Consortium for Energy Efficiency

Commercial and Industrial Transformers Initiative

November 20, 2000

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CEE

An Initiative to Transform the Market for Commercial and Industrial Distribution Transformers: INITIATIVE DESCRIPTION AND MARKET ASSESSMENT

I. EXECUTIVE SUMMARY

Most of the electricity that powers the commercial and industrial sectors flows through distribution transformers located on the customer side of electricity meters. These transformers are relatively efficient; most convert in excess of 95 percent of input power to output power. However, because most transformers are energized 24 hours per day, 365 days per year, even small improvements can yield big energy and dollar savings for power users.

Manufacturers know how to make more efficient equipment and the technology to do so is readily available. However, due to a variety of market barriers, end-users have failed to demand even the most cost-effective energy-efficiency improvements for a large segment of the distribution transformer market. Power users fail to demand efficient equipment for multiple reasons:

- market channel participants (distributors, specifying engineers and electrical contractors) and facility owners lack knowledge of the efficiency opportunities;
- the typical purchaser or specifier of the equipment is not the entity ultimately responsible for the electric bill (split incentives);
- widespread perception that the equipment is already energy-efficient;
- information about equipment efficiency is not readily available; and,
- more efficient equipment is not readily available for certain product classes.

A cumulative result of these barriers is that the commercial and industrial distribution transformer market is largely first cost driven. Specifiers and purchasers search for the lowest priced equipment that meets the facility's needs and manufacturers compete by attempting to keep prices as low as possible.

This initiative is a national collaborative effort intended to address these barriers to efficiency in order to bring about a permanent change in the transformer market. The initiative's ultimate goal is a market in which more efficient transformers are produced, specified and purchased. Utilities and other organizations interested in this market transformation will implement the initiative. Moreover, the initiative will work in collaboration with the voluntary programs of the U.S. EPA and U.S. DOE. The initiative will consist of four key components:

- **A voluntary low voltage transformer efficiency performance specification**
- **Guidelines for using cost-of-ownership methods in transformer purchases**
- **Awareness building**
- **Incentives (where possible)**

The Consortium for Energy Efficiency (CEE) is a national, non-profit organization consisting of utilities, government agencies and efficiency groups. CEE's role in this initiative is that of organizer, facilitator and information clearinghouse. To the extent needed, CEE coordinates the development of materials and tools. CEE's partners, including members of CEE and other organizations, implement the initiative. These implementers include electric utilities and state or regional efficiency organizations. Implementers are said to participate in the initiative when they adopt the CEE efficiency performance specification and undertake to carry out the awareness building aspects of the initiative.

Voltage classes	Type	Owners and Use
Medium-voltage distribution transformers (primary voltage between 2.4kV and 35kV)	Liquid-filled and dry-type	Utilities purchase almost exclusively liquid-filled equipment. Commercial and industrial users split their purchases between dry-type and liquid filled equipment. General C&I applications include stepping down utility primary distribution voltage to building voltage for powering feeder circuits and large motors.
Low-voltage (primary voltage under 600 volts)	Dry-type only	Most low voltage equipment is owned by commercial and industrial facilities. General C&I use if for stepping down building voltage (typically 480 V) to lower voltages for powering plug loads and lights.

Table 1. This table provides a breakdown of the distribution transformer market by product type. High-voltage (69 – 765kV) transformers are considered power transformers, not distribution transformers, and thus are not included.

The Market Transformation Opportunity

In general, commercial and industrial distribution transformers are less efficient today than they were twenty years ago. In a highly competitive market driven by first cost, manufacturers have found ways to cut costs that harm efficiency performance. At the same time, the utility industry's use of purchase criteria that take into account operating costs have driven technological developments. Thus far, these technological developments have been applied rarely for commercial and industrial applications. Absent interventions that address the lack of demand for energy efficient transformers, we would expect efficiency performance for commercial and industrial transformers to stay about the same.

National regulatory events have driven manufacturer interest in voluntary programs to increase market penetration of energy efficient transformers. The Federal Energy Policy Act of 1992 directs the Department of Energy to investigate mandatory minimum efficiency standards for distribution transformers. In the fall of 1997, the DOE found that such standards appear to be technically feasible and economically justified and, therefore, initiated the process that could lead to minimum standards. It is estimated that the earliest such standards could be completed would be 2004.

In light of potential standards, manufacturers have taken several steps to move the market to higher efficiencies on a voluntary basis. As an industry, the manufacturers have published a voluntary standard defining energy efficient transformers, NEMA standard TP-1. Some manufacturers have already begun to market "energy-efficient" product lines of low voltage equipment meeting the TP-1 standard.

