Promoting Equipment Energy-Efficiency Through Public/Private Cooperation

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Market compression analysis fully exploits the near-term potential for increasing energy-efficiency levels and estimating energy savings from market-influencing mechanisms. The purpose of market compression analysis is identification of high-performance equipment currently in the marketplace that is readily available, but may not be purchased. This technique can be used to identify appropriate energy-efficiency levels for many types of energy-consuming equipment through analysis of populations of models available for sale. These energy-efficiency levels can be incorporated into utility demand side management and public incentive programs, public procurement activities, regulatory functions, and consumer education. This paper describes a major application of this analytical method in demand side management planning and program support.

New York State's Appliance Directories Project was the first public/private cooperative venture in the U.S. voluntarily linking several major investor-owned electric utilities with a government agency for the purpose of establishing consensus energy-efficiency levels for equipment as thresholds for utility incentive programs. Market compression analysis is the primary method used to identify energy-efficiency levels that are the basis for reaching consensus. This statewide approach to identifying energy-efficiency levels is appropriate because the energy-efficiency of models currently manufactured and available for sale is not unique to each service territory.

Since its inception in 1991, this Project has identified energy-efficiency levels and compiled directories of qualifying models for the following equipment types: fluorescent lamps and ballasts, compact fluorescent lamps and ballasts, commercial lighting fixtures, motors, residential and commercial central air conditioners and heat pumps, residential refrigerators and freezers, electric chillers, residential room air conditioners, heat-operated cooling equipment, and residential water heaters. These directories assist utility staff, consumers, building contractors, and design professionals in the selection of such equipment, and provide a more uniform basis for manufacturers to identify incentive-qualifying energy-efficient equipment for shipment to the State. This information is also a valuable resource for regulatory work and energy-efficient state procurement.

Introduction

The energy-efficiency of equipment and appliances sold in U.S. markets for residential and commercial applications can be influenced in a number of ways. Some influences occur infrequently and may redefine entire markets.

Some examples of influences that redefine markets include: a major shift in the cost or availability of energy resources (e.g., the impact of the 1970s' fuel costs on heating system efficiency) or a significant technological breakthrough (e.g., electronic ballasts), or targets for efficiency of "next generation" products in codes or standards (e.g., federal refrigerator standards).

Examples of market influencing mechanisms that result in incremental changes include: implementation or the threat of implementation of near-term regulations affecting equipment use or sale; financial incentives to increase the manufacture, distribution, sale, or purchase of energy-efficient equipment or appliances; inclusion of energy-efficiency requirements in purchasing standards, and increasing public awareness and access to information about energy-efficient appliances and equipment.

For these near-term regulations, purchasing standards, financial incentives, and public information programs to be effective, consumers and other decision-makers must be able to identify appropriate levels of equipment energy-efficiency within an existing market. Levels that are too high overreach the market, creating the potential for contested regulations and purchasing standards ,

underutilization of financial incentives, and misleading public information programs. Levels that are too low weaken the potential impact of regulations and purchasing standards, may result in overutilized and inappropriate financial incentives, and are ineffective sources of public information.

Methodology

Overview

For any type of equipment, models are available on the market in a wide range of energy efficiencies, independent of characteristics which affect the serviceability of the equipment. State or federal regulations and standards compress the market by limiting selection of some equipment to those models which meet minimum energy-efficiency requirements. Incentive programs can further compress the market by rewarding the selection of models at levels of energy-efficiency beyond those levels that market forces alone would achieve.

Market compression analysis can be used to identify an energy-efficiency level above the minimum requirements at which a reasonable selection of highly-efficient equipment is available. A low degree of market compression would result in many models which meet or exceed minimum requirements but would also result in low per-unit demand reduction or energy savings. A high degree of market compression would result in few models which meet or exceed minimum requirements but would also result in higher per-unit demand reduction and energy savings. For example, an energy-efficiency level set at a 75% market compression would indicate that only 25% of all available models meet or exceed this level.

