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PRELIMINARY ESTIMATION OF ENERGY MANAGEMENT METRICS FOR THE BEST PRACTICES PROGRAM

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Executive Summary

The Best Practices Energy Management Program is an implementation program aimed at improving energy utilization and management practices in the industrial sector. It targets distinct technology areas for clients in the industrial sector, including pumps, process heating, steam, compressed air, motors, and insulation. This targeting is accomplished with a variety of communication mechanisms and channels, such as computer software, printed publications, Internet-based resources, technical training, and technical assistance. Oak Ridge National Laboratory (ORNL) has conducted a preliminary assessment of the FY 2001 energy savings of this Program.

This assessment enumerates levels of program activity for each information mechanism, enumerated across delivery channels, for each technology area–pumps, process heating, steam, compressed air, motors, and insulation–and for several mechanisms that target multiple technology areas–Collaborative Targeted Assessments, Plant-Wide Assessments, and the *Energy Matters* newsletter.

The estimation relied on previous evaluations, where possible, for estimates of energy savings from particular actions. These included the two evaluation reports by Xenergy, *Final Report, Evaluation of the Motor Challenge Program* (May 2000) and *Evaluation of the Compressed Air Challenge Training Program* (January 2002); the Industrial Assessment Center (IAC) Data Base; and ORNL's detailed evaluations of the IAC. We relied on three sources of primary information, the Collaborative Targeted Assessment (CTA) energy savings estimates, Showcase Appraisal energy savings estimates, and estimates and reported savings from Plant-Wide Assessments (PWAs), all conducted by other ORNL staff members. These sources offered estimates of energy savings per application and survey estimates of implementation likelihoods and ratios of attendees to facilities at training workshops.

The total estimated energy savings for the Best Practices Energy Management Program (including the savings of the plant-wide assessments) in 2001 is 0.078 quad, about 0.21 percent of total industrial energy use in the United States. The Best Practices technology areas with the largest estimated savings are pumps with 43 percent and steam with 35 percent. The mechanism with the largest savings is software, with three-quarters of Program-wide savings, followed distantly by software training and CTAs.

Possible sources of overestimation of energy savings derive from (1) possible overlap between software tools provided as part of training and those directly distributed and (2) overestimate of the use of separate tools on a CD containing five separate tools. Any overestimation attributable to these sources probably is outweighed by underestimation deriving from the exclusion of any stock effects, the use of Best Practices information products in multiple years and the continued utilization of equipment installed or replaced in previous years.

Next steps in improving these preliminary energy savings estimates include coordinating the tracking of the distribution of Best Practices products and services and obtaining more detailed information on the use of software tools.

1. The Structure of Best Practices Energy Management

This report describes the estimation of the energy savings of the Best Practices Energy Management Program conducted by ORNL. The Best Practices Energy Management Program is an information program aimed at improving energy utilization and management practices in the industrial sector. It targets distinct technology areas for clients in the industrial sector, including pumps, process heating, steam, compressed air, motors, and insulation. This targeting is accomplished with a variety of communication mechanisms and channels, such as computer software, printed publications, Internet-based resources, technical training, and technical assistance. These relationships are shown in Table 1.

Table 1. Structure of Best Practices Energy Management Program: technology areas and delivery channels.

Delivery Channels	Technology Areas						
	Pumps	Process Heating	Steam	Compressed Air	Motors	Insulation	General
computer based tools	X	a	X	X	X	X	
printed information	X	X	X	X	X	X	X
internet resources	X	X	X	X	X	X	X
training	X		X	X	X		
internet resources	X	X	X	X	X	X	X
technical assistance	X	X	X	X	X	X	

X: Delivery method applied in this technology area.
a: Computer-based tool ready in Beta version but not available for general distribution in 2001.

An early component of the Best Practices Program, started in 1993, was Motor Challenge, directed at motors and pumps. Motor Challenge was followed by a comparable program focused on compressed air, Compressed Air Challenge. Motor Challenge as a distinct program was phased out by 1997, but motors remain a technology area targeted by Best Practices. Other technology areas that Best Practices targets are process heat, steam, and insulation. The Allied Partners Program, begun in 1996 around the time Motor Challenge was phased out, targets all technology areas rather than just motors. Under Allied Partners, individual firms sign an agreement with DOE to undertake various actions to promote energy efficiency in their own facilities. Additionally, Allied Partners are another outreach mechanism for reaching companies outside that program with technology-specific information, workshops, and demonstrations.

The Best Practices Program uses a variety of mechanisms to disseminate information. First, it provides a number of tools in the form of computer programs that can help a firm identify opportunities to improve their operations in a number of specific technology areas. Software tools have been developed by Best Practices for motors, pumps, steam, process heat, compressed air, and insulation. Five of them are available on a single compact disk. These tools are available through several channels: they can be obtained from the Best Practices Information Clearinghouse at Washington State University; Allied Partners may distribute some; and some may be downloaded directly from the DOE/OIT website.

Second, Best Practices publishes a variety of material on technical and market-related subjects. Most of these documents can be ordered from the Clearinghouse, some are disseminated by Allied Partners, and others are available through direct web download. The categories of publications are technical fact sheets and handbooks, tip sheets (two-page reports providing quick technical advice), Best Practices Resources (ranging from topics like "Hosting a Showcase Demonstration Event" to "Pump Life Cycle Costs"), market assessments, source books, and repair documents. The Program also publishes a newsletter, *Energy Matters*, which is disseminated from several sources. These written materials are supplemented by the availability of a technical assistance telephone line at the Clearinghouse.

