathered momentum, including the CEE specifications, a forthcoming ENERGY STAR specification for vending machines, development of additional new products, utility and public benefit promotion programs, and consideration of additional standards at both the state and national levels. The key appears to have been development of a multi-pronged set of initiatives sufficient to generate the sense that "the train is pulling out of the station," and market participants would be best served to be on board.

Commercial Lighting Design (Including Daylighting)

Target: High-quality, energy-efficient commercial lighting design strategies, including daylighting

Who's Doing What: Recognizing the significant successes in adoption of energy-efficient lighting technology (particularly linear lamps and electronic ballasts) in commercial buildings, a number of market transformation organizations have launched programs targeting lighting design and controls as a means to capture additional energy savings and further improve the lit environment. These programs typically utilize education and technical

assistance rather than widespread marketing and financial incentives to reach their target audience. At the national level, the Light Right Consortium is a partnership of manufacturers, distributors, and public and private sector organizations promoting high-quality, energy-efficient lighting. Light Right is particularly interested in exploring the links between lighting and productivity through the concept of "ergonomic lighting" (Light Right Consortium 2003).

The Daylighting Collaborative focuses on incorporating cool daylighting (i.e., daylighting designed to reduce cooling load) into mainstream design and construction through training for designers, building owners, and builders; a design review service and limited design assistance; and demonstration rooms with simple approaches that can be replicated in other buildings. Started in Wisconsin, the program has expanded to serve other parts of the country (Hinge, Titus, and Thorne 2002).

Regional lighting design programs run by NYSERDA and NEEP and its partners target small commercial customers that typically work with less sophisticated lighting contractors and distributors than those available to larger firms. The NYSERDA program works with lighting contractors and others to promote implementation of projects meeting their criteria for "effective, energy-efficient lighting" (Hinge, Titus, and Thorne 2002). In the Northeast, utilities and other energy organizations working with NEEP comprise the DesignLights Consortium (DLC). It has developed a series of lighting design guidelines and case studies for schools, small retail, offices, warehouses, and industrial buildings to provide model design layouts and templates for practitioners. The program also conducts customer and contractor education and demonstration projects (DesignLights Consortium 2003).

In the Northwest, the NW Alliance has supported the Lighting Design Lab in Seattle, and Daylighting Labs in Seattle, Portland, and Eugene (the latter in conjunction with university architecture departments). These labs provide training, consultation, and product information. The Daylighting Labs also provide analysis aimed at architecture firms (Gardner 2003).

Overall Level of Effort: Medium

Accomplishments: Traditional indicators of success such as sales, market share, and energy savings are not applicable or prove harder to quantify for lighting design practices than for specific technologies and products. The programs are working to develop tools to better assess the benefits. It is clear that commercial lighting design programs have made some headway in educating lighting contractors and commercial customers about the benefits of effective, energy-efficient lighting design. However, it is difficult to quantify the extent that educational programs have resulted in lighting projects incorporating the preferred design strategies. In Wisconsin, the Daylighting Collaborative has been very successful in working with a limited number of local design-build firms and a leading window manufacturer and its key distributor; each firm is committed to incorporating cool daylighting principles into its business (Vogen et al. 2002). In the Northwest, many of the larger architecture firms routinely consult with daylighting labs on projects and over 200 major projects per year now incorporate advanced daylighting strategies. In addition, two grocery chains have recently adopted daylighting as a strategy for all new stores (Gardner 2003).

Rating on Progress Towards MT: 2 (some progress). Daylighting design is starting to catch on in some market segments and regions (e.g., Wisconsin and the Northwest). However, many daylighting programs are still young and lighting design is a new and difficult field for market transformation.

Lessons Learned: Education of end-users on the many benefits of high-quality, energy-efficient lighting design is crucial to program success. Many programs have strong training and education components targeting designers and installers, but a lack of awareness by end-users remains a barrier to increased demand for and acceptance of improved lighting design. Primary challenges for lighting design programs include: (1) ensuring that the design process is comprehensive; (2) determining cost-effectiveness including both energy savings and the hard-to-quantify non-energy benefits; and (3) developing methods for evaluating lighting quality including subjective and objective criteria. The LightRight Consortium, among others, is exploring methods of quantifying and demonstrating the energy and non-energy benefits of improved lighting design for a variety of end-users. Design approaches, when compared to simple technology replacements, are not as standardized. Measurement of savings, and of programmatic success and market progress, can be quite difficult. Programs in the Northwest have found that for an advanced practice such as integrated daylighting design, an aggressive technical and marketing support package is needed. For complicated markets, such as lighting design, partnerships that bring together all of the market actors are vital. Programs may also have success by offering relatively simple design-based technology approaches (e.g., one lamp fixtures or lighting controls) in addition to broader, systematic lighting design efforts.

Exit Signs

Target: High-efficiency exit signs (primarily LED exit signs)

Who's Doing What: EPA's Green Lights program began promoting energy-efficient exit signs in the early 1990s. In 1996, EPA developed an ENERGY STAR labeling program for exit signs. The current specification, which limits power draw to five watts or less per face, effectively requires the use of LEDs and electroluminescent technology for qualified products. The specification is currently under revision; key changes under consideration will lower the required power draw to no more than three watts per face and change the product definition to allow photoluminescent and self-luminescent signs (EPA 2002c). The ENERGY STAR program only covers new exit signs, but retrofit kits are available for users interested in retrofitting existing fixtures with LEDs. FEMP offers guidelines for federal purchases of ENERGY STAR exit signs as well as LED retrofit kits (FEMP 2003). A number of utilities offer rebates for the purchase and installation of LED and electroluminescent exit signs. Some program operators (including SCE and SDG&E) offer rebates for both new signs and retrofit kits; others restrict rebates to retrofit kits (including Xcel Energy and Anaheim Public Utilities) or to new exit signs (including National Grid, Portland General Electric, Efficiency Vermont, and NYSERDA).

Overall Level of Effort: Medium

Accomplishments: Since the inception of the ENERGY STAR program, the availability of qualified products has increased and product costs have dropped. Utility incentives for LED exit signs also helped build market share for the product, further helping to lower costs. The incremental cost of a basic LED exit sign has dropped to about $20 compared to incandescent signs; maintenance and energy cost savings yield a simple payback of less than one year (PG&E 2000). As costs have dropped, adoption of LED exit signs has increased even in areas without utility incentives. Rapid improvements in LED technology and manufacturing are expected to yield further price reductions. As of January 2003, there are 21 manufacturer partners in the ENERGY STAR program (EPA 2003i); this number is likely to grow if program revisions allow labeling of photoluminescent and self-illuminating signs. As of 2000, LED exit signs accounted for at least 78% of market share in California, up from 43% in 1998 and 20% in 1995 (PG&E 2000). California has adopted a minimum-efficiency standard for exit signs equivalent to the current ENERGY STAR specification. And several states have included comparable requirements in their building codes. Legislation establishing federal standards for exit signs passed the U.S. Senate in 2002 and is likely to be enacted into law in 2003, with the standard taking effect in January 2005.