Market compression analysis can also be used to estimate program savings when there is a general correlation between models available for sale and models sold. This is true for many types of equipment. For example, of the refrigerator/freezer models for sale listed in the 1993 New York State Energy Office (NYSEO) data base, 64.6% are top-freezer, automatic defrost models and approximately 1% are partial automatic defrost models. According to the Association of Home Appliance Manufacturers, the percentage of models shipped to retailers in 1992 (the most recent data available) was 62.3% for top-freezer, automatic defrost models and 1.7% for partial automatic defrost models[1].

Data regarding the energy-efficiency and performance characteristics of models available for sale is non-proprietary, readily available, and not dependent on expert opinion. In contrast, sales data is highly proprietary and typically is released after considerable delay and in aggregate categories inadequate for the detailed analysis required to identify energy-efficiency levels.

Market compression analysis is innovative in recognizing that the energy-efficiency of models currently manufactured and available for sale is not unique to each region or utility territory, although ready access to such models has historically varied by distributor and geographic area. This technique fully exploits the near-term potential for energy savings from market-influencing mechanisms by concentrating on high-performance equipment that is currently available in the marketplace, but which is not generally purchased.

Other techniques, such as focus groups, review of census data, and customer or dealer surveys, depend on collecting information about current purchasing habits. By concentrating on changing the mix of purchasing habits that already exist, market transformation activities supported entirely by these techniques may underestimate the degree of market change possible. In contrast, market compression analysis recommendations include all models which existing distribution networks could bring to the New York market. For example, highly-efficient split-system residential central air conditioners were actively marketed in the Southwestern states in 1991, but consumers in New York were typically unaware of their existence. Studies of the existing New York purchasing practices for this equipment had resulted in energy-efficiency levels for demand side management programs as low as 10.0 SEER, or 50% of the models available for sale. Using market compression analysis, including written assurances from manufacturers concerning New York-available equipment, consensus was reached regarding a minimum energy-efficiency threshold of 11.0 SEER.

Data Collection

The initial step in conducting market compression analysis is the creation of a database for each type of equipment through collection of energy-efficiency and performance data. For analysis purposes, the data collected must result from standardized test procedures and be representative of the models currently available for sale.

For equipment such as central air conditioners and heat pumps, performance information generated according to standards established by the Air-Conditioning and Refrigeration Institute (ARI) is available in an existing database which is then verified independently by the manufacturers. Performance data for many other types of equipment, such as fluorescent lamps and ballasts, compact fluorescent lamps and ballasts, fluorescent and high intensity discharge lighting fixtures, and electric chillers, while generally derived from standardized tests, are available only from the manufacturers.

NYSEO staff initially prepared for collecting data directly from manufacturers by holding meetings with representatives of each group of manufacturers to explain the purpose of the data collection, to discuss technical aspects of their equipment performance, and to develop a consensus on the kind and format for information requested. These meetings helped build relationships with equipment manufacturers necessary for continuous updating of the databases.

Analysis

Once data collection is completed and a database has been created, the analysis begins with grouping the equipment into categories. Categories are either established directly through analysis to identify correlated groupings or by using existing categories established by the New York State Energy Conservation Construction Code (Energy Code), the National Appliance Energy Conservation Act (NAECA), or industry standards. Decisions made during the segregation of equipment into categories establish the framework for all additional analyses. To describe this process, examples from the analyses conducted in 1992-93 to identify appropriate categories for large fluorescent lighting fixtures are provided.

Many fixture characteristics were initially examined for possible correlation with fixture energy-efficiency, measured as the total luminaire efficiency (TLE). Characteristics that intuitively appeared to be important, such as fixture dimensions or the number of lamps per fixture, failed to demonstrate any significant correlation. Tables 1 and 2 are excerpts from this analysis.

Figure 1 is an illustration of lumen distribution characteristics for fluorescent lighting fixtures. Fixtures are classified as narrow, moderate, or wide depending on the percent of lumen output that occurs within a radius of 40 degrees from the vertical. A significant correlation was found between lumen distribution characteristics and energy efficiency (TLE) for large-cell louver fixtures as illustrated in Figure 2. Fixtures with narrow lumen distribution characteristics tend to be less energy efficient.