Third, training workshops are sponsored by DOE Best Practices Program and through several other mechanisms. These include software training; train-the-trainer ("qualification") workshops; Collaborative Targeted Assessments (CTA), which are conducted before a corporate training event so the results can be used in the training; and regional training, coordinated by state agencies, utilities, and others. The CTA is a walk-through examination of an Industry-of-the-Future (IOF) industrial facility with one or more software tools, examining the scope for saving energy by applying specific changes in equipment or practice. Our energy-savings evaluation separated training workshops from CTAs.

Fourth, the Plant-Wide Assessment (PWA), initiated in 1999, is a cost-shared assessment of utility and process-related energy efficiency opportunities across a plant. IOF plants are eligible through competitive solicitation, while non-competitive awards are made for Showcase plants.

These multiple sources of information act in concert to provide technical information and practical solutions to energy managers in industrial facilities, much as an advertising program might deliver identical and complementary messages to a target audience with the overall goal of changing purchasing patterns. A particular energy manager at a specific industrial facility may have received the newsletter, downloaded all the steam tip sheets, and received a CD from the Clearinghouse with the STEAM software system. The newsletter may have whetted his or her appetite for more specific information, which one or more of the tip sheets may have furnished. He may have then acquired the

STEAM software to get a better estimate of what benefits he could get by a number of specific actions. Finally, convinced that some changes would make a material difference in his facility's energy bill, he contracted with an outside company to a make detailed study of his facility and propose a project to be implemented.

The messages and the approach are complementary. It is not clear that any one of the information delivery mechanisms by itself would comprise the sufficient cause for a change in energy management practices. If the same implementation strategies were addressed in the newsletters and the tip sheets as were offered in the steam software, attributing the energy savings to the newsletters and the tip sheets, as well as to the software, would involve multiple counting. This overlapping and interactive structure of these mechanisms leads to the distinct possibility of overestimating the energy savings from the Best Practices Energy Management Program by estimating savings attributable to each component of the Program separately. Nonetheless, it is these separate components which offer quantification to an assessment of the Program's accomplishments, and we have followed in the footsteps of previous assessments of the Program's energy savings by focusing on savings possibilities from the individual components. After the summary of current findings, we assess the likely magnitude of overlapping effects and discuss ways to compensate for potential overestimates.

2. Structure of Energy Savings Estimates

To strive for more precise estimates of energy savings, we enumerate levels of program activity for each information mechanism, enumerated across delivery channels, for each technology area. For example, to assess the energy savings of the software tool in the steam area, we count the copies of the steam scoping tool downloaded from the web, the number of copies sent individually by the Clearinghouse, those sent out as part of the Decision Tool CD, and, were the information available, the number acquired in the DOE Reading Room. For each technology area, we identify the number of CTAs undertaken, the number of workshops (regional and otherwise) held and their attendees, the number of software tools distributed, the number of tip sheets distributed, the number of other technical publications distributed, and the number of technical assistance telephone calls fielded by the Information Clearinghouse. In addition to itemizing and evaluating the activity levels within each technology area, we included a separate assessment of the energy savings attributable to the newsletter as an information mechanism cutting across all the technology areas.

The observational unit taking an action that saves energy is the individual industrial plant. Accordingly, for each information mechanism, we converted the numbers we received into the number of plants they represented. For example, when dealing with workshops, the numbers of workshops and of attendees are the measures typically recorded. We converted each of those numbers into the numbers of industrial facilities represented in a workshop. Similarly with the number of software tools and newsletters distributed: those items are distributed to individuals, but we convert the number of individuals receiving them into the number of industrial facilities with which those individuals are associated. Once we have the number of facilities receiving one of the information products or services, we multiply that number by the proportion of those facilities that implement some action on the basis of the information. The resulting number gives us the number of facilities taking an action. We multiply that number by the average energy savings that a particular mechanism identifies, yielding the total energy savings estimated to have derived from the distribution of that particular information product or service. A number of past assessments helps us to estimate actual impacts at the plant level which are discussed in greater detail below. The Xenergy Motor Challenge Evaluation Report attempted to assess through interview and survey what proportion of energy-savings actions a firm would have undertaken without the intervention of the Motor Challenge activities. We have not attempted to reduce our estimated energy savings to take account of such a "would-have-undertaken-anyway" effect, strictly for lack of empirical evidence.

We have excluded the qualification training ("train the trainer") workshops. Working through how these training sessions would save energy, it was clear that all the savings attributed to these newly trained trainers would show up in the savings achieved by trainees in subsequent training workshops. To count the energy savings of the trainers would be double-counting.

An appendix identifies the data sources on which the estimates rely. The appendix also details assumptions we have made regarding the transfer of energy saving information from one distribution channels, such as the CTA, to another, such as the software tool in the corresponding technology area.