This initiative seeks to seize this window of opportunity to encourage more manufacturers to produce and actively market energy efficient transformers.

II. INITIATIVE GOALS AND OBJECTIVES

A. Overall Long-Term Market Transformation Goals

This initiative aims to permanently change the commercial and industrial distribution transformer market so that energy-efficient equipment comes to dominate product sales. This market transformation will be achieved when end-users demand energy-efficient transformers and multiple manufacturers offer highly energy efficient products.

The long-term market transformation goal can be achieved by focusing on the following interim objectives:

- Encourage increased product availability for low-voltage equipment as standard, catalog products
- Increase awareness among key market actors (vendors, specifiers, contractors and end-users) of energy-efficient transformers and provide them with tools to make better decisions.
- Improve the information available to vendors, specifiers and end-users on equipment nameplates, in catalogs and through other tools as needed.
- Create a strong near-term demand for energy-efficient transformers.

B. Exit Points

Two paths for eventually reducing the level of market intervention are possible. The first potential exit point would be reached when customers become aware of the benefits of energy-efficient transformers and value those benefits above the incremental cost of the equipment. At that point, market forces may allow most program interventions to cease. However, some ongoing level of third-party labeling and market education will probably be needed to avoid backsliding to a first-cost only market.

A second exit point would be the implementation of minimum efficiency standards by the Federal Government at or above the energy-efficient level. In October 1997, the Department of Energy initiated a rulemaking process that eventually could lead to economically justified minimum efficiency standards. It is unlikely that mandatory standards could be implemented before 2004.

III. INITIATIVE SCOPE

A. Geographic Coverage

The initiative is focused on the North American market for commercial and industrial distribution transformers. As such, the effort will seek participants and partners from throughout the United States, Canada and Mexico.

B. Covered Equipment and Market

This initiative is concerned with low- and medium-voltage, three phase and single phase, open-wound and cast-resin, distribution transformers between 15 kVA and 2.5 MVA. This range covers the most common transformers and the bulk of the market by capacity.[1] Because transformers have no moving parts, equipment tends to last a long time. Distribution transformers generally have a useful life of 14 – 35 years; estimated average life is 30 years (ORNL 1996).

Most equipment goes out of service either at the time of a major remodeling or when a building is torn down. New facility construction, facility expansion or major renovation are the market events most likely to lead to transformer purchases. A significant market for used equipment exists, particularly for larger size equipment.

Low voltage. The low voltage market is comprised entirely of dry-type equipment and purchased by large commercial, industrial, institutional and agricultural customers. About 233,000 units with a capacity of 12,400 MVA are sold annually in this market. Sales are estimated to be growing at 1 – 2.5% annually. A total of 200 – 400 manufacturers produce dry type transformers between 15 and 2500 kVa. However, only about 20 major manufacturers dominate the market producing about 85% of total sales (Barnes 1997). The small manufacturers tend to fill highly specialized niches or have very low total production (ORNL, 1996).

Medium voltage. Both utilities and their commercial and industrial customers purchase medium voltage transformers. Utility purchases make up nearly 97% of the unit sales volume for medium voltage transformers and 80% of the sales volume by capacity. Nevertheless, commercial and industrial concerns are an important market for medium voltage equipment, purchasing 34,000 units per year with a combined capacity of 15,000 MVa. As more facilities elect to purchase power at distribution system voltages, the C&I portion of this market will grow.

While utility purchases are almost exclusively liquid immersed equipment, medium voltage commercial and industrial sales are almost evenly split between dry-type and liquid immersed equipment. In general, utility purchasers reliant on total owning cost methodologies have driven the liquid-immersed market to higher levels of efficiency. As a result, currently available liquid-immersed equipment can reach higher efficiencies at lower equipment cost than comparable dry-type equipment.

Despite the lower first costs and higher efficiencies of liquid-immersed equipment, industrials have generally specified dry-type equipment for indoor and, in some cases, outdoor equipment due to fire and safety concerns. With the availability of improved insulating materials, more users may be willing to consider liquid-immersed equipment for both outdoor and indoor applications.

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[1] Although equipment under 15 kVA comprise a large percentage of sales by unit volume, they comprise less than 5% of sales in terms of distribution transformer capacity and thus represent a small portion of the overall efficiency opportunity. Much of this equipment is sold to OEMs.