Rating on Progress Towards MT: 5 (largely transformed). LED exit signs dominate the new construction market. Minimum-efficiency standards are completing the transformation process.

Lessons Learned: By including fire and life safety concerns in the energy and visibility criteria of the ENERGY STAR program, EPA was able to get increased buy-in for the ENERGY STAR program. EPA was able to use this experience when developing specifications and building support for it traffic signal program. Utility incentives have also increased market share and enabled cost reductions that have improved adoption of the technology in regions with and without incentive programs. Product specifiers often rely on first cost as the key criteria in purchasing decisions. Education and tools demonstrating the overall life-cycle cost savings and short payback from energy-efficient exit signs were important in convincing specifiers to broaden their purchasing criteria. With the continued reductions in first cost for LED exit signs, replacements may soon be as attractive as retrofits for many end-users. The emergence of self-illuminating exit signs, which do not require a power source or external light source, demonstrates the importance of ongoing review and revision of the ENERGY STAR specifications in providing an avenue for manufacturers of innovative products to access key markets.

Commercial New Construction

Target: Increase use of equipment and design practices that exceed local code requirements, in order to reduce energy use by approximately 10–30% relative to a new building that minimally complies with codes. Many programs also emphasize a comprehensive design approach in which an integrated package of energy-saving measures is developed, allowing more energy to be saved at a lower cost per unit of energy saved.

Who's Doing What: Many utilities and some states are operating programs that typically combine technical assistance, rebates for specific measures (e.g., high-efficiency chillers),

and custom incentives for integrated packages of measures. Leading programs are operated by utilities in Connecticut, Massachusetts, Minnesota, and Rhode Island (York and Kushler 2003). In recent years, programs have begun in other states including California, New York, and Vermont. A few utilities and states are offering "Green Building" programs in which owners and designers receive technical assistance and recognition that incorporate many aspects of sustainable design, including energy efficiency. These latter programs are often built around the Leadership in Energy and Environmental Design (LEED) rating system.

Overall Level of Effort: Medium (high in a few leading states, medium or low elsewhere)

Accomplishments: Northeast Utilities (Connecticut and Massachusetts) had nearly 3,000 new buildings participating in their Energy Conscious Construction program from 1990 to 2001. Northeast Utilities estimated that participating new buildings now account for about 80% of the new commercial floor area built in its service area each year. National Grid (Massachusetts and Rhode Island) estimated that about 50% of new floor area participates in their Design 2000 Plus program, 73% of which goes through its "comprehensive design approach," including most large new buildings (York and Kushler 2003). While the participation levels are way up in new construction programs, the actual performance of these buildings needs further monitoring. Anecdotal information suggests discrepancies between modeled versus actual energy performance and attention needs to be given to this issue moving forward (Hinge 2003).

Xcel Energy Minnesota also targets large buildings and a comprehensive design approach in their Energy Assets program. It estimated that in recent years the program has assisted about 30% of the new building floor area, including 50% of the floor area of the large buildings (over 80,000 square feet) that they target. On average, participating buildings reduce electricity and gas use by 30 and 22%, respectively, relative to buildings just meeting local code and peak electrical demand is reduced by 28% (Vaidya et al. 2002). Other newer programs are still "ramping up." For example, the California Savings by Design program, which began in 1999, reported a 14% participation rate in 2001 (Quantum Consulting, Inc. 2002).

Another effort that is just beginning is the development by the New Buildings Institute of a set of Advanced Building Guidelines that will help designers and program implementers to develop and promote new buildings that reduce energy use by 30–50% relative to current model building codes. Publication is expected in mid-2003 (NBI 2003).

Many of the long-running programs report that architects, engineers, and building developers have changed their design practices as a result of the programs. When a new energy-saving measure works well in one new building, it is often incorporated into subsequent projects. Also, as measures achieve high market share, they are frequently dropped from programs and instead incorporated into local building codes.

Rating on Progress Towards MT: 4 (transformation likely) in states with extensive programs, 3 (substantial progress) elsewhere

Lessons Learned: Leading programs have gradually built up market share and trust among building professionals over time. Further attention needs to be paid to monitoring the performance of participating buildings. Commercial new construction programs are a long-term effort. These programs can also be fairly expensive—Xcel spends about $4 million per year on its program, Northeast Utilities about $9 million per year, and National Grid has averaged about $13 million over the past few years. Increasingly, programs are paying more attention to the building code revision process, in order to move proven measures into codes, thereby increasing penetration rates and reducing incentive costs. For example, influencing the code is a very conscious part of the California Savings by Design program.

Building Operator Training and Certification

Target: Train and certify building operators in order to improve the quality of building maintenance and provide a way to recognize skilled operators so that good maintenance skills have value in the marketplace.

Who's Doing What: The Building Operator Training and Certification Program (often abbreviated BOC) began in the Northwest in 1997 under contract with the NW Alliance, building upon previous work in Idaho and Washington state. Operated by the Northwest Energy Efficiency Council in Washington and Oregon, the program includes two levels of training—basic (level 1) and advanced (level 2). Participants attend a series of courses spread over several months. At the end of the course, a test is given and those who pass are certified. The original program has since spread, with the Northwest Building Operators Association beginning courses in Idaho and Montana in 1998; NEEP beginning courses in New England, New York and New Jersey starting in 2000; the Sacramento Municipal Utility District and Wisconsin Focus on Energy Program beginning in 2001; a statewide California initiative sponsored by four investor-owned utilities in 2002; and the Midwest Energy Efficiency Alliance beginning in 2003.

Overall Level of Effort: High

Accomplishments: Since the program's inception, more than 1,500 operators have achieved certification. In the Northwest, where the program has been operating the longest, more than 10% of the target market has participated. An evaluation of the Northwest program found that over 65% of program participants apply concepts learned in training and 26% undertake specific measures such as energy conservation projects and indoor air quality improvements (York and Kushler 2003). Energy savings among participants has averaged 0.5 kWh per square foot of building area (Peters and McRae 2001), which is a reduction in energy use of about 2.5% (Putnam 2002). Employers of BOC graduates overwhelmingly (98%) said they will recommend BOC to their peers, and 92% said they would look for BOC certification on resumes of job applicants. And nearly 50% of graduates have seen an increase in job responsibilities and compensation since earning certification (York and Kushler 2003). Similar results were found in an evaluation of the program in the Northeast. Ninety percent of BOC students and their supervisors said students have improved comfort, saved energy, or saved money in their facilities. Annual savings per facility averaged 238,490 kWh, 930 million Btus of fossil fuel, 77,000 gallons of water annually, and $20,000 in reduced energy

and water costs. On a per square foot basis, savings are very similar to the Northwest program (Peters et al. 2002).