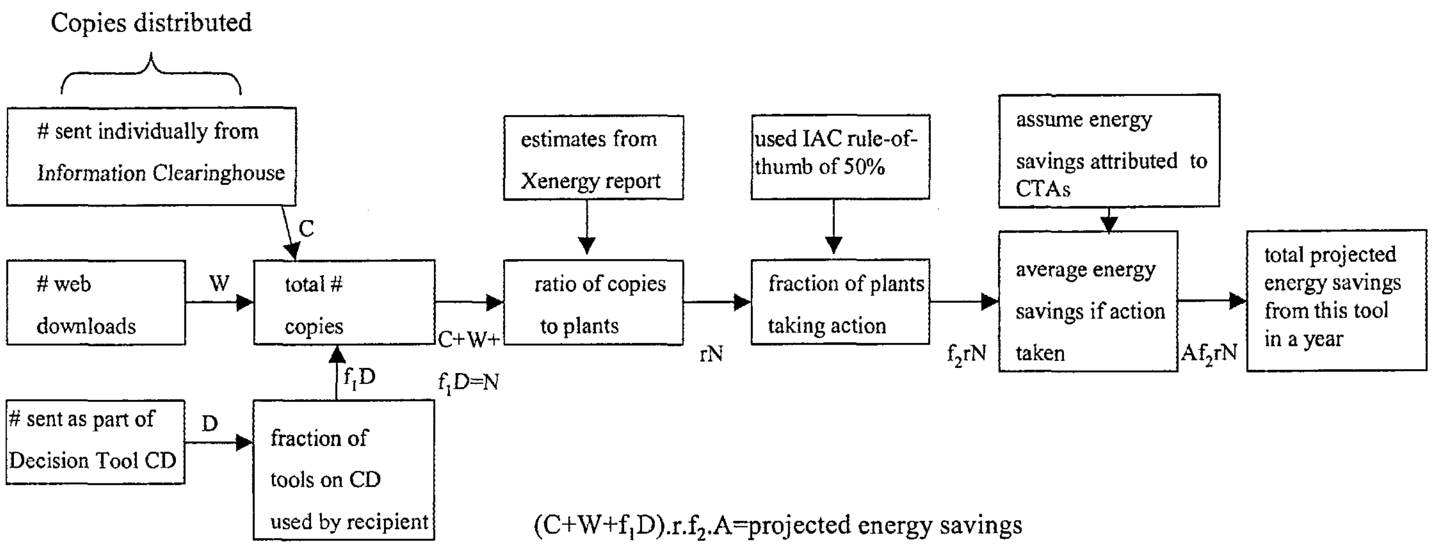
Figures 1 and 2 depict the structure of energy savings estimates for two types of delivery channel, software and technical assistance telephone calls. The figures show the sequence of actions leading to energy savings and identify the information required to estimate savings. Figure 1 shows the structure of the energy savings estimation procedure for a Best Practices software tool that identifies energy savings opportunities in an industrial plant's steam system. The central line of boxes, with arrows pointing from left to right, describe how ORNL's assessment enumerates the actions taken that lead to energy savings: count copies of the software tool distributed; determine how many different industrial facilities received them, as distinct from individuals; determine the number of plants taking action on the basis of the software tool's results; the average energy savings per facility if action is taken; and finally the total energy savings estimated from the distribution of all the copies of the software tool.

The top row of boxes tells where the information came from to determine: the ratio of different industrial facilities to the number of individuals receiving a copy of the software; the fraction of facilities taking action; and the average energy savings if action is taken.

The five boxes at the left end of the diagram identify the counting procedure used to arrive at the number of software tools distributed from various sources—those sent individually from the Best Practices Information Clearinghouse, the number downloaded directly from the web, and the number sent as part of a Decision Tool compact disk, which contained five software tools. This last source required some "deflation," because many of the Decision Tool CDs would have been ordered with one particular tool in mind. The tool that prompted the order would have been the primary, and possibly the only, one used, but once a user had the entire set of tools, he or she might have explored one or more of the other tools. So rather than divide the number of Decision Tool CDs sent out by five to estimate the number of any particular tools actually used, ORNL divided by four to allow for some use of another tool or two on average.

Figure 2 depicts the structure of actions in another component of the Best Practices Energy Management Program, the fielding of technical assistance telephone calls by the Best Practices Information Clearinghouse at Washington State University. Again, the next step of the assessment accounts for the ratio of callers to different industrial facilities, the fraction of agencies taking action, and the energy savings per call in each technology area. The notes below the horizontal line of boxes indicate the sources of the information used to account for these "deflation" ratios.

FIGURE 1. Projecting energy savings from a software tool that calculates energy savings from various actions taken on steam systems, tailored to an industrial plant's technical configuration.



$(C+W+f_1D).r.f_2.A$=projected energy savings

•3 sources of distribution

•"count" copies distributed (Decision Tool CD has 5 separate tools on it)