Utility transformers. This initiative is concerned with commercial and industrial transformer purchases only. While many utilities use some type of purchasing criteria that takes into account operating costs, some have turned toward low first cost, high loss equipment to cut costs in the face of industry uncertainty. For utilities interested in evaluating their transformer purchases, the U.S. EPA's Energy Star Transformers Program builds partnerships with and offers assistance to utilities for the application of efficient transformers.[2]

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[2] Contact Alison tenCate, Program Manager of the EPA's Energy Star Transformer program at tencate.alison@epamail.epa.gov for information on this program.

Attachments: Appendices A and B.

IV. MARKET ASSESSMENT

A. Market Structure

Figures 1 and 2 summarize the players in the commercial and industrial distribution transformer market. Market events that lead to transformer purchases include facility renovation or expansion, new facility construction, equipment failure and retrofits.

Figure 1. The C&I distribution transformer market
Solid lines represent most common market channel.
Based on (ORNL 1996).

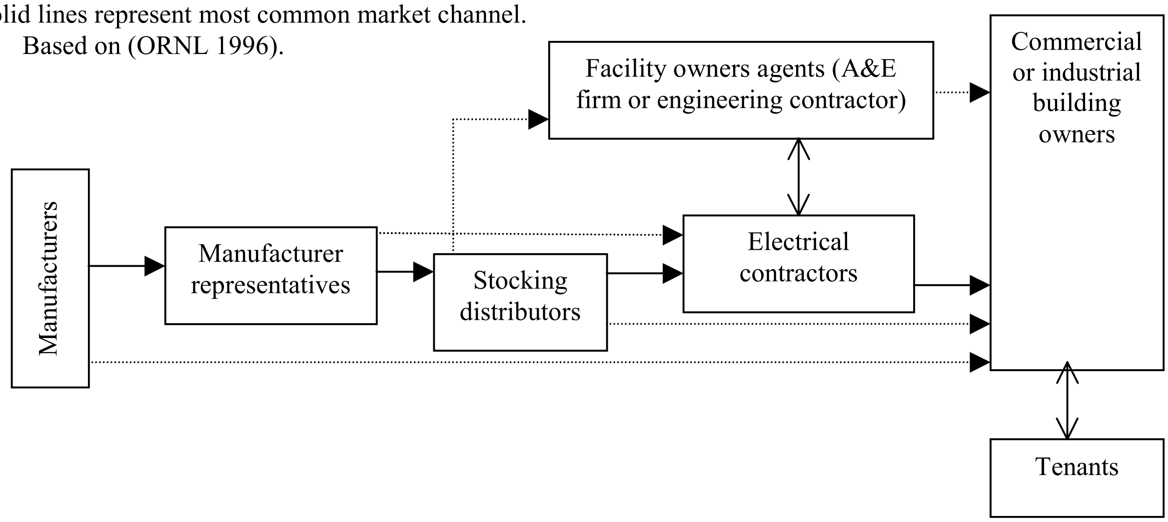

Figure 2. Key market players

Manufacturers: About 20 manufacturers dominate C&I transformer sales. A given manufacturer may make low-voltage and medium-voltage equipment or just one voltage class. Some manufacturers make only liquid immersed or dry-type equipment; many make both.

Manufacturer representatives: These representatives serve as the marketing arm of the manufacturers and may be salaried sales personnel or independent agents. They are a key source of technical information.

Stocking Distributors: Independent electrical equipment sellers that maintain an inventory of low-voltage equipment and often sell used equipment as well.

Electrical contractors: Contractors are responsible for electrical system installation, but have no direct concern regarding energy bills. Electrical contractors purchase transformers from stocking distributors, or, in the case of larger equipment or very large orders, directly from the manufacturer representative. Equipment specifications are determined by the electrical contractor or the end-user's agent and rarely include efficiency. Their incentive is to purchase the least expensive transformer possible.

Facility owners agents: This group consists of architect and engineering firms or engineering contractors selected by the building owner to evaluate design options and specify equipment. They generally provide a specification to the electrical contractor who actually procures the transformers. Currently, they place little emphasis on efficiency.

Commercial and industrial facility owners: Owns the transformer, but is rarely involved in actual purchase transaction. Some large industrials maintain in-house experts who give them the capacity to order equipment directly from manufacturers. Owner-occupants pay the electric bill.

Tenants: Most commercial and some industrial space is tenant occupied. In these instances, transformer losses are paid for by someone other than the equipment owner.