Table 1. Large Fluorescent Lighting Fixtures

Fixture Dimensions	Number of Models	Average TLE
1 ft. round	395	0.66
2 ft. round	198	0.74
1 x 2 ft.	117	0.56
2 x 2 ft.	642	0.62
1 x 4 ft.	1282	0.66
2 x 4 ft.	1157	0.64

Table 2. Large Fluorescent Lighting Fixtures

Number of Lamps	Number of Models	Average TLE
1	2337	0.63
2	2023	0.64
3	772	0.63
4	583	0.61

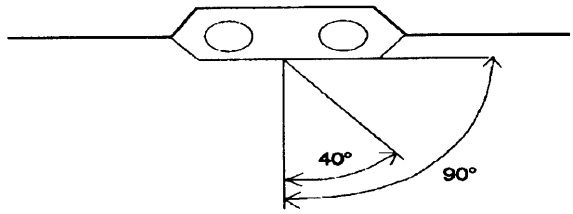

Figure 1. Illustration of Lumen Distribution Characteristics

Figure 3 illustrates a lack of correlation between VDT factor (a measurement of glare) and TLE for this same fixture type.[3] Figure 4 compares VDT factor to the lumen distribution characteristics of large-cell louver fixtures. These fixtures are available in a range of VDT factors independent of lumen distribution characteristics.

After categories have been identified for a type of equipment, a curve is plotted for each category illustrating the distribution of models on energy-efficiency. For categories of equipment not recently subject to regulations, models tend to have a normal distribution of efficiency. This distribution, with most models near the middle of the energy-efficiency range and relatively few models at the high and low ends of the range, is readily seen in graphs of equipment categories with a large population of models.

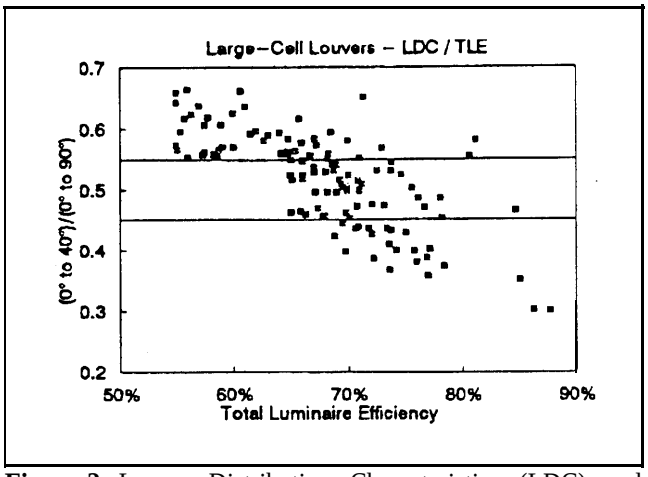

Figure 2. Lumen Distribution Characteristics (LDC) and Energy Efficiency (TLE) Related for Large-Cell Louver Lighting Fixtures

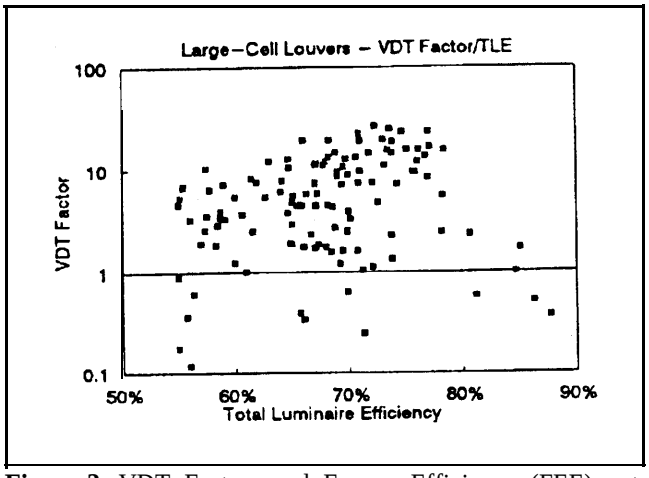

Figure 3. VDT Factors and Energy Efficiency (FEE) not Related for Large-Cell Louver Lighting Fixtures