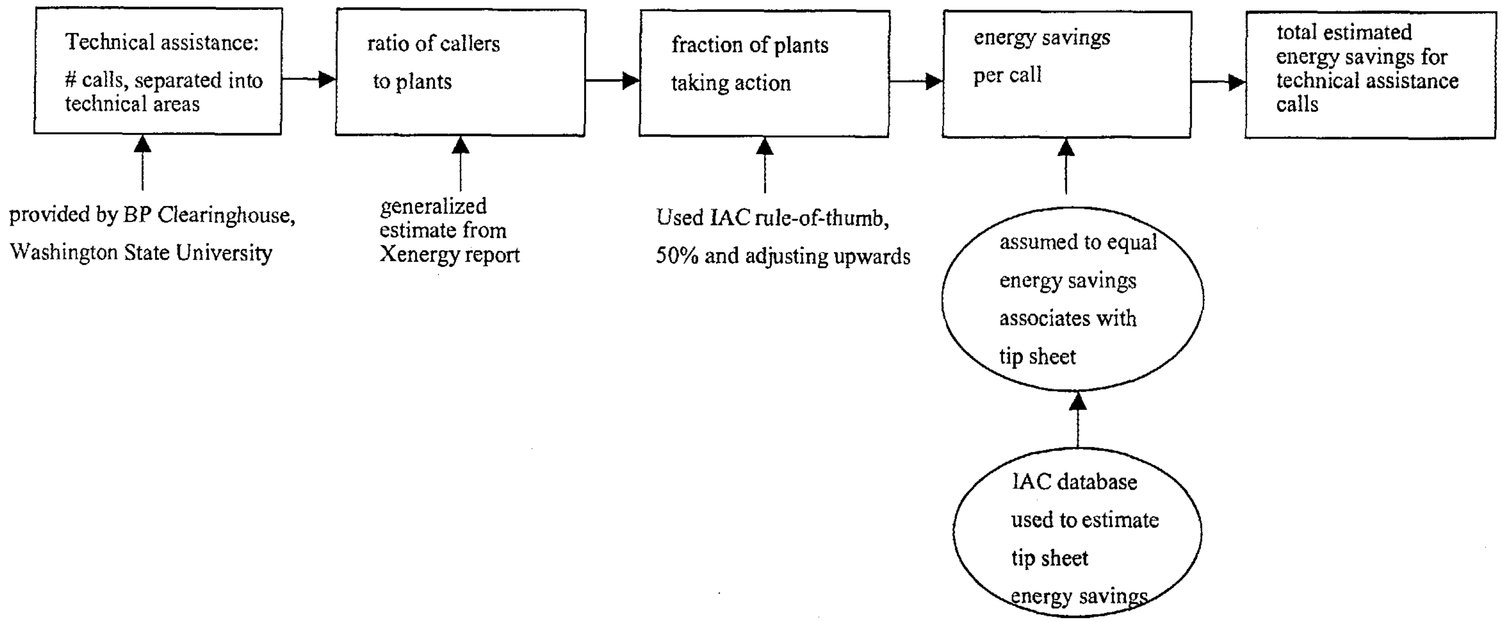
•reduce # of software tools to represent # plants receiving them

•reduce # of plants taking action based on using tool

•average energy savings per action taken

•total energy savings from tool

FIGURE 2. Projecting Energy Savings From Technical Assistance



3. Sources of Information

The present estimation relied on previous evaluations, where possible, for estimates of energy savings from particular actions. These included the two evaluation reports by Xenergy, *Final Report, Evaluation of the Motor Challenge Program* (May 2000) and *Evaluation of the Compressed Air Challenge Training Program* (January 2002); the Industrial Assessment Center (IAC) Data Base; and ORNL's detailed evaluations of the IAC. We relied on three sources of primary information, the Collaborative Targeted Assessment (CTA) energy savings estimates, Showcase Appraisal energy savings estimates, and estimates and reported savings from Plant-Wide Assessments (PWAs), all conducted by other ORNL staff members. These sources offered estimates of energy savings per application and survey estimates of implementation likelihoods and ratios of attendees to facilities at training workshops. Estimates of energy savings from Case Studies were provided by Lawrence Berkeley National Laboratory (Aimee McKane).

For energy savings per application, we used savings estimates from CTAs to represent savings that could be obtained from application of the corresponding software tool. Generally, a CTA was able to survey only one-third to as much as three-quarters of an industrial facility, depending on the facility's size, so this transfer of energy savings is likely to offer a low estimate of using the software tool over an entire plant. We used the savings estimate from the steam Showcase Appraisals to represent the savings potential from use of the 3E+ software tool for insulation. The steam applications in the 2001 Showcase Appraisals incidentally worked mostly with steam distribution systems. Because insulation was the salient issue in those Appraisals, the use of steam savings to represent insulation savings is appropriate, at least in this particular year.

The data on counts of activities (e.g., numbers of copies of software tools and publications distributed, trainees in workshops, etc.) were taken from several sources as well. The single published source was the *Best Practices Fiscal Year 2001 Activity Report* (preliminary draft 04-12-02). Project Performance Corporation (Craig Cheney and Amanda Dosch) promptly fulfilled our requests for specific activity counts on training and publication distribution through Allied Partners from the Allied Partners Data Base, and the Best Practices Information Clearinghouse at Washington State University (Rob Penney) assembled information we requested on software and publication distribution from that source and on technical assistance calls. The National Renewable Energy Laboratory (NREL; Anne Jones) supplied information on downloads of the two software tools, 3E+ and the steam scoping tool.

The energy savings from implementing the specific recommendations from individual tip sheets were calculated using technical information from the IAC Assessment Data Base and, for motors, the NEMA publication on motors and generators, MG 1-98, Rev. 2 and the Motor Challenge report.

4. Summary of Findings

Findings for 2001 are presented. We have reported findings of three types. First is the direct, quantitative projection of energy savings from the Best Practices Program. Second are a number of qualifications we discovered during the process of making these projections that hinge on the logical structure (implementation rates, etc.) of our energy savings projections. Third is the sensitivity of the projected savings to the estimated savings from software.

4.1 Energy savings

The total estimated energy savings for the Best Practices Energy Management Program (including the savings of the Plant-Wide Assessments) in 2001 is 0.078 quad, about 0.21 percent of total industrial energy use in the United States. Table 2 reports these estimated savings, in trillion Btu, by technology area. Savings estimates are reported separately for the *Energy Matters* newsletter, the Plant-Wide Assessments, and the Case Studies, all of which cut across technology areas.

Table 2. Preliminary, estimated energy savings, by technology area, FY 2001

	Energy savings, trillion Btu	Percent of all energy savings from Best Practices Energy Management
Pumps	33	43
Process Heating	2	3
Steam	27	35
Compressed Air	6	7
Motors	a	1
Insulation	7	9
Plant-Wide Assessments	1	1
Case Studies	1	1
Newsletter	a	a
Total	77	100

a: less than 1 TBtu or less than 1 percent.