The market for transformers can be broken down between stock and built-to-order equipment (see table 2). Low-voltage transformers at and below 300 kVA are almost always stock items. Over 300 kVA, standard voltage combinations tend to be stock items while less common combinations are built-to-order. All medium-voltage equipment is built-to-order.

	Stock	Built-to-order
Low-voltage <= 300kVA	X	
Low-voltage > 300kVA	X	X
Medium-voltage		X

Table 2

B. Market Status

Currently, efficiency plays next to no role in the commercial and industrial transformer market. Less than 5% of low voltage sales meet the voluntary standard for energy efficiency established by NEMA. This standard, called TP-1, provides a useful definition for low voltage distribution transformer energy efficiency. It serves as a minimum efficiency threshold for this initiative. (See section entitled "Efficiency Specification" for a full description of TP-1.) Despite the small percentage of low-voltage equipment currently meeting TP-1, all NEMA manufacturers approved TP-1 as a voluntary standard. NEMA's approval of the standard implies broad acceptance of these efficiencies as readily achievable. Multiple manufacturers have indicated their readiness to begin or to consider supplying products meeting TP-1 as a regular product line.

In the medium voltage market, few customers outside of the utility industry incorporate energy efficiency into their purchase decisions. However, utility practices and some exceptions in the industrial sector offer a path for broader application of purchase decision methods favoring cost-effective energy efficiency (Haggerty and Malone, 1998).

C. Magnitude of the Efficiency Opportunity

For individual power users, energy-efficient transformers can translate into large savings. Transformer losses account for 2-6% of a typical commercial building's electricity consumption (Howe 1995). Assuming a 15%-25% reduction in distribution transformer losses, the average commercial building could cut .3 – 1.5% off its annual electric bill by choosing more efficient equipment. Facilities that rely on smaller, low-voltage transformers would see savings toward the upper end of this range while those using medium-voltage equipment may be toward the lower end of the savings range. The range for industrial facilities is anticipated to be similar.

Appendix B provides a table showing incremental costs and savings for typical standard efficiency and energy-efficient transformers and annual dollar savings at a range of electricity costs. A standard efficiency dry-type 75kVA three-phase transformer costs between $800 and $1000. A standard efficiency dry-type 1500kVA transformer costs between $15,000 and $17,000

On an economy wide basis, commercial and industrial transformer losses total to about 79 billion kWh per year (ORNL 1997). Energy efficient transformers could cut this total by at least 15%, reducing the total U.S. electric bill by $725 million.[3]

D. Barriers to Improved Efficiency

This initiative's success is contingent on successfully addressing the barriers to efficiency. The strategies and activities of each effort intended to help change the transformer market for greater efficiency should focus on addressing the following barriers:

1. Lack of awareness among key market actors including vendors, A&E firms, contractors and end-users. Since efficiencies often exceed 95%, most market players perceive that transformer losses are negligible.

2. Split incentives - owner/occupants v. electrical contractors: The electrical contractor that purchases or specifies the transformers for a facility lacks any incentive to consider anything other than the lowest first cost transformer.

[3] Based on 1997 sales-weighted average of commercial and industrial rates ($0.0613/kWh).

3. Split incentives - building owners v. tenants: Most commercial and many industrial facilities are leased. Owners lack a strong incentive to specify energy-efficient transformers since they are not responsible for operating expenses. The predominance of owner occupied facilities in the industrial sector means that the third barrier is less likely to be a problem for this sector.

4. Lack of equipment availability: In early 1998, energy-efficient products are not available as off-the-shelf, stock products for the low voltage market, but can be built to order. All equipment for the medium voltage market is built to order, so availability is not a barrier in this portion of the market.

5. Difficult to identify energy-efficient equipment: Efficiency data are not published in catalogs or on the transformer nameplate. Currently, the manufacturer must be contacted to find out the efficiency of a given transformer unless efficiency information was specifically requested as part of a custom order.

V. INITIATIVE STRATEGY AND TOOLS

This initiative's fundamental strategy is to build demand for more efficient transformers. As discussed above, manufacturers appear poised to respond to such demand. For the commodity type, low-voltage market, the strategy revolves around creating a clear definition of efficiency and developing understanding of the value in specifying equipment meeting this definition. Since the medium voltage equipment is provided on a build-to-order basis, greater flexibility in providing cost-effective energy efficient equipment is possible. Therefore, emphasis is placed on education regarding the opportunity and method for cost-of-ownership evaluation.