Rating on Progress Towards MT: 4 (transformation likely). Programs in the Northwest and Northeast are well established and well received. While it will take time to fully penetrate the market of building operators, these programs appear to be on-track toward this goal.

Lessons Learned: The BOC concept was carefully thought out at the beginning to appeal to both students and their employers. Students receive high-quality training, certification, and opportunities for promotions and higher compensation. Employers receive documented improvements in building operations and reductions in operating costs. The program found an important market niche, and developed a successful strategy to fill it.

Retrocommissioning

Target: Retrocommissioning (RCx) of existing commercial and institutional buildings

Who's Doing What: Programs to promote RCx include those offered by Portland General Electric, Xcel Minnesota (formerly Northern States Power), Texas A&M, Sacramento Municipal Utility District, N-Star (formerly Boston Edison), Northwest Energy Efficiency Alliance, New York State Energy Research and Development Authority, City of Oakland (California), the Minneapolis Center for Energy and the Urban Environment, and Xcel Colorado (formerly Colorado Public Service). The Portland, Minnesota, and Texas programs are broad-scale ones that have already served dozens of buildings. The other programs are pilot, demonstration, or start-up efforts, although several of these are expanding to broad-scale in 2003. In addition, several new pilot programs are also being planned for 2003. Program activities include financial incentives to building owners and RCx providers; training of RCx providers; education of building owners and operators on the benefits of RCx; demonstration projects; dissemination of RCx guidelines, specifications, and sample documents; and development of case studies (Thorne and Nadel 2003).

Overall Level of Effort: Low (becoming medium as of 2003)

Accomplishments: The various programs and pilots conducted to date have helped to raise awareness of RCx and document the potential energy savings and building performance improvements resulting from RCx. The first full-scale program, conducted by Portland General Electric, has documented cumulative energy savings of more than 18 million kWh from 1998 to 2002 on 47 projects covering more than 10 million square feet. As a result of these successful early efforts, RCx has been recognized as an important component in a number of other efficiency efforts. For example, an Executive Order in New York State requiring all state agencies to cut energy consumption in their facilities highlights RCx as a key strategy for meeting the program goals; high levels of facility staff participation in educational programs on RCx has been an early indicator of the potential for RCx in state buildings. The U.S. Green Building Council will require RCx in its LEED certification program for existing buildings. Increased efforts to train RCx providers and building

operations and maintenance staff are also helping to build the market for RCx (Thorne and Nadel 2003).

Rating on Progress Towards MT: 2 (some progress). Programs have gained some momentum in Portland, Minnesota, and Texas, and additional programs starting.

Lessons Learned: Efforts to document the opportunity for savings from RCx can play an important part in building owner confidence in the anticipated results. It is also important to show building owners and occupants the full range of energy and non-energy benefits from RCx. In many areas, the pool of qualified RCx providers is limited. Effective programs must work to attract and train these providers to meet demand as program marketing and outreach ramps up. It is important that owners are informed that the savings from RCx can be less predictable than savings from other efficiency measures since it is unclear what the true opportunities are until the project is underway. Offering a no-cost scoping study to determine the suitability of a facility for RCx, identify key areas for improvement, and develop a more informed estimate of savings potential has worked well in Portland to encourage owner participation (Peterson 2002).

Real Estate

Target: Energy efficiency improvements in the commercial real estate sector.

Who's Doing What: Under the ENERGY STAR umbrella, EPA manages the ENERGY STAR for Commercial Real Estate program. In addition to offering an ENERGY STAR label for buildings that meet its criteria, the program offers a suite of interactive tools, software, and calculators to help its commercial real estate partners determine the improved financial performance that can result from energy efficiency upgrades in their properties. These tools are designed to translate investments in energy efficiency into the language of commercial real estate—reductions in building operating costs, increased net operating income or funds from operations, and improved asset value. A similar program targets corporate real estate managers interested in improving their energy performance and saving their company money. Local and regional market transformation program operators are looking for ways to build on the ENERGY STAR platform to expand energy upgrades in commercial real estate properties in their service areas. For example, NEEP is working with its utility partners to evaluate the value of the ENERGY STAR benchmarking tool for the utilities and their partners and to develop a billing-based Energy Performance Report using the benchmarking tool to be presented to large end-user customers. And the Wisconsin Focus on Energy program is using these tools to help building owners and managers to identify and evaluate energy-saving opportunities in their buildings and develop and implement energy-saving action plans.

Overall Level of Effort: Low (EPA is doing a lot, other efforts are limited.)

Accomplishments: More than 100 commercial real estate firms, including many of the nation's largest, are ENERGY STAR partners. Sixty-eight companies participate in the corporate real estate program. Service providers, energy services companies, and product

manufacturers are also members. Leading industry associations (including BOMA International, the National Association of Real Estate Investment Trusts, the Real Estate Roundtable, and the Society of Industrial and Office Realtors) have endorsed ENERGY STAR and promote the program to their members. Thousands of buildings have been benchmarked and close to 700 office buildings have received the ENERGY STAR label. Commercial and corporate real estate properties account for a majority of the labeled buildings (EPA 2003j).

Rating on Progress Towards MT: 3 (substantial progress). Activities to date have successfully engaged a number of influential players in a very competitive, high-profile market.

Lessons Learned: Demonstrating the ways that energy efficiency improvements can help customers meet their business goals is key to motivating them to pursue efficiency upgrades. Providing simple, packaged tools to assist in the evaluation of properties and opportunities for energy savings and improved financial performance encourages greater participation. Developing strong relationships with industry leaders can encourage wider adoption of the program among industry peers.

Schools

Target: Energy-efficient design and construction of new schools and major additions/renovations and energy efficiency improvements in existing schools

Who Is Doing What: Schools have been the subject of a flurry of recent market transformation planning and activity as a frenzy of new school construction and renovation has started in many areas of the country. This activity stems from growing enrollments, the poor condition of many school facilities, and increasing recognition of the impact that the school environment has on student and teacher health and performance. At the national level, the EPA ENERGY STAR Schools Program offers tools and resources to help schools evaluate their energy performance, identify the best opportunities and strategies for improvement, and find qualified service providers and financial resources to complete energy efficiency projects. Buildings with energy performance in the top 25% for their region qualify for the ENERGY STAR label.

Working with a network of architects, contractors, energy service companies, financial institutions, and nonprofit organizations, DOE's Energy Smart Schools program provides training, design guidelines, technical assistance, and financing to reduce school energy consumption. The program also helps schools reinvest savings from energy improvements, enhance the learning environment, and raise awareness of energy and energy-related issues throughout school communities.