The Best Practices technology areas with the largest estimated savings are pumps with 43 percent and steam with 35 percent, followed at some distance by insulation with 11 percent and compressed air with 7 percent. These relative contributions of particular technology areas to total estimated energy savings are moving targets. Both pumps and steam are system-wide technical areas, such that implementation of BP recommendations affect a facility's entire energy system. Motors applications are component-oriented, and their scope for saving energy is more restricted, in the sense that they affect only specific pieces of equipment in any one implementation, rather than an entire plant's operation in that area. The increment to efficiency provided by assessment with MotorMaster+ is tightly circumscribed by the previous equipment choices of firms. The Motor Challenge report determined that savings came from systems improvements, not strictly from motors. The magnitude of pumps savings is heavily influenced by our estimate of the fraction of firms implementing measures with the PSAT software, (48 percent),[1] whereas we used smaller fractions for steam and insulation (17 and 5 percent).[2] Insulation, with the third-largest percent of estimated savings for 2001, is component-oriented, since the 3E+ software tool is designed to assess insulation on steam lines, which affects only the distribution component of a steam system.[3] The estimated energy savings in the insulation area are as large as they are because insulation's application to the steam distribution system in a facility is in fact systemic. Process heating also is systemic, but in 2001 was estimated to save much less energy principally because the software tool targeting that application area was only in Beta version and had not been generally distributed. It is anticipated that process heating will yield considerably larger savings in subsequent years, after the software tool PHAST becomes widely distributed. The newsletter can be credited with only a small direct savings, with our estimation methods, but this method may understate the extent to which it brings the other delivery channels, such as software tools and training, to the attention of energy managers.

Plant-Wide Assessments completed in FY 2001 accounted for somewhat under 1 percent of total Program energy savings, about 0.66 trillion Btu. Comprising these savings was only one corporate internal replication (applications to other plants operated by the same firm). That replication saved three-and-one-half times the implemented energy savings of the initial PWA and six times the cost savings. If a substantial fraction of the other plants for which a PWA was conducted implemented comparable internal replications, the additional energy savings could amount to 2.4 trillion Btu, or nearly an additional 3 percent of total Program-wide savings. Some, possibly many, of these replications will occur in FY 2002. More generally, most replications from a PWA conducted in one year may be expected to be implemented in the following year, or possibly the following two years.

Table 3 disaggregates the energy savings estimates by general delivery method (e.g., training, software, etc.) for each technology area (e.g., motors, steam, etc.), in trillion Btu. The mechanism with the largest savings is software, with nearly three-quarters of Program-wide savings, followed distantly by software training and CTAs.[4] Within insulation, nearly all of the estimated savings derives from the 3E+ software tool. Although software tools are the information delivery mechanism

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[1]Taken from survey data on pump training reported the Xenergy Motor Challenge evaluation.

[2]The 17 percent figure for steam relied on survey results for MotorMaster implementation reported in the Xenergy Motor Challenge evaluation, while the 5 percent for insulation was a judgment estimate of a small fraction, to remain on the conservative side.

[3]The full steam system is comprised of generation, distribution, end use, and condensate return. The 3E+ software tool affects only the distribution component.

[4]If the PHAST software had been distributed during FY 2001, it could have accounted for roughly 80 percent of all projected savings (meaning that estimated savings could have been 80 percent larger than the current 0.078 quad).

credited with largest share of energy savings in the Best Practices Program, the extent of software's contribution to savings in insulation is attributable to the absence of any other delivery mechanisms besides miscellaneous technical publications. In the steam area, distributed software accounted for over three-fifths of the projected savings, with software training and CTAs delivering equal proportions of most of the remainder. Software, with the largest savings of any information delivery mechanism, experienced three-fifths of its program-wide savings in the pumps area, followed by roughly a fifth in steam and about fifteen percent in insulation. Steam as a technology area delivers a major share of savings attributed to each of the delivery mechanisms.

Table 3. Contributions of delivery channels to estimated energy savings in each technology area, in trillion Btu.

Delivery Channels	Technology Areas							
	Pumps	Process Heat	Steam	Compressed Air	Motors	Insulation	General	Measure (row) total, trillion Btu
Corporate Targeted Assessments	1	2	2	1	0	0		6
Training	3	0	2	1	a	0		6
Software systems distributed	28	0	23	3	a	7		62
Printed information	a	a	1	1	a	a		2
Plant-Wide Assessments							1	1
Case Studies							1	1
Technology area total	32	2	28	6	1	7	2	78

a: less than 1 TBtu. A zero indicates that a delivery channel did not target a particular technology area.

4.2 Qualifications and extensions

The preliminary energy savings estimates presented above are subject to at least three sources of bias of which we are aware, but for which empirical evidence to support adjustment currently is lacking. The first bias has the effect of elevating the preliminary estimates, but to an extent that we assess to be relatively small. This effect derives from the fact that many of the Best Practices measures act in tandem, much as multiple-medium advertising, and we are unable to identify the overlap in their effect. The second potential bias derives from the fact that five of the software tools are available on the Decision Tool CD. If people order that CD because they want to use one particular tool, using the full number of CDs distributed as representing the number of each of those tools implemented by recipients would be likely to overstate the effective distribution of wanted software. We do not have a direct check on the magnitude of the likely bias from this source, but our attempt to mitigate it could actually over-correct.

The third bias depresses the current estimates below their true magnitude. This effect results from the current-year-only status of the energy savings estimates. Lessons learned and actions taken in previous years continue to save energy in the current year, possibly with some deterioration, but equally possibly augmented by growth in applications. Correcting for this bias could multiply a current year's energy savings by a factor close to the number of previous years in the program. We discuss each of these effects below.