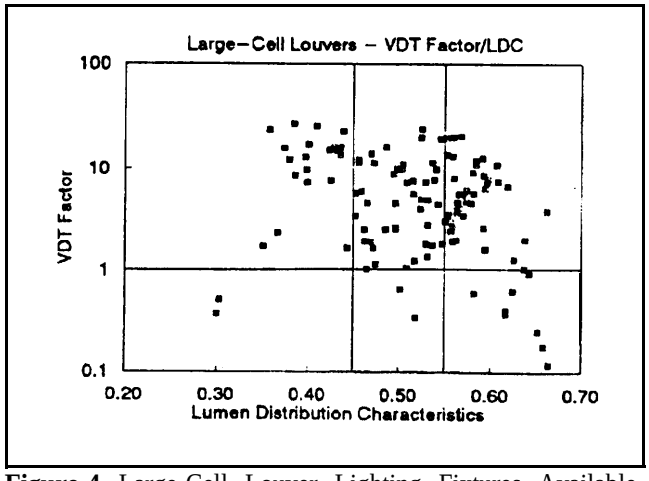

Figure 4. Large-Cell Louver Lighting Fixtures Available in a Range of VDT Factors Independent of Lumen Distribution Characteristics (LDC)

Regulations such as energy codes, which are subject to many legal and political considerations, historically have tended to eliminate the least efficient 30% to 50% of each category of models in an existing market. Effective financial incentive programs are targeted to the most efficient 10-30% of the market. An important consideration of incentive programs is the inclusion of a sufficient selection of models from more than a single manufacturer to permit appropriate applications. For example, selection of an oversized energy-efficient central air conditioner because it is rebate-qualified can defeat program objectives.

Figure 5 depicts the SEER distribution of single-phase, air-cooled, split-system central air conditioners under 65 Btuh shortly after the implementation of new NAECA requirements on January 1, 1992. The steep line of the curve is typical of model distribution immediately following a regulatory change, as many models just meet, or barely exceed, the new requirements.

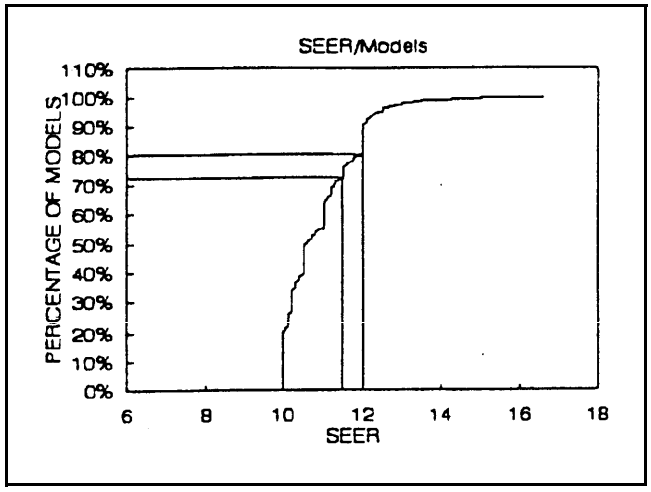

Figure 5. SEER Distribution of Single-Phase, Air-Cooled Air Conditioners[4]

A distribution of models still exists, however, permitting the identification of levels which exceed minimum requirements. The lines on Figure 5 are the energy-efficiency levels identified for the Appliance Directories Project. Two levels were identified. Level 1, 12.0 SEER or approximately 18% of all models, which represented the most stringent energy-efficiency level at which a sufficient selection of models were available to operate a demand side management (DSM) incentive program. Level 2, 11.5 SEER or approximately 25% of all models, which represented a threshold below which a utility was likely to experience a disproportionate number of participants who would have installed the equipment anyway, without an incentive. The consensus threshold reached for this equipment was 11.5 SEER. Figure 6 is a scatter diagram of the same category of equipment.