Regional and local awareness building and education programs are strategy elements for addressing awareness and split incentive barriers. These regional and local efforts can be complemented by incentives used to draw attention and close the incremental cost gap. Finally, awareness building will be easier and specifying efficient product will be simpler if low voltage, energy-efficient products carry a label. EPA has launched such an effort, Energy Star Transformers. Table 3 matches the barriers described above with the strategies that are envisioned to address those barriers and the tools needed to carry out the strategies. Greater detail on each of the strategy elements follows.

A. How to Choose Energy-Efficiency: An Efficiency Specification

Low-voltage. Widespread adoption of a common efficiency specification provides a consistent signal for all market actors. This initiative adopts the low voltage efficiency values of table 4-2 in NEMA standard TP-1 as the CEE efficiency level.

For the low voltage market, promotion of a minimum efficiency specification makes sense for two reasons. First, most customers are unable or unwilling to perform the loss evaluations performed by utilities. Less than 1% of non-utility purchases are subject to such an evaluation (ORNL 1996). Second, for the mass-produced, low-voltage equipment class, manufacturers can produce lines of equipment meeting standard criteria much more cost-effectively than responding to the specific needs of each customer individually. *Efficient low voltage transformers will be less costly in the long term if manufacturers develop mass production capability rather than building energy-efficient transformers to order to meet the specific needs of many different types of customers.*

Medium voltage. A simple specification for medium voltage equipment would be useful for those cases where cost of ownership evaluation is not possible. NEMA standard TP-1 sets different minimum criteria for liquid immersed and dry-type equipment. CEE would like to support the development of a technology neutral standard of the medium voltage market, but declines to support the NEMA standard since most equipment already meets it and it sets criteria based on technological approach (liquid v. dry).

Background on the efficiency specification. The NEMA efficiencies are based on typical operating conditions and economic criteria. NEMA developed the dry-type standard by estimating average loading for and calculating what efficiency level could be achieved within a three-year payback. The standard is based on $.065 cost of power and 35% loading on low-voltage equipment (50% loading on medium-voltage). Manufacturers were surveyed to determine what efficiencies they would provide given these criteria. The standard reflects the results of this survey.

Revisions to CEE efficiency criteria and potential Tier 2 efficiency. During the initial implementation phase of the initiative, CEE and its partners have decided to not establish a tier 2 efficiency level. The current lack of low-voltage equipment meeting even the TP-1 efficiencies and a desire to align CEE's effort with the consensus industry standard motivated this decision. However, CEE may consider a second tier ("super efficiency" or "premium efficiency") in the future. A second tier could provide a consistent benchmark for those programs that wish to promote even more efficient equipment and offer a path for technical improvements. Manufacturers have indicated the technical feasibility of providing efficiencies above TP-1 levels (ORNL 1996, 4-10). Certain implementers may find a second tier particularly useful. These include program implementers that work with customers willing to accept longer paybacks (e.g., government), implementers that are able to offer incentives, and/or those that work in high electric rate areas.

In coordination with the other organizations developing efforts for this market (see below), CEE intends to gather market data to inform a decision about future CEE efficiency specifications. Although very little low-voltage product meets the TP-1 standard, it appears that the medium-voltage market may be significantly more advanced. Therefore, a standard higher than TP-1 may make sense. CEE will work to promote consistent efficiency specifications among all efforts supporting an expanded market for energy-efficient transformers.

B. How to Choose Energy-Efficiency: Cost-of-ownership

A cost-of-ownership analysis offers the surest way to choose equipment that cost-effectively meets users' needs. As the name implies, this method takes a user-specified time interval and compares equipment options based on capital cost plus operating cost over that interval. Although companies often are limited to considering operating savings for the first three years or less, equipment life often exceeding thirty years justifies longer intervals.

Using data on typical load, annual duty hours and the purchaser's cost of electricity as inputs, the cost-of-ownership method calculates a cost per Watt of no-load losses (core losses) and per Watt of load losses (winding losses). The cost per Watt of no-load losses and load losses are termed the A and B factors, respectively. Once these factors have been calculated and competing manufacturers or project bidders have supplied data on no-load and load losses, the user, specifier or contractor can identify the most cost-effective choice. This approach for using the owning cost methodology works when purchasing standardized, off-the-shelf equipment. In general, low voltage equipment below 300kV falls into this category.