4.2.1 Possible sources of overestimation

The principal source of potential overestimation of energy savings derives from a combination of the present approach to estimating the Program's energy savings by individual components and the overlapping structure of many of the Best Practices Energy Management Program's components. A concrete example may provide the best explanation of this potential problem. To estimate the energy savings of one of the software tools, we count the number of copies distributed, deflate the effective number distributed to account for multiple distribution of a single facility, probability of implementing the tool's recommendations, etc. We multiply this deflated number of copies distributed by the average energy savings per implementation to arrive at a total estimate of energy savings. Parallel to this estimate of savings attributed to software, we estimate savings from training workshops, various publications, and technical assistance calls, with each estimate deflated to account for likelihood of implementation, etc. The aggregate energy savings of the entire Best Practices Program then is the sum of the savings from each component. However, these different products and services may not be completely independent of one another. Attendance at a workshop may encourage use of one of the software tools, such that the independently estimated energy savings from workshop attendance and software use may overstate the total energy savings from both of those components. Similarly with the separate estimation of energy savings from tip sheets, various publications, and technical assistance calls. The scope for overlapping effects of CTAs and PWAs with the other delivery channels is unknown but could be small since those are stand-alone activities.

It may be possible to eliminate most of the overlap between training workshops and software distribution by subtracting the number of people attending software training workshops from the number of copies of software distributed. Generally the number of individual software units distributed far exceeds the number of workshop attendees; consequently, if this procedure were to largely eliminate the overlap of attributed energy savings, a substantial proportion of the savings initially attributed to the software would still remain. The overlap of attributed energy savings could vary substantially between pairs of components, e.g., between workshops and software versus between software and technical assistance calls.

How large could this source of overestimate be? If all of the software training were disallowed because it was believed that implementation of energy savings from that component of the Program was completely subsumed under the estimation of savings directly from software tools, the total estimated energy savings would fall by only about 10 percent. The largest single delivery channel in terms of energy savings is software (not software training), which delivers 73 percent of the estimated total savings of the Program. CTAs are the next remaining largest delivery channel for energy savings at around 9 percent, and the other channels are minor energy savers, at around 2 percent or less. We conclude that the scope for upward bias because of overlapping delivery channels is limited, and at the worst case could not be greater than about 10 percent of the total savings estimated, and probably is considerably less.

A second source of upward bias derives from the fact that the Decision Tool CD contains five software tools. As the projections are structured, the Decision Tool CD is one of the three principal distribution sources for each of the software tools. To obtain the total count, of, say the MotorMaster+ tool, we add the number ordered separately from the Information Clearinghouse, the number downloaded from the web, and the total number of Decision Tools distributed. It is reasonable to treat the copies distributed through the first two sources as though they were ordered because someone wanted to use, or at least examine, the MotorMaster+ tool, but someone could have ordered the Decision Tool CD because he or she wanted MotorMaster+ or any of the other four software tools. To count the effective copies of MotorMaster+ distributed via the Decision Tool CD as being equivalent to those distributed through the other two sources seems quite optimistic.

One solution to this potential overweighting of tools distributed through the Decision Tool CD is to divide the number of those CDs distributed by five when enumerating the copies of each software tool received by energy managers. However, it seems reasonable that even if a person did order the CD for one specific tool, he or she might well explore the other tools and use one or more of them, even if not all of them. To account for this exploratory effect, we divided the number of Decision Tool CDs distributed by four rather than by five, and added that number to the copies distributed via the other two channels to reach a total, "effective" number of software tools distributed in each technology area. We believe this adjustment is large enough to eliminate an upward bias that would be imparted by not adjusting the count of Decision Tool CDs at all, and it may over-compensate, leaving a small downward bias to the estimate of energy savings from software tools. This particular item is important because of the large percentage of the software tools distributed via the Decision Tool CD, as well as the importance of the software in generating the energy savings estimated for the entire Program.

4.2.2 Possible sources of underestimation

Another implicit assumption in the current projection method is that the only energy savings deriving from the Best Practices Energy Management Program are those deriving from information distributed and actions taken in the current year. The Xenergy Motor Challenge Evaluation Report made an allowance for a time lag between exposure to the information distributed by that program and a facility's implementation, but we have not attempted that here. However, our projections assume that the only energy savings the program generates are those from its current year's activities, when in fact the actions the program induced last year (and the year before and the year before that) continue to yield savings. This effect, which we call a "stock effect" is completely excluded and is almost certain to be large relative to a single year's incremental savings, which is what the current procedure effectively generates. Another component of this stock effect is the additional savings that information—software tools, tip sheets, workshop attendance, etc.—distributed in previous years can continue to generate. This effect—we could call it the educational component of the stock effect—is also excluded, although it probably is not nearly as large as the previous-actions component of the stock effect. Both components may be subject to some annual degradation, as people forget, equipment experiences normal wear and tear, companies are reorganized and individuals reassigned, some companies are sold, and the forefront of energy-management recommendations change.

As the Program grows and reaches more facilities over time, the magnitude of this stock effect will grow in future years. During the first few years of the Program, the stock effect could have been small, simply because few facilities had been reached. The Program may be reaching a point presently where the current-year energy savings deriving from actions taken in the previous year are large relative to current-year savings deriving from actions taken in the current year alone. Additionally, since many actions that can be taken involve the use of software distributed in previous years, re-use of the software in more extensive applications in the first couple of years after its distribution will yield energy savings that go completely uncaptured by the net of our current estimation method.