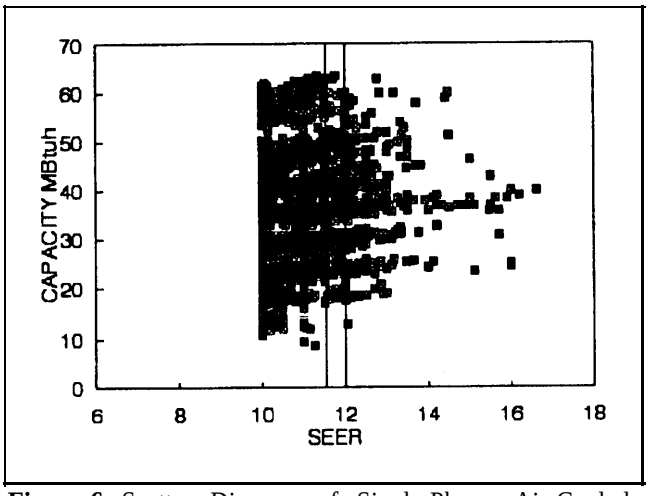

Figure 6. Scatter Diagram of Single-Phase, Air-Cooled, Split-System Central Air Conditioners

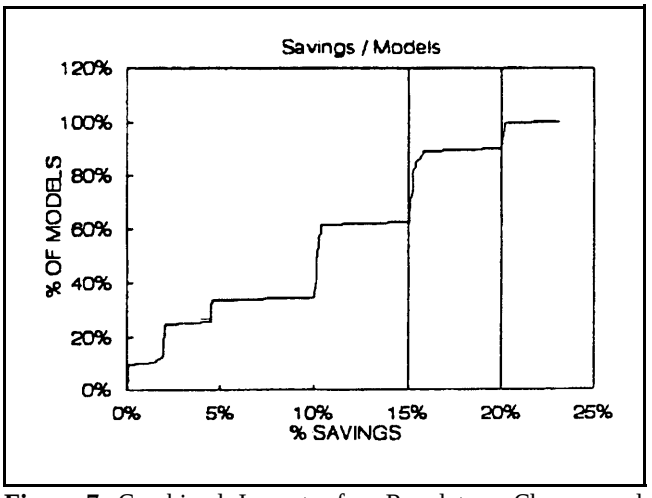

Figure 7. Combined Impact of a Regulatory Change and Financial Incentives[b]

For residential refrigerator/freezers, NAECA energy efficiency requirements are described as a formula based on adjusted volume for models within a category (top freezer, side freezer with ice, etc.). For comparison purposes, the energy efficiency of each model within a category is described in terms of its percent improvement beyond the NAECA requirement. The categories established by NAECA were maintained for analysis purposes.

Figure 7 illustrates the combined impact of a regulatory change and financial incentives for side-by-side refrigerator/freezers with through-the-door ice. Although the 1993 NAECA regulatory change represented a major increase in minimum energy-efficiency requirements for refrigerator/freezers, this distribution curve of percent savings beyond NAECA requirements is not as steep as anticipated. Energy efficiencies range from exactly meeting the NAECA requirement to exceeding it by more than 20%. Further, the distribution has a stepped pattern, with clusters of models at 10%, 15%, and 20% savings beyond NAECA requirements. This pattern most likely resulted from manufacturers targeting model improvements and test report results to meet energy-efficiency requirements for existing financial incentive programs, particularly in California.

The distribution of models permitted the identification of a Level 1 at 20% savings beyond NAECA which still captured 11% of all NAECA-complying models. A less stringent Level 2 was identified at 15% savings beyond NAECA which included 39% of all NAECA-complying models. A consensus threshold of 15% savings beyond NAECA was identified for demand side management purposes. NYSEO elected to use Level 1 (20% savings) as the qualifying threshold for this category of models in its own refrigerator rebate program.

Figure 8 is a scatter diagram of this same category of equipment depicting the NAECA requirements as well as Levels 1 and 2.