At the local and regional level, a number of program approaches are being tested. In California, the Collaborative for High Performance Schools (CHPS) works to facilitate the design of high-performance schools by marketing information, services, and incentive programs directly to school districts and designers. CHPS is also working on a school

certification program, a best practices manual, and a number of demonstration school buildings. Programs in Massachusetts, New York, and Wisconsin (sponsored by National Grid, NYSERDA, and the Wisconsin Focus on Energy program, respectively), work to help school districts improve the energy performance of both new and existing schools through education, technical assistance, and in Massachusetts and New York, incentives. Another approach is the Resource Conservation Manager (RCM), a school district staffer that works with key school facilities personnel to identify and implement energy-saving measures throughout the district's buildings. The program sponsor, typically a utility or state agency, puts up the initial seed funding to get the program started; within two years the RCM program is typically self-sustaining with energy savings covering all project costs. RCM programs have been established in California, Idaho, Massachusetts, New York, North Carolina, Ohio, Oregon, Pennsylvania, Texas, and Washington (Thorne 2000).

A database of school efficiency case studies, including schools covered by these programs, has been compiled by CEE (CEE 2003h).

Overall Level of Effort: High

Accomplishments: A tremendous amount of energy has been directed toward capturing the energy savings potential in schools available during the current boom in school construction and renovation. Only a small portion of the efforts underway are described here. For the programs that are included, results to date reveal notable accomplishments. More than 350 schools have qualified for the ENERGY STAR schools label, while many hundreds more have been benchmarked using the program's web-based tool (EPA 2003j). The Energy Smart Schools program is working with thousands of schools through its partnerships with more than 100 schools districts and DOE's 500 Rebuild America partnerships (DOE 2003a). An early assessment of RCM programs demonstrates average energy savings of 10 to 20%—more than enough to cover program costs, thereby generating additional funds to meet other school needs. Efforts in Wisconsin have assisted more than 100 schools in achieving energy savings averaging 15%. In New York, more than 80 schools have received comprehensive energy audits and 35 school districts have received incentives for energy improvements (NYSERDA 2002). National Grid's efforts in Massachusetts have assisted 28 new schools and 40 existing schools. New schools save roughly 15% of their projected energy use; existing schools reduce their consumption over 20% on average (York and Kushler 2003). In California, the CHPS program has held training workshops that were attended by more than 900 architects, engineers, project managers, and school administrators. Approximately 100 schools have been CHPS certified with an additional 80 schools in the design phase that are expected to be certified. Schools around the country have expressed interest in CHPS national best practices manual (York and Kushler 2003).

Rating on Progress Towards MT: 3 (substantial progress). Schools have become the target of market transformation efforts around the country, engaging many players from the diverse range of stakeholders active in the schools market.

Lessons Learned: Strategic partnerships and alliances are absolutely critical to program success in the schools market. The diverse and extensive range of stakeholders influencing

facilities decisions in schools requires program operators to take the time and effort to reach out to all interested parties, address varied needs, and develop a forum for all to share their concerns. CHPS attributes much of its initial success to effective communication of a central message (improved student performance) that resonates with all of the relevant audiences. Ongoing research and data that demonstrate the links between the school environment and student performance will serve to strengthen the message. Best practices and guidelines are also important tools for providing overall guidance on school design while allowing flexibility for the differences in school size, construction budgets, timelines, and other factors. Information is also an important aspect of these programs. School administrators need information to understand the many benefits of better energy performance and to see that better schools are attainable regardless of scheduling and budget restraints. Architects and engineers need the tools and expertise to help them improve their school designs and to bolster confidence in new approaches. Finally, energy efficiency is a much easier target for new construction. For existing schools, the use of incentives and dedicated resources, such as a RCM, can help existing schools realize energy savings and other benefits.

Commercial Clothes Washers

Target: Residential-style clothes washers used in commercial applications that meet the ENERGY STAR specification and also are water efficient (meet the CEE Tier 1 specification)

Who's Doing What: CEE developed an efficiency specification and market research information for use by its members. As of January 2003, CEE lists 30 programs being offered in the United States, primarily by water utilities (CEE 2003e). The ENERGY STAR program for commercial clothes washers began in 1999, based on extending the residential specification to commercial applications. Appliance manufacturers have been marketing complying units for several years, based primarily on lower operating costs but also highlighting improved cleaning performance. Programs to date have been fairly limited in scale, although a statewide program in California recently began. This California program is called "LightWash" and targets owners and managers of multifamily housing properties and "route operators" (who provide and service machines). The program includes outreach to and educational information for the target audiences as well as incentives for efficient washers ranging from $175–450 (varying by water utility) (LightWash 2003).

Overall Level of Effort: Low

Accomplishments: Most of the programs being offered have only limited promotion and low participation rates, although some of the California water utilities have provided rebates for several thousand machines. However, leading manufacturers have been heavily marketing efficient products and one major manufacturer reports that ENERGY STAR machines account for about one-third of its sales of residential-style machines in the commercial market. California has recently adopted a minimum-efficiency standard for these machines that will essentially mandate ENERGY STAR levels of performance as of 2007 plus also require efficient use of water. Other states are considering similar standards.

Rating on Progress Towards MT: 4 (transformation likely). The California standards, plus standards that are likely to be adopted in several other states, will complete the transformation process for energy-efficient machines.

Lessons Learned: For programs to be successful, they need to be actively promoted. Without promotion, participation rates are likely to be low. On the other hand, active manufacturer promotion efforts can achieve significant gains, particularly in situations like this one where the more efficient machines provide very substantial savings in operating costs. Adoption of minimum-efficiency standards can accelerate and complete the market transformation process.

Traffic Signals

Target: LED traffic signals including red and green signals and pedestrian signals

Who's Doing What: Traffic signals have been the focus of significant market transformation activity over the past five years. At the national level, an ENERGY STAR specification for traffic signals establishes efficiency criteria that can only be met with LED technology at this time. The ENERGY STAR specification has been adopted by CEE's Energy-Efficient Traffic Signal Initiative and its 31 participants and is being promoted to CEE members across the country (CEE 2003g). Initiatives to promote LED traffic signals have been particularly strong in California, Massachusetts, New York, and Oregon, but many other jurisdictions have undertaken retrofit activity. Market transformation activities include outreach to state and local transportation officials responsible for traffic signal purchasing and installation, development of calculators and other tools to demonstrate energy and maintenance cost savings, procurement and bulk purchasing arrangements, and grant and loan programs for LED signal installations.