Alternatively, commercial and industrial users can approach the market like many utilities do. Instead of accepting product efficiency characteristics as a given, the user provides their A and B factors to potential bidders. Bidders can trade off load losses, no-load losses, and first cost in their designs to offer products that minimize user costs over the selected time interval. This approach to using the cost-of-ownership method is particularly appropriate for the build-to-order market since manufacturers are already responding to a purchaser's specification. As noted, all medium voltage distribution transformers are built-to-order as are the largest low voltage transformers. Large orders of low voltage equipment may be built-to-order as well. NEMA standard TP-1 and draft IEEE standard C57.12.33 provide descriptions of how to apply the cost-of-ownership method for commercial and industrial applications. CEE encourages the use of the cost-of-ownership method as described in these two industry-based standards.

C. Education and Awareness Building

Initiative implementers will undertake to educate key market players regarding the benefits of choosing energy-efficient transformers. Key groups in descending order of likely receptiveness to the efficiency message are:

- Large industrial owner/occupants
- Larger Architectural and Engineering firms and engineering contractors
- Smaller industrial and commercial owner/occupants
- Electrical contractors
- Stocking distributors

Education and awareness building is fundamental to the success of this initiative. However, this component of the initiative will be primarily carried out on a regional and local level. The local participant will determine the appropriate approaches and tools for each region or local area. CEE will serve as a clearinghouse for sharing approaches and tools. As needed, CEE will undertake development of specific tools that can be used by multiple regions.

D. Incentives

Utilities and related organizations have successfully used incentives to draw attention to efficiency and to reduce the initial cost of efficiency measures. Some participants may elect to use incentives. Like awareness building activities, regional and local participants will determine incentive strategies and levels. These participants will also identify who should receive any incentive. One approach would offer incentives to distributors to encourage stocking of efficient equipment. Another approach would be to offer the incentive to the purchaser or the end user to draw their attention to efficiency and to reduce the incremental cost of the efficient model.

Appendix B to this document provides data on incremental costs and savings for dry-type transformers of different sizes as well as liquid immersed, three phase medium voltage transformers. Program implementers can use this information to develop incentive levels.

E. Product Label

For the off-the-shelf portion of the market (low-voltage equipment), a ready mechanism for determining if product is energy-efficient is needed. CEE has coordinated closely with the Energy Star Transformers program. This labeling and education effort for low voltage energy efficient transformers began in spring 1998. Lists of qualifying equipment will be posted at EPA's website, www.epa.gov/energystar.

Market Barrier	Program Strategy	Needed Tools
Lack of awareness	Implement aggressive local and regional education campaigns targeted at a. end-users and b. specifiers. Customer incentives could be an important element of education campaigns where possible. Incentives offer an effective means of drawing customer attention to energy-efficient choices and reducing incremental costs.	1. Educational brochures 2. Software tool for estimating kWh and dollar savings 3. Slide rule or other relatively simple tool for quickly estimating savings 4. Database of qualified products
Split-incentives	Provide information, education and tools to facility owners so that they can more easily specify efficiency. Provide information, education and tools to specifiers so they are able to demonstrate to facility owners why energy-efficient choices make sense.	1. Awareness tools (see above) 2. Model purchase specification demonstrating how to ask for energy-efficient equipment
Equipment availability	Create incentives for manufacturers to provide compliant equipment by addressing demand side barriers and publicizing availability of equipment from specific manufacturers that offer energy efficient equipment.	1. Awareness tools (see above) 2. Database of qualified products 3. Regular initiative newsletter provided to participants to inform them of market developments including product availability and manufacturer promotions
Difficult to identify equipment	Encourage manufacturers to participate in the Energy Star transformers labeling program.	1. Database of qualified products 2. Product label

Table 3: Barriers, strategies and tools

VI. EVALUATION PLAN

A full evaluation plan for the initiative will be developed. It is anticipated that each implementer will develop and carry out a local evaluation to determine local program effectiveness. CEE is committed to supporting local evaluation and will provide coordination for national elements of all local and regional evaluations. Working with its partners, CEE will develop a list of "proximate indicators" which program evaluators may choose to measure to determine progress toward program goals. Examples of proximate indicators include: manufacturer decisions to produce lines of qualifying equipment, distributor stocking patterns, and channel participant and facility owner familiarity with efficiency choices. CEE will track those proximate indicators best monitored from a national perspective while local programs will measure progress against those indicators best measured locally. The overall effectiveness of the initiative will be measured by the combined effect of individual participating programs.

VII. RELATED EFFORTS

Each of the following efforts offers partnership opportunities for CEE and the participants in this initiative.

NEMA: The manufacturers trade association has established a voluntary efficiency standard, TP-1, and is promoting its acceptance. NEMA manufacturers will report sales of TP-1 qualifying equipment to the trade association. NEMA plans an advertising campaign that will include energy-efficient transformers. NEMA member manufacturers represent most of the distribution transformer market.