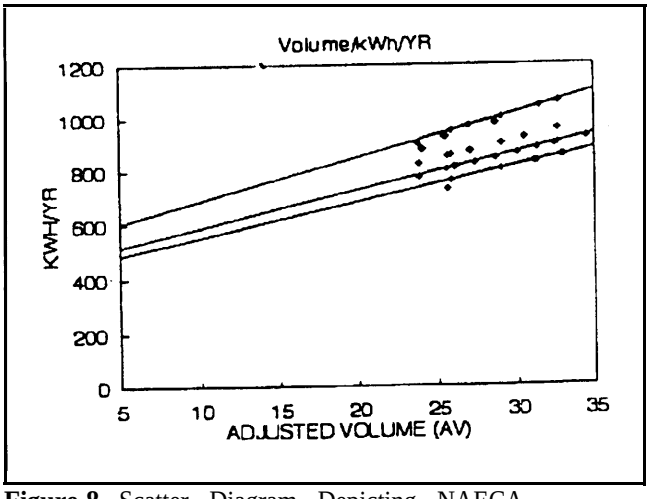

Figure 8. Scatter Diagram Depicting NAECA Requirements'

The degree of potential savings to be achieved by levels imposed immediately following a major regulatory change would not have been apparent without the benefit of this type of analysis. In comparison, the stated goal of the Golden Carrot program, a major competitive grant awarded to develop the "next generation" of refrigerators, is production of models free of chlorofluorocarbons which exceed NAECA by 30% or more. This goal was established before models were redesigned in response to NAECA and financial incentive programs.

Results

The results of market compression analysis is not only useful in identifying energy-efficiency levels that exceed minimum requirements, it is also useful in identifying types of equipment for which an insufficient distribution of energy efficiency exists to permit setting levels. Both types of information have immediate applications for DSM planning and program operations, financial incentive programs (grants, loan subsidies, and rebates) operated by public agencies, regulatory planning, procurement standards, and consumer information programs. Categories of equipment which evidence a particularly limited range of efficiencies are not suitable subjects for incentive programs targeted toward existing models; however, the energy efficiency of such categories may be improved by programs targeted to promote development of more efficient models.

The energy-efficiency levels identified through market compression analysis may be used to generate lists of qualifying equipment. These lists, which must be updated periodically to maintain their effectiveness, may be arranged by energy efficiency or by manufacturer and model number.

Applications

As previously discussed, the analysis uses straightforward statistical methods to present performance characteristics of the population of models for sale. These methods are an appropriate activity for a public agency because they do not depend on proprietary information or expert opinion and are highly transferable.

The results of this type of analysis are focused entirely on the energy-efficiency of equipment; this approach permits evaluation, discussion, and consensus-building among different entities based solely on the availability of energy-efficient equipment. Once such consensus on an energy-efficiency level or levels has been reached, these entities may combine other factors specific to a program, company, or agency with the consensus levels to determine whether a particular application is appropriate.

Demand Side Management Planning and Utility Financial Incentive Programs

Specific attention will be given in this section to the Appliance Directories Project, which commenced in 1991. The purpose of the Project is to produce a series of directories for fifteen different types of residential and commercial equipment. The directories identify models which meet energy-efficiency thresholds established by consensus among seven investor-owned utilities in New York State. This work is directed by an Advisory Committee consisting of a representative from each participating utility company. The purpose of the Advisory Committee is to evaluate the energy-efficiency recommendations made by NYSEO and to reach consensus among all co-sponsors concerning a minimum energy-efficiency threshold. This consensus threshold identifies the lowest energy-efficiency level at which a DSM financial incentive might be considered for a specific type of equipment.

The utilities typically combine the consensus energy-efficiency information with other utility-specific DSM planning parameters, such as economic indicators, peak usage, and customer demographics, to determine the feasibility of a financial program. Financial incentive programs, where determined appropriate, are generally offered at energy-efficiency levels at or above the consensus thresholds. The lists of equipment provided in the directories are used as a reference by staff in identifying models that meet program criteria.

The value of a consensus threshold is that it provides a consistent statewide floor for energy-efficiency by equipment type to which manufacturers can respond through distribution networks. While inclusion on “the list” of qualifying models carries no guarantee that it will be considered a suitable target for DSM incentives by all New York utilities, failure to meet the qualifying criteria for inclusion assures that a model will not be considered. This approach also encourages manufacturer participation in submitting model performance data.