Overall Level of Effort: High

Accomplishments: The rapid adoption of LED traffic signals since 1997 is astonishing. In California, programs operated by CEC and the state's three investor-owned utilities (PG&E, SCE, & SDG&E) led to signal change-outs in more than 30% of the state's intersections in 2000 and 2001. As of March 2002, virtually all of the traffic signals in SDG&E's territory had been retrofitted to LEDs (York and Kushler 2003). Oregon's program, which offered rebates for green LEDs only, converted more than 30% of the state's known green incandescent signals to LEDs in seven months. The rebates for green LEDs also encouraged the adoption of red LEDs by those systems that had not yet upgraded their red signals (York and Kushler 2003). In New York, lower prices negotiated by the state are available to small municipalities with a limited number of intersections, allowing broader participation and retrofits. New York City is in the final stages of a project to replace all of the red, green, and pedestrian signals in the five boroughs—a total of 11,090 intersections (Borock 2001). The increased demand has led to steep drops in signal prices (e.g., 30% decline in the past two years; more than 60% over the past five years) and increased product availability throughout the country. It is no longer uncommon to see LED traffic signals in many parts of the country without active market transformation or other energy efficiency programs. The state of

California has adopted minimum-efficiency standards for traffic signals effective March 1, 2003. The federal energy bill under consideration in the 2002 Congress included provisions to set national minimum-efficiency standards for traffic signals.

Rating on Progress Towards MT: 4 (transformation likely). Red and green LED lights are increasingly common. Standards will complete the transformation process.

Lessons Learned: The non-energy benefits of LED traffic signals (e.g., primarily maintenance savings but also improved safety, lower liability costs, and simplified inventory control) may outweigh the energy cost savings and may be of greater importance to the decision-makers that specify and install traffic signals. Outreach efforts should focus on both energy and non-energy benefits. Statewide procurement agreements or bulk purchases from several local governments can ensure product availability and expedite purchases by eliminating the need for competitive bidding and enabling smaller towns to take advantage of the greater purchasing power and administrative resources of larger agencies.

Cool Roofs

Target: Highly reflective and emissive roof coatings and materials ("cool roofs") primarily for commercial and institutional buildings

Who's Doing What: Research from Lawrence Berkeley Lab's Heat Island Group and the Florida Solar Energy Center has demonstrated the potential of cool roofs to reduce building energy consumption and reduce the heat island effect in urban areas. This research has spurred the development of several market transformation initiatives aimed at increasing the use of cool roofs in new and existing buildings. In 1999, EPA launched the ENERGY STAR Roof Products program. The program establishes performance criteria for minimum initial solar reflectance of roofing materials. The ENERGY STAR list is used to identify qualified products for each of the programs discussed here (EPA 2003k). Several cool roofs programs are operating in California—only the limited areas in the state with heating load-dominant climates are excluded. CEC, working with Sacramento Tree Foundation and the San Diego Regional Energy Office, is distributing incentives for the installation of cool roofs on nonresidential and multifamily buildings with electrically powered, compressor-based air conditioning systems (CEC 2003). SMUD's Cool Roof Program pays incentives for the installation of cool roofs directly to roofing contractors with the understanding that these incentives will be passed on to consumers through lower project costs. The program relies on contractors to educate consumers and distribute marketing and promotional materials directly to them. The program also maintains a list of participating contractors (SMUD 2003b). Through its third-party initiative, PG&E provided incentives to contractors to install cool roofs in the city of San Jose. Customer education is the goal of Southern California Edison's Customer Technology Center (CTAC), which offers classes on cool roof technologies and their benefits. At the national level, the Cool Roof Rating Council has been established to develop standard ratings for cool roof performance.

Overall Level of Effort: Low (effort limited to ENERGY STAR and California)

Accomplishments: Since its inception in 1999, the ENERGY STAR program has attracted 143 manufacturer partners offering more than 400 qualified roofing products. Between the beginning of 2001 and May 2003, CEC will distribute incentives totaling $21 million for cool roof installations. At $0.20 per square foot, this translates to as much as 100 million square feet of cool roof. As of August 2002, the program had already committed funding for projects totaling 44 million square feet. SMUD's Cool Roof program paid incentives for 195 projects in 2001–2002 and boasted 33 participating contractors in 2002. PG&E funding supported installation of cool roofing materials on 1.8 million square feet of roof space in San Jose. California's Title 24 building code now gives energy performance credits to buildings with cool roofs.

Rating on Progress Towards MT: 2 (some progress). Given relatively new commercialization of the technology on a broad scale, ENERGY STAR has captured lots of manufacturer interest and contractors in California have been very responsive to programs.

Lessons Learned: It is important to sell both energy and non-energy benefits, particularly for a technology that does not have an obvious function. Since the technology is relatively new and customer interest and demand is low, it makes sense to have roofing contractors market the program directly to customers. This reduces overall program administrative costs and encourages contractors to develop a strong, sustainable program for selling the technology to customers.

Dry-Type Transformers

Target: High-efficiency dry-type transformers, most commonly defined as meeting the National Electrical Manufacturers Association (NEMA) TP-1 performance level (dry-type transformers are 3-phase low-voltage transformers, primarily used inside buildings)

Who's Doing What: Most efforts to date have focused on the NEMA TP-1 standard (1996). For 3-phase, low-voltage, dry transformers, this requires efficiencies rising from 97% (15 kVA) to 98.9% (1,000 kVA). TP-1 does not exhaust the potential for efficiency, but is the highest level at which there are reasonable amounts of product available. ENERGY STAR, FEMP (for federal purchasing), and CEE (coordinated utility incentive programs) all have recommendations at this level. New York State sponsored a market transformation program to promote more widespread use of these products. This program ended as TP-1 performance was adopted in the New York Energy Code. TP-1 has been made the state standard or brought into the state building code in Massachusetts, Minnesota, Oregon, and California, and is under consideration elsewhere.

Overall Level of Effort: Low (just a few states active)

Accomplishments: Overall, sales of TP-1 low-voltage dry-type transformers have been modest. According to data compiled by NEMA, less than 2% of units sold in 2001 met TP-1 (NEMA 2003). However, this share is likely to increase as several state transformer efficiency requirements went into effect in 2002. Efforts to increase sales of TP-1 units have been on two parallel tracks: incentives and standards/building codes. New York State

attempted a large-scale program of incentives and outreach to the distribution channel and specifiers. Program offerings included a tailored life-cycle cost calculator, promotional and explanatory services, and "circuit riders" who did presentations to target audiences. Although there was an extensive effort to document changes in awareness and penetration of TP-1 at the conclusion of the New York program, too few responses were received to be confident that the program had made a difference in the market (Sachs and Smith 2003). On the other hand, it had increased awareness among policy-makers, leading to adoption of the requirement in the code.

Codes and standards have also been adopted in other states as noted above, although the low market share reported by NEMA implies that these codes and standards may not be fully enforced as states with codes and standards account for much more than 2% of the U.S. population. In 2002, both the U.S. House and Senate adopted legislation containing a national minimum-efficiency requirement at the TP-1 level. This did not pass due to controversies on other parts of the legislation but passage is likely in 2003.