Manufacturers: As of summer 1998, four manufacturers have indicated their plans to sign on as Energy Star partners and to produce energy efficient low voltage equipment. At least two will offer equipment as standard, catalog product lines.

Utilities: NEES Companies has included transformers in its new construction and retrofit commercial and industrial efficiency programs. Under these programs, NEES has offered incentives to customers that purchase low temperature rise transformers for the past few years. However, the incentives, which are part of a larger program, have not been heavily promoted by the utility field representatives and there has been little participation to date. Other utilities may have also included low temperature rise transformers in multi-measure programs, but none is known to have placed much emphasis on transformers.

Canadian Standards Association: CSA has published a standard that is believed to be less aggressive than the NEMA standard. The CSA standard is structured differently from the NEMA standard, specifying load losses and no-load losses at 100% load. British Columbia and Ontario have adopted this standard as a mandatory minimum. The Canadian government has proposed to make the CSA standard a national mandatory minimum efficiency standard.

U.S. Environmental Protection Agency: EPA has an ongoing program for utility transformers. In the C&I area, EPA has developed a software selection tool for incorporating efficiency into purchase decisions, which could be adopted for CEE member use. EPA is also considering incorporating transformers into its Energy Star buildings program. See www.epa.energystar.gov.

U.S. Department of Energy Motor Challenge: Motor Challenge is interested in supporting voluntary efforts that contribute to overall motor system efficiency. Transformers are an element of the complete motor system which offer an efficiency opportunity roughly equal in magnitude to that of more efficient motors.

Federal Energy Management Program (FEMP): A program operated by the U.S. DOE, FEMP determines purchasing guidelines for Federal procurement. FEMP published its Product Energy Efficiency Recommendation for transformers in the spring of 1998. See www.eren.doe.gov/femp/procurement.

U.S. Department of Energy, Codes and Standards: The U.S. DOE has initiated a rulemaking process for determining minimum standards for distribution transformers. In all likelihood, the earliest a mandatory standard could become effective would be 2004.

VIII. SOURCES

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APPENDIX A
CEE criteria for determining "energy-efficient" transformers

Low voltage reference conditions: 75 degrees C, RMS load of 35% of nameplate
Medium voltage reference conditions: 75 degrees C, RMS load of 50% of nameplate

Single Phase Transformers							Three Phase Transformers						
kVA	Low Voltage			Medium Voltage			kVA	Low Voltage			Medium Voltage		
	baseline eff'cy	"energy-efficient"	reduction in losses	baseline eff'cy	"energy-efficient"	reduction in losses		baseline eff'cy	"energy-efficient"	reduction in losses	baseline eff'cy	"energy-efficient"	reduction in losses
15	96.7	97.7	29.4%	95	97.6	52.0%	15	95.7	97	29.4%	93.8	96.8	48.4%
25	97.2	98.0	29.4%	95.9	97.9	48.8%	30	96.5	97.5	29.0%	95.2	97.3	43.7%
37.5	97.3	98.2	33.1%	96.3	98.1	48.6%	45	97.0	97.7	23.4%	96	97.6	40.0%
50	97.4	98.3	33.7%	96.6	98.2	47.1%	75	97.3	98	24.7%	96.5	97.9	40.0%
75	97.8	98.5	30.7%	97.1	98.4	44.8%	112.5	97.6	98.2	23.5%	97.3	98.1	29.6%
100	97.9	98.6	33.8%	97.4	98.5	42.3%	150	97.9	98.3	19.3%	97.4	98.2	30.8%
167	98.1	98.7	31.5%	97.7	98.7	43.5%	225	98.1	98.5	19.0%	97.9	98.4	23.8%
250	98.3	98.8	30.2%	97.9	98.8	42.9%	300	98.3	98.6	18.1%	98.1	98.5	21.1%
333	98.3	98.9	34.0%	98.1	98.9	42.1%	500	98.4	98.7	16.4%	98.4	98.7	18.7%
500	98.0			98.3	99	41.2%	750	98.6	98.8	13.0%	98.6	98.8	14.3%
667	98.3			98.5	99	33.3%	1000	98.7	98.9	13.1%	98.7	98.9	15.4%
833	98.4			98.6	99.1	35.7%	1500	98.8			99	99	0.0%
							2000	98.9			99	99	0.0%
							2500	99.0			99.1	99.1	0.0%

Note: CEE "energy-efficient" criteria are identical to NEMA Class 1 efficiencies for covered equipment

Baseline = average efficiency sold in market today (Source: ORNL)

The equipment classes in the chart that are shaded each constitute less than 1% of sales by MVA volume. In total the shaded area includes just 6.5% of the market by MVA sales volume. The range of potential reduction in losses for those classes of equipment that make up at least 1% of sales is 0%-33.7%. For the largest, medium-voltage equipment, more than half of sales are already in excess of "energy-efficient" levels.