4.3 Sensitivity of energy savings estimates: the importance of software

The energy savings estimates presented in this report are preliminary. We have used results of previous evaluations to the extent possible, but many parts of the Best Practices Program have not been evaluated directly. We discussed in section 4.2 the potential for the current estimates to under- or overstate actual savings for structural reasons and were able to put quantitative bounds on those potential sources of error. The remaining scope for error in these estimates resides in the estimates of energy savings per application—e.g., per trainee, per software tool distributed, per publication, etc.—particularly in the instances where we had to transfer a directly measured savings per application from one delivery mechanism to another mechanism.

Estimated energy savings are not clumped in any single technical area, but three areas are the major contributors, as shown in Table 1: insulation, steam, and pumps. Table 3 clearly points to individually distributed software systems as the dominant channel of delivering energy savings: 73 percent of total estimated BP-Energy Management savings. That table shows the prominence of software systems in contributing to the energy savings in each technical area, ranging from almost all estimated savings in insulation (because of the absence of most other delivery mechanisms targeted at that technical area) to still over half in compressed air and motors. Software makes no contribution to process heat energy savings in 2001 because PHAST did not become available for distribution in time for that year, or software would have taken an even more dominate role.

No direct estimates of energy saving per application were available for distributed software tools, so relying on expert engineering judgment, the estimated energy saving per CTA in a specific technology area was used for the energy savings per application for both individually distributed software and software training. The basic observation for software training was the number of attendees, but the basic unit for energy savings was the individual industrial facility, so survey information from the Xenergy Motor Challenge Report was used to convert the number of attendees at a training workshop to the number of individual establishments represented. The energy savings from software training was further reduced by accounting for the fraction of industrial establishments represented at a training session who subsequently took action with the software tool, again using survey information from the Xenergy Motor Challenge Report. When estimating the energy savings from individually distributed software tools, we did not reduce the number of units distributed to attempt to account for distribution to multiple individuals at the same industrial facility, but we did assume that without the training, users would implement only half of the recommendations that users who attended a training session would implement.

Thus, while the projected (estimated) energy savings from software tools have been reduced substantially from the comparable magnitude of the corresponding CTA savings to account for the discrepancy between possession and use, the basic energy savings per application rests on the assumption that the savings realized from *use* of the software tool is the same as the CTA savings. Considering the dominance of software's contribution to the total estimated energy savings from the Best Practices Program, probing the accuracy of this assumption through direct evaluation should have a high priority.

5. Suggestions for Subsequent Information Collection

Our data collection effort pointed to a number of actions that would improve monitoring of the program's accomplishments in future years. We identify these under "activity tracking." A second group of suggestions focuses on obtaining more precise estimates of energy savings. Accomplishing the improvements in savings estimates generally requires the collection of additional information, generally through surveys of participating companies, which we identify in the third subsection.

5.1 Recommendations for improved program activity tracking

- Develop and maintain a comprehensive list of all BP publications. Classify each publication into one of the six technology areas.

- Track the exact number of each tip sheet distributed by the Clearinghouse and Allied Partners, and downloaded from the Web.

- Develop the ability to determine what BP products specific plants have received over time. This ability would form the basis for a powerful analysis of the relative effectiveness (or persuasiveness) of different BP products.

- Have the parties responsible for the different dissemination channels—e.g., Allied Partners, Information Clearinghouse—maintain consistent records when they distribute the same materials.

- Track the company and plant affiliations of attendees at training workshops.

5.2 Recommendations for improving energy estimates

- Determine the representativeness of plants receiving CTAs. In this analysis, and possibly in future analyses, systems-oriented software systems' (e.g., PSAT, STEAM) energy savings were based on average CTA-estimated energy savings. These estimates may need to be adjusted up or down if the typical plant receiving a CTA is larger or smaller than an average plant.

- Exercise the software packages to develop energy savings estimates. In future assessments, instead of basing software energy savings on CTA energy saving estimates, it may make more sense to run each software package over a set of prototype plants to determine the energy savings the software packages would estimate for those plants.

- Develop energy savings estimates attributable to key publications. In other words, if a plant were to acquire and use a certain publication to guide its implementation of energy savings measures, how much energy could it expect to be saved?

- Improve the characterization and tracking of the different types of training activities. Essential for metrics estimation is knowing what application area the training was in, how many people received training at each session, whether the training was for trainers or people who could actually implement energy savings measures, the number of plants represented at each training, and whether the training included the relevant software package. If the training focused on how to use the relevant software package (e.g., PSAT, PHAST), then energy savings attributable to the training could be related to average energy savings attributable to using the software. If software was not part of the training exercise, then some other means for estimating energy savings attributable to this type of training is needed.

- The potential magnitude of the stock effect warrants examination of its magnitude in the case of Best Practices, as well as its persistence, and the precise mechanisms by which it occurs and eventually attenuates (if it in fact does). Such a multi-year stock effect would derive from the persistence of savings from measures implemented in past years and from continued use of the tools in the future. ORNL recently has found a 10-year persistence of energy savings in the Industrial Assessment Center Program, and those results may illuminate the stock effects in the Best Practices Program.

5.3 Recommendations for additional data collection

- Additional data are needed that describe the rate of use of BP products. Specifically, more information is needed about the rate of use of software products, tip sheets, and publications. Counts of products distributed are not sufficient to indicate how often the products are actually used. To establish the scope of the multi-year stock effect, information is needed on the extent to which the software tools are used year after year.