Updates of directories previously prepared include an evaluation of market trends and project updated consensus levels for DSM planning purposes. For example, from 1991 to 1993, the number of 120-volt four-foot, 2-lamp, 40 watt T-12 fluorescent lamp ballasts included in the database increased from 8 to 22 models while the average input watts per model declined by 2.8% The number of models in the database increased by 128% during this period, while the input watts per model declined in 13 out 18 ballast categories, some by as much as 17%.

This process has many advantages including greater potential for market impact as manufacturers are more likely to respond to a statewide approach to encouraging changes in distribution patterns. Utilities benefit from a coordinated approach to analysis and listings in terms of both access to reliable information and economies of scale.

Public Financial Incentive Programs

The results of market compression analyses also have direct application to publicly-funded financial incentive programs, such as rebates, loan subsidies, and matching grants for the purchase of high-efficiency equipment.

NYSEO has successfully used criteria based on these results for programs providing financial assistance to not-for-profit organizations and public schools.[8] To qualify for assistance, applicants select fluorescent lamp ballasts and fluorescent and high intensity discharge lighting fixtures from a qualifying list or demonstrate through submission of test report results that an unlisted model meets the criteria. Discussions are currently underway regarding extending use of these materials in other programs.

Procurement Practices

NYSEO has begun a cooperative program with the New York State Office of General Services (NYSOGS) to use the results of market compression analyses in developing energy-efficient procurement practices. As part of this cooperative process, NYSEO staff, in conjunction with NYSOGS staff, are developing Energy Efficient Procurement Guidelines. These Guidelines are a series of publications that present suggested criteria for specifying a variety energy-efficient equipment. These documents are suitable for use by any organization involved in procurement, whether public or private.

The analyses also provide the technical support for a Department of Energy- funded initiative by NYSEO to develop a national consortium of state procurement and energy officials interested in promoting energy-efficient procurement practices.

Regulatory Activities

Market compression analysis originated from techniques developed by NYSEO staff during analysis of the impact of proposed point-of-sale equipment standards and later during the process of amending the NYS Energy Code. In 1991, these techniques were successfully combined with economic factors in the promulgation of the first component-based performance requirements for commercial lighting fixtures in the U.S.

Similarly, these techniques permit periodic assessment of the impact of existing and planned Energy Code requirements. Analysis results may be used to support NYSEO's position as well as to quickly evaluate additional considerations raised during the public comment period.

Consumer Education

Identifying appropriate levels of energy-efficiency through analysis also is useful for consumer education purposes. Establishing levels that assure a sufficient selection of models provides realistic goals for such programs that maximize potential savings. Increasing consumer demand can effectively alter distribution patterns of equipment only if energy-efficient models are readily available to meet the demand. Databases created for analysis purposes may also be used to produce lists of qualifying equipment to assist consumers in locating such models.

Cost-Effectiveness

Consensus may be reached concerning energy-efficiency levels among participants for whom consensus on cost-effectiveness is difficult or impossible to achieve. The process described in this paper allows for the identification of consensus energy-efficiency levels net of other considerations. These levels are then combined with individual criteria for cost-effectiveness in determining final program criteria. Experience with the Appliance Directories Project and NYSEO programs has demonstrated that such programs are typically offered at or above consensus energy-efficiency levels.

For many equipment types, no correlation has been found between cost and energy-efficiency. For example, the first application of analysis recommendations in NYSOGS procurement led to a contract for fluorescent lamp ballasts at a lower per unit cost ($15.30 in January 1994 versus $16.08 in June 1992) than in earlier contracts with less stringent requirements. If energy-efficiency is not the most important criteria in consumer selection, it is consistent that other market forces such as competition or the desirability of other features would obscure any net increase in production costs due to higher efficiency.

For some equipment types, energy-efficiency carries a cost premium. In these cases the presence of high-efficiency models on the market, in a sufficient selection to support an incentive program, indicates that this equipment is already cost-effective for some consumers. The addition of financial incentives would tend to make it cost-effective for a larger number of consumers.

Energy and Environmental Benefits

The net outcome of market-influencing mechanisms is increased availability of energy-efficient models through distribution networks within the State and improved consumer access to information regarding such models. For the Appliance Directories Project alone, it is estimated that market compression analysis and the resulting consensus thresholds increased the overall DSM energy savings for New York State in 1992 by 5% or 61.7 million kWh. The annual environmental benefit of these DSM savings are estimated as the reduced emission of 290 tons of sulfur dioxide, 110 tons of nitrogen oxides, 44,180 tons of carbon dioxide, 0.6 tons of volatile organic compounds, and 6.2 tons of particulate matter.[9]

Conclusion

Market compression analysis is a highly versatile tool for identifying energy-efficiency levels for regulations, financial incentive programs, purchasing standards, and consumer education programs within existing markets of energy-consuming equipment. It can also be used to estimate energy savings. The results of such analysis are applicable anywhere in the continental U.S. in support of a variety of market transformation activities designed to increase the energy-efficiency of residential and commercial equipment and appliances.

Since such analysis is straightforward and based on information readily available to the public, the results can be used effectively to bridge differing interests in the public and private sector leading to consensus on energy-efficiency levels. Identification of consensus thresholds for energy efficiency within a state or a region creates a common basis to which manufacturers and distributors can more readily respond, greatly increasing the likelihood that near-term market transformation actually will occur.

Acknowledgements

The author greatly appreciates the contributions of Eric Noble, Appliance Directory Project Manager, and the Appliance Directories Team, without whom this paper could not have been written.

Endnotes

1. AHAM Information Center. May 1994. "Refrigerators-Energy Use Tables and Percent of Shipments". Association of Home Appliance Manufacturers, Chicago, Ill.

2. This schematic of a fluorescent fixture illustrates that lumen output measured between O degrees and 40 degrees and between O degrees and 90 degrees from the vertical determines whether the lumen distribution characteristics (LDC) are narrow, moderate, or wide.

3. VDT factor is a multiplier of the maximum brightness at 65 degrees from vertical recommended in the Illuminating Engineering Society Recommended Practice 24 (IES RP-24). A fixture with a VDT factor of 1 or less conforms to RP-24.

4. This is a cumulative distribution of models on efficiency (SEER) of air-source, split-system, single-phase central air conditioners less than 65 MBtuh. There are 26,159 models in this category. Approximately 18% of all models meet or exceed the proposed Level 1 of 12.0 SEER. Approximately 26% of all models meet or exceed the proposed Level 2 of 11.5 SEER, which is also the consensus threshold.

5. This scatter plot of capacity on efficiency illustrates the distribution of models across the capacity range for air-source, split-system, single-phase central air conditioners less than 65 MBtuh and their relationship to Level 1 of 12.0 SEER and Level 2 of 11.5 SEER.

6. This is a cumulative distribution of models on percent savings improvement beyond minimum NAECA requirements for refrigerator/freezers in the side freezer with ice category. There are 123 models in this category, 11% of these models meet or exceed the Level 1, 20% savings. 39% of these models meet or exceed the Level 2, 15% savings. Level 2 is also the consensus threshold.

7. This is a scatter plot of energy usage on adjusted volume for refrigerator/freezers in the side freezer with ice category. The upper line represents the 1993 NAECA maximum annual kWh. The next lower line represents Level 2, 15% savings compared to the NAECA requirement. The lowest line represents Level 1, 20% savings compared to the 1993 NAECA requirement.

8. The Not-for-Profit Energy Incentive Program and the Energy Aid for Public Schools Program.

9. DSM savings based on 1234 GWH annualized savings derived New York State Public Service Commission "Order concerning 1993 and 1994 Demand Side Management Plans and HIECA Business Plans" issued and effective March 19, 1993, attached staff analysis memo, Table 3B, p. 12. Environmental benefits are based on the emissions rates estimated for a 'typical marginal gigawatthour' of electricity generated by a New York State utility. These estimates are based on fuel mix information developed by Department of Public Service staff in the 1992 Long Run Avoided Cost proceeding and on NYSEO estimates of emissions by power plant type.