Rating on Progress Towards MT: 4 (transformation likely, primarily due to the new federal efficiency standard)

Lessons Learned: In general, market transformation for distribution transformers has been very hard work, because the transformers are generally not purchased separately, but as parts of an electrical equipment package whose bidding structure promotes intense price (first cost) pressure on vendors. Because the trade association, NEMA, generally supports TP-1 requirements, it is more likely that TP-1 will gain market share with state building code requirements and federal standards.

Industrial

Premium-Efficiency Motors

Target: To increase the *NEMA Premium*™ share of new motor purchases

Who's Doing What: CEE has been coordinating premium-efficiency motor programs among its members since 1996. A forthcoming survey of premium-efficiency, motor incentive programs run by its members identifies approximately 30 initiatives. Of those, approximately 17 offer prescriptive rebates to end-users, dealers, and/or vendors. While the CEE study focused on programs with financial and technical incentives, it also notes anecdotal information regarding the existence of programs that offer strictly educational assistance. Premium-efficiency motor programs are often included within general energy efficiency programs. Therefore it is difficult to quantify specific results as information on motors is not tracked separately (Mason 2003).

Overall Level of Effort: High

Accomplishments: The most important accomplishment in recent years has been the issuance of the *NEMA Premium*™ specification for motors and its adoption by CEE for use in

member premium-efficiency motors programs. In 1996, CEE brought national consistency to many of the programs with its premium-efficiency specification (Nadel et al. 2002). However, this specification required that both the customer and the program verify that the nameplate efficiency of each motor met program criteria. With the establishment of a national labeling specification, both program administration and increasing customer awareness are greatly simplified.

Actual impact on the market has varied by program with the greatest impact happening in the Northeast where the MotorUp and NYSERDA programs have achieved approximately 30% market share for premium motors, as compared to a national average of about 10%. In other regions with active programs, the share has been in the 16 to 20% range (XENERGY 2001). However, as a result of the economic slowdown, motor manufacturers report that total motor sales have declined in the past year. In addition to a total sales decline, the share of these sales accounted for by *NEMA Premium*™ motors has also declined nationally. However, the premium share has remained essentially constant in those markets where premium-efficiency motor programs are operating (CEE 2002c).

Rating on Progress Towards MT: 3 (substantial progress). Significant growth in market share in regions with active promotions

Lessons Learned: We have learned that transaction costs associated with identifying premium products can represent a barrier to increased market share. The savings from picking *the* most efficient product were offset by the additional customer cost and reduced participation. With a shift to the easily identified *NEMA Premium*™ label, this barrier has been addressed. While some variation in efficiency does continue to exist within qualifying products, these are small compared to the difference between the installed base and the premium product (Nadel et al. 2002).

A second lesson is that program persistence leads to success. Efficient motor programs have now run continuously in the Northeast for over 15 years, and these programs have clearly had an impact on these markets—achieving the highest market share of *NEMA Premium*™ motors in the country. However, we are unlikely to shift the entire motor market to premium products. EPAct motors are already very efficient, and premium products are only cost-effective in applications with high hours of operation, so a majority of the market will in all likelihood remain with the less efficient product (Nadel et al. 2002).

Motor Management

Target: Dual goals of promoting management practices that shift installed motor population toward greater efficiency, and encouraging senior company management to implement motor management plans including such practices as preventative maintenance and evaluating the economics of replacing motors before repairing them

Who's Doing What: Eight years of discussions between energy efficiency programs led by CEE, motor manufacturers led by NEMA, and the motor service industry represented by the Electric Apparatus Service Association (EASA) led to the formation of *Motor Decisions*

Matter™ (MDM) in 2001. This national initiative sponsored by 26 organization involves a national awareness campaign, educational website, and materials that can be used by sponsors in their own marketing or program delivery efforts (MDM 2003).

Overall Level of Effort: Medium

Accomplishments: The greatest accomplishment of MDM has been to bring the energy efficiency community together with the motor manufactures and motor service companies. MDM has also proven an important platform to support adoption of *NEMA Premium*™ motors. The NEMA program also participates in MDM at both the regional and national levels.

The MDM initiative has achieved some success in raising awareness, both through trade articles and presentations, as well through the popular press (e.g., an Associated Press story that was picked up by more than 50 newspapers, and a recent Forbes Online article). As a result of this publicity, the website has garnered significant traffic and received good reviews.

Clear, quantifiable results of the MDM program would be shown in increased sales of premium-efficiency motors. Unfortunately, no solid pattern of sales increases has occurred. This lack of market impact, however, may be the result of a slowdown in overall motor sales due to the current economic situation (discussed above under Premium-Efficiency Motors). A positive indicator regarding the success of the program is that although the national market share of premium-efficiency motors is decreasing, the market share in regions where MDM is in place remains unchanged (MDM 2003). The one motor management program for which there is evaluation is the *Drive Power Initiative* operated by the Northwest Energy Efficiency Alliance. This program predates the MDM initiative but was able to influence over half of participating customers to change their motor management policies, though the evaluation was not able to identify quantifiable market effects (PEA 2001)

Rating on Progress Towards MT: 2 (some progress). Early results encouraging, but too soon to say

Lessons Learned: One of the challenges faced by those promoting efficient motors has been crafting a consistent, clear, and concise message. MDM has attempted to overcome this problem by creating a message that motor decisions should be planned in advance, based on what makes the best economic sense for the customer on a lifecycle-basis. Having both a national label and a national message offers advantages to regional programs, as there is less market confusion among companies that operate in several service territories. Also, the presence of a national program has made it easier for manufacturers and motor service companies to support regional programs by embracing the national initiative**.**

The challenges faced by MDM programs should not be underestimated. External market effects, such as the current economic slowdown, compete for attention. These factors may also mask actual results, so longer-term evaluation is needed to ascertain the true impact of the efforts. Several studies have indicated that market transformation efforts in industry need

to persist for three to five years to show meaningful results (Elliott, Pye, and Nadel 1996; Megdal et al. 2002).

Compressed Air System Improvements

Target: Improvements to compressed air systems in industrial plants including both capital (e.g., new compressors or new controls) and operational measures (e.g., leak detection or reducing excess pressure and airflow); such improvements can reduce compressed air system energy use by 30% or more (Nadel et al. 2002).