- Additional data are needed to improve estimates of energy savings attributable to BP products that are used. This is especially important with respect to BP software products. Software systems such as PSAT, AirMaster, and STEAM assist plants in understanding how they can improve entire pump, compressed air, and steam systems, respectively. When used in conjunction with CTAs, these software packages typically identify actions that could reduce energy use by 25 percent or more. Plant wide, the energy savings, and corresponding benefits attributable to the BP program, could be quite substantial if all energy savings opportunities are pursued. However, it has been the experience with the Industrial Assessment Center Program, for example, that plants only implement about half of recommended energy savings measures. This rate could be more or less in the BP context. The total BP energy management metric estimate is quite sensitive to energy savings attributable software use. The same concern exists with respect to tip sheets and publications, especially handbooks that may describe numbers ways of saving energy.

- Additional data are needed to better understand energy savings attributable to technical assistance provided by the Clearinghouse. Call-backs for in-depth telephone assistance should be conducted by TA support Staff to assess implementation and, if possible, energy savings.

- In-depth data are needed about how plants make use of the broad portfolio of BP products and services. Such data are needed to better deal with the difficult methodological issues discussed above: double counting and stock effects. For a statistically defensible number of plants, data would need to be collected about what BP products were received over a several-year period, how and how often the products were used, and what energy savings can be attributed to the products.

- The requisite information for the suggestions in this section would come from interviews with participating plants. Such interviews would have to be constructed so as not to be a burden on firms participating in the program, yet deliver reliable information.

6.0 Conclusions

6.1 Summary of findings

Best Practices touches a large number of industrial plants, and the industrial sector contains many individual applications that use considerable amounts of energy per year. Energy management savings are substantial, approximately 0.078 quad, or about 0.21 percent of total industrial energy use in the United States.

Pumps and Steam were the technical areas with the largest estimated energy savings, at 43 and 35 percent of total Program savings respectively. Collaborative Targeted Assessments accounted for 8 percent of the Program savings, allocated across the technical areas for which CTAs were conducted. Plant-wide Assessments accounted for a little under 1 percent of savings in 2001, but their scope for greater savings in future years is believed to be considerable. Individually distributed software tools were the dominant delivery channel for savings across all technical areas for which such tools were available in 2001, 79 percent of total Program savings. Since the energy saving per application for software tools was estimated indirectly from CTA savings rather than by direct estimation or survey, this particular element of the present estimation warrants closer examination in subsequent evaluation efforts.

The estimates presented here can be improved, with further analysis of 2001 activity and, in future years, with improved activity tracking, supplemented by selective interviews with, and more in-depth reporting by participating firms. We turn to next steps to accomplish these improvements below.

6.2 Next Steps

The next steps that we recommend fall into three principal branches: more targeted tracking of Best Practices products and services, more detailed examination of the energy savings from the software tools, and a survey of plants participating in PWAs to determine the extent of internal replications. The desirability of more precise tracking of who received exactly what became evident early in the evaluation process, but the end point of the evaluation, despite its preliminary character, unambiguously reveals the importance of software to the energy savings of the Best Practices Program. While improving tracking of all the products is worthwhile, further study of the software is of first-order importance.

Currently, it is possible to track most of the distribution of materials and services fairly well, even if one must go to several different places to find the information and must repackage what can be supplied directly. It would help to have the different distribution channels–Allied Partners, the Information Clearinghouse, Macro, Inc., direct web downloads–maintain consistent reporting formats when they distribute the same materials. Being able to identify the number of distinct industrial facilities represented at a training workshop would, in an important way, be more valuable than knowing the number of trainees. The present recording system focuses, understandably, on the materials and services distributed, rather than on the facilities receiving them. However, knowing what materials and services individual facilities have received would permit more insightful analysis and evaluation to be performed on the effectiveness of different materials. One-page tasking statements ("cut sheets") should be developed for each organization involved in the distribution channel, detailing what information to maintain on each product distributed. Phase Two of this project will make specific recommendations for improving the effectiveness of tracking.

These tracking steps lead into some supporting database work. The different organizations distributing material currently have different database organizations and capabilities. At the least, some direction should be given to the organizations on how to manage their databases.

It would be useful to learn more about the distribution of material over the Internet. It also would be useful to know the number of visits each page on the Best Practices website receives and the number of downloads of each item.

We will develop a survey design for collecting information required for improving energy savings estimates, focusing on the individual plant as the unit of study. Particular attention will be given to software.

In light of the dominance of the software tools in delivering the estimated energy savings for the Best Practices Program, the first priority in the next phase of work should be directed at the distribution of those tools and the training for the use of them. Among both workshop trainees and people receiving tools outside of trainings, it is important to have a more direct estimate of the proportion of recipients using them, and the proportion of recommendations actually implemented. The dominance of the current estimate of pump system savings highlights the importance of obtaining more direct information on this parameter. It would be useful to obtain information on differences in these two attributes between users receiving training on the tools and those not receiving training. In the preliminary evaluation to date, we have estimated energy savings based on potential savings; having more direct estimates of implemented energy savings would be very useful. The preliminary evaluation also attributes all savings to the use of the tools, whereas some facilities might have implemented some of the actions that saved energy without the use of the tools. The extent of this would-have-saved-anyway effect should be explored.

An effort should be made to determine the representativeness of facilities hosting CTAs. How typical are they of facilities in their respective industries? Although the share of Program-wide energy savings contributed by CTAs is only around 9 percent, we have relied on those savings in a "typical" plant for preliminary estimates of energy savings that can be derived from use of the software tools. Consequently the importance of clarifying the technology-specific savings from a CTA in a typical plant goes beyond the scope for saving energy through the CTAs alone.

It will also be useful to clarify the energy savings potentials of the recommendations made in the specific publications