Appendix B
Annual Savings and Paybacks for Selected Energy-Efficient Transformers

Dry Type
Three Phase Low Voltage

Capacity (kVA)	% of Total MVA sales	Incremental cost	Annual kWh savings	at $.05/kWh annual savings	at $.05/kWh payback (years)	at $.08/kWh annual savings	at $.08/kWh payback (years)	at $.11/kWh annual savings	at $.11/kWh payback (years)
15	8.9%	$314	1,032	$52	6.1	$83	3.8	$113	2.8
30	12.5%	$296	1,299	$65	4.6	$104	2.8	$143	2.1
45	13.8%	$313	1,687	$84	3.7	$135	2.3	$186	1.7
75	15.0%	$476	2,071	$104	4.6	$166	2.9	$228	2.1
112.5	13.6%	$629	3,030	$151	4.2	$242	2.6	$333	1.9
150	14.2%	$789	3,944	$197	4.0	$316	2.5	$434	1.8
225	5.6%	$879	4,964	$248	3.5	$397	2.2	$546	1.6
500	7.5%	$1,274	6,178	$309	4.1	$494	2.6	$680	1.9

Dry Type
Three Phase Medium Voltage

Capacity (kVA)	% of Total MVA sales	Incremental cost	Annual kWh savings	at $.05/kWh annual savings	at $.05/kWh payback (years)	at $.08/kWh annual savings	at $.08/kWh payback (years)	at $.11/kWh annual savings	at $.11/kWh payback (years)
750	12.9%	$3,176	16,747	$837	3.8	$1,340	2.4	$1,842	1.7
1000	15.3%	$3,554	22,172	$1,109	3.2	$1,774	2.0	$2,439	1.5
1500	29.9%	$3,865	25,302	$1,265	3.1	$2,024	1.9	$2,783	1.4
2000	11.9%	$3,974	25,403	$1,270	3.1	$2,032	2.0	$2,794	1.4
2500	16.6%	$4,467	30,065	$1,503	3.0	$2,405	1.9	$3,307	1.4

Liquid Immersed
Three Phase Medium Voltage

Capacity (kVA)	% of Total MVA sales	Incremental cost	Annual kWh savings	at $.05/kWh annual savings	at $.05/kWh payback (years)	at $.08/kWh annual savings	at $.08/kWh payback (years)	at $.11/kWh annual savings	at $.11/kWh payback (years)
150	5.2%	$495	2,892	$145	3.4	$231	2.1	$318	1.6
300	11.7%	$907	5,158	$258	3.5	$413	2.2	$567	1.6
500	14.7%	$1,030	6,831	$342	3.0	$546	1.9	$751	1.4
750	11.9%	$1,338	8,665	$433	3.1	$693	1.9	$953	1.4
1000	9.6%	$1,585	11,117	$556	2.9	$889	1.8	$1,223	1.3
1500	13.7%	$2,261	13,662	$683	3.3	$1,093	2.1	$1,503	1.5

Notes:

This analysis is based on data submitted by manufacturers to Oak Ridge National Laboratory (ORNL). Savings are based on manufacturer responses to a survey that requested data on both an "non-evaluated" transformer and a transformer designed to meet TP-1. The submitted non-evaluated losses that underlie the savings in Appendix B are significantly higher than typical losses making up the baseline in Appendix A. The Appendix A baseline is ORNL's assessment of typical (average) losses; the Appendix B baseline is the product that manufacturers would provide if no efficiency criteria were specified.

For simplicity, only those transformers with sales greater than or equal to 5% of the MVA in their class are represented here. For example,45 kVA low voltage, dry-type transformers represent 13.8% of the MVA sold in the three-phase, low voltage, dry-type transformer market. Lack of data precluded inclusion of some transformers, however. In the case of large liquid immersed transformers, 2000 and 2500 kVA, each comprise more than 5% of MVA sales of three-phase liquid immersed transformers, but no manufacturer data was reported by ORNL.

ORNL warns that little confidence should be placed in paybacks for specific transformer categories because of low survey response. However, the general results and trends should be more dependable.