Who's Doing What: DOE facilitated the formation of the Compressed Air Challenge (CAC) initiative, working with a variety of partners including utilities, states, and compressed air manufacturers, distributors, and service providers. CAC has developed a variety of tools to help compressed air service providers to offer improved energy-saving services and to encourage end-users to make some improvements in their facilities. These tools include seminars (Fundamentals and Advanced), a Guideline for Selecting a Compressed Air System Service Provider, market definitions for three levels of system analysis, and a best practices manual. CAC also partnered with DOE to offer Qualified AIRMaster+ Specialist training designed to recognize compressed air system professionals with a demonstrated skill in applying AIRMaster+ software in system assessments. Some utilities and other energy efficiency program operators have also developed technical assistance and incentive programs to encourage their customers to implement compressed air improvements. For example, many of the New England utilities offer technical assistance and rebates for compressed air projects. PG&E with its Compressed Air Market Transformation Program (CAMP), is taking a more comprehensive approach. CAMP includes standardized tools for compressed air testing, training for trade professionals and end-users, and development of case studies and other marketing materials. These components are designed to build the supply of professionals who can provide compressed air services, and to increase end-user interest in purchasing these services. A similar program is being started by NYSERDA. The NW Alliance has a program called Sav-Air, which encourages systems analysis, installation of system improvements, and installation of remote monitoring and control systems to monitor systems over time in order to catch problems as they develop (Nadel et al. 2002).

Overall Level of Effort: Medium

Accomplishments: An evaluation of the CAC program found that it has trained more than 3,000 individuals representing approximately 1,450 separate businesses, including more than 500 individuals who play an active role in disseminating information about energy efficiency to end-users and equipment vendors. A survey of end-user participants found that 76% report making significant capital and/or operating improvements to their compressed air system since attending the CAC training. A review of measures implemented estimated that for those customers who implement improvements, savings have averaged 7.5% of compressed air system energy use, saving 149,000 kWh per year on average, with a value of $7,428. In addition, the majority of facilities that implemented measures report significant non-energy benefits as well, such as reduced downtime, more constant pressure in the system, etc. A review of 19 specific comprehensive projects found non-energy benefits of $55,000 or more.

A survey of compressed air system service providers who attended training found that 52% reported that their companies have begun to offer new efficiency services such as analyses of system efficiency, measurements of system flow/pressure and energy use, and/or ultrasonic leak detection (DOE 2003b).

The NW Alliance program is proceeding slowly but steadily; after 2.5 years of operation, the program has undertaken system optimization at four sites (relative to a goal of six demonstration sites). Among the four sites, energy savings of 31–56% (average of 42%) have been achieved. Ongoing system monitoring has yet to begin (PEA 2002). The PG&E and NYSERDA programs are just getting going and it is too early to report results.

More broadly, compressed air market programs appear to have come at a critical juncture in the compressed air industry, and program efforts have given a critical "nudge" to industry players to change their overall business approach to one that emphasizes service delivery instead of just equipment sales. Key industry players were realizing the limits of the old business model, and program efforts came at the right time to help the industry move in a direction favorable to energy efficiency.

Rating on Progress Towards MT: 3 (substantial progress). Many end-users are more aware of compressed air system inefficiencies and many manufacturers and service providers are expanding their energy-saving services.

Lessons Learned: A key to the success of the CAC program was that program planners met with all of the key industry players (e.g., compressor manufacturers, distributors, compressed air system consultants, and major end-users) in order to understand the market and the interests of the market players. Through this process, they recognized that the industry was at a "tipping point," and developed a strategy that helped to push the industry in the desired direction. Independent compressed air consultants were key players in this effort, as they provided key market intelligence and had credibility with major end-users. A leading manufacturer broke with the other manufacturers to move in this new direction, which ultimately pushed the other manufacturers to go along. At the end-user level, programs have developed interest by educating end-users on how much they are paying for compressed air services, and the opportunity for large, cost-effective savings. End-user outreach has also taken advantage of the fact that many end-users were dissatisfied with the service provided by their existing compressed air systems, and are open to suggestions to improve these services.

SUMMARY

Overall, the 28 initiatives have varied in level of effort and success in transforming markets. Table 1 summarizes our assessment of the overall level of effort and progress towards market transformation for each initiative. In compiling these, we used a three-level rating scheme for level of effort (low, medium, and high) and a five-level rating scheme for progress towards market transformation (where 1 = little progress, 2 = some progress, 3 = substantial progress, 4 = transformation likely, and 5 = largely transformed). Of the 28 initiatives, 10 had a high

level of effort, 11 = medium, and 7 = low. On progress towards market transformation, the breakdown is as follows:

- Two are rated as "largely transformed" (residential clothes washers and commercial exit signs);
- Seven and one-half are rated as "transformation likely" (condensing furnaces in cold climates, residential central air conditioners and heat pumps, residential appliances, commercial packaged air conditioners, commercial clothes washers, building operator training and certification, dry-type transformers, and traffic signals);
- Ten are rated as "substantial progress" (residential windows, residential new construction, compact fluorescent lamps and fixtures, home electronics, packaged commercial refrigeration, commercial new construction, real estate, schools, premium-efficiency motors, and compressed air systems);
- Seven and one-half are rated as "some progress" (furnace fan motors, central air conditioner installation and maintenance practices, residential duct sealing, ground source heat pumps, cool roofs, retrocommissioning, commercial lighting design, and motor management practices); and
- One is rated as "little progress" (heat pump water heaters).

LESSONS LEARNED

In general, the measures that have made significant progress over the past five or so years share one or more of the following attributes.

- The measures have low incremental cost (e.g., home electronics and dishwashers).
- The measures have rapid paybacks (e.g., LED exit signs and traffic lights, and CFLs).
- The measures have substantial other benefits besides energy savings (e.g., LED exit signs and traffic lights have long lives, efficient clothes washers provide improved cleaning performance, and efficient new homes can be more comfortable).
- The measures generally are improvements in the efficiency of an existing technology, rather than a totally new technology or changes in practices or design methods (i.e., most of the energy-saving practices have a progress rating of 2, with a few at three and only one—BOC—at 4).
- The measures are incorporated into new codes and standards, (e.g., residential and commercial clothes washers, residential and commercial air conditioners, transformers, LED traffic lights and exit signs, and packaged commercial refrigeration equipment).

Furthermore, unsurprisingly, there is a correlation between level of effort and progress towards market transformation, with measures with a high level of effort averaging 3.5 on progress, measures with a medium level of effort averaging 3.1, and measures with a low level of effort averaging 2.6.

A review of the sections above also provides many other examples of what has worked, what has not, and why. Among the lessons that are illustrated by multiple initiatives are the following:

Table 1. Summary of Market Transformation Initiative Level of Effort and Progress

Initiative	Level of Effort	Progress Towards Market Transformation
Residential		
Residential New Construction	Medium	3
Residential Windows	High	3
CFL Bulbs and Fixtures	High	3
Residential Clothes Washers	High	5
Other Residential Appliances	High	4
Home Electronics	Medium	3
Residential Central Air Conditioning Equip	Medium	4
Central A/C Installation & Maintenance Practices	Low	2
Residential Furnaces	Medium	4 (condensing furnaces in cold climates); 2 (fan motors)
Residential Duct Sealing	Low	2
Ground Source Heat Pumps (includes some commercial applications)	Medium	2
Heat Pump Water Heaters	Low	1
Commercial		
Commercial Packaged Air Conditioning Systems	Medium	4
Packaged Commercial Refrigeration	Medium	3
Commercial Lighting Design	Medium	2
Exit Signs	Medium	5
Commercial New Construction	Medium	4
Building Operator Training & Certification	High	4
Retrocommissioning	Low	2
Real Estate	Low	3
Schools	High	3
Commercial Clothes Washers	Low	4
Traffic Signals	High	4
Cool Roofs (includes some residential applications)	Low	2
Dry-Type Transformers	Low	4
Industrial		
Premium Efficiency Motors	High	3
Motor Management	Medium	2
Compressed Air Systems Improvements	Medium	3

- It is important to work with the major players in the market, to enlist their input, participation, and support. For example, equipment manufacturers have been critical players in the compact fluorescent lamp and home electronics efforts, real estate management companies in the real estate initiative, and roofing contractors in efforts to promote cool roofs. In working with these partners, flexibility helps; by responding to their concerns and motivations, greater support can be obtained.
- The target for the initiative needs to be achievable, but it also needs to be aggressive enough to attract the interest of program operators. Examples of such initiatives include those for dry-type transformers, commercial packaged air conditioners, refrigeration systems, and home electronics. If a level is set too high (as CEE did for its initial Tier 2 for packaged commercial air conditioners), there will be little participation and interest. On the other hand, if the target is set too low (as manufacturers of air conditioners,

motors, and vending machines have suggested at various times in the past), the amount of savings is not sufficient to attract the interest of energy efficiency program operators.

- In developing programs, some attention needs to be paid to the efficiency metrics that are used, since manufacturers will tend to focus on the metric to the exclusion of other parameters. Thus, the air conditioning initiatives have succeeded in raising efficiency levels as measured by the metrics, but field performance and performance on other important parameters has lagged.
- Success in the market often happens when efficient products and services can be successfully differentiated in the eyes of purchasers from conventional products and services. Generally, differentiation will depend not just on efficiency, but also on related parameters. The ENERGY STAR Homes program has succeeded by differentiating an ENERGY STAR Home as higher quality and more comfortable than conventional homes. Efficient clothes washers are known for their efficiency and better cleaning ability. BOC certification allows employers to differentiate between operators when hiring. And LED traffic lights and exit signs have lower maintenance costs in addition to their energy savings.
- Promotion (e.g., advertising and educational materials) is a key component of most initiatives. Promotion raises awareness among potential purchasers as well as those who sell equipment and services. Promotion should emphasize the full range of benefits and not just energy savings. Many of the initiatives that have not fared well are impeded by limited consumer awareness and limited promotion efforts (e.g., duct sealing, air conditioner installation and maintenance practices, and motor management). In undertaking promotion activities, the clearer the message, the better. For example, schools programs have done well by focusing on the clear message of student performance.
- Training of service providers and equipment salespersons and installers can also be an important part of a market transformation initiative. Training has been central to the success of the Building Operator Training and Certification program and has contributed to such efforts as those promoting commercial building retrocommissioning and sales of high-efficiency residential clothes washers (where training focused on salespeople and taught them how to better sell premium-priced efficient machines).
- Incentives can be an important part of an initiative, particularly in the initial stages. Incentives attract attention and help address the higher initial costs of many efficient products and services, costs that are often high when a technology or practice is first introduced to the market. For example, incentives were very important ingredients in efforts to promote efficient clothes washers, compact fluorescent lamps, efficient new homes and commercial buildings, high-efficiency air conditioners, condensing furnaces, and duct-sealing. As consumer awareness, local stocking, and salesperson and installer experience improve, costs often come down, permitting incentives to be reduced, and in quite a few cases to be ended entirely (for example, incentives are now rare for efficient exit signs, traffic lights, and residential clothes washers).
- Most of the successful market transformation initiatives are multi-pronged efforts that involve several different market interventions (e.g., training, incentives, and promotion) and multiple organizations, and that evolve over time. For example, without a multi-pronged approach, efforts to improve the efficiency of packaged refrigeration equipment

would probably not have gotten off the ground. And schools programs have benefited from efforts to work with all the major stakeholders.

- While programs may be multi-pronged and complicated from the perspective of program implementers, for program participants, they should be kept simple. Premium-efficiency motors programs were greatly aided by the development and promotion of a single efficiency specification. Efforts to promote efficient lighting design and heat pump water heaters have been constrained by complexity (e.g., difficulty differentiating between efficient and inefficient designs in the former case and the need for two installers in the latter case).
- Ultimately, an initiative can succeed only if the product or service is valuable and works well. Heat pump water heaters have suffered from performance problems, which can "poison" the market and make it difficult to succeed in the future. Broad market transformation initiatives should probably not be undertaken until products are ready (for products in earlier stages of market development, research and demonstration efforts will generally be more suitable).

DISCUSSION AND CONCLUSION

In the past decade, market transformation initiatives have generally made good progress in the United States. Several initiatives have largely transformed markets and most have made substantial progress. But not all market transformation initiatives have succeeded, indicating that the market transformation approach is not a cure-all for all of society's energy efficiency problems.

So far, efforts to promote more efficient equipment have been more successful than efforts to promote more efficient practices. These efforts are much simpler to develop and implement, and also to sell to customers. Efforts to promote efficient equipment should continue, because chances of success are relatively high. But more efficient practices can offer very large opportunities for savings and deserve increased attention. For example, a 2002 ACEEE analysis of 38 possible targets for market transformation initiatives found that about 60% of the available savings come from efficient practices (Nadel 2002b). However, practices are much more complex than equipment/technology replacement. In the case of the Building Operator Training and Certification program, success has been achieved in promoting an efficient practice by identifying a need, making a compelling case to decision-makers that participation would benefit them, and doing a good job with program implementation. Such a model can and should be employed for other practices.

Based on the success of market transformation initiatives in many regions of the United States, we would recommend that other regions and countries seriously consider expanding their use of the market transformation approach to program design. However, funding will be needed to help these programs succeed—including funding for training, promotion, and incentives. Minimum-efficiency standards and building codes have also been very useful for completing the transformation process for many technologies, making the market transformation approach particularly attractive for regions and countries with established procedures for adopting codes and standards. Market transformation initiatives can advance technologies to the point where codes and standards are not controversial. By working in

tandem, voluntary market transformation initiatives and mandatory codes and standards can achieve greater savings than either approach can achieve alone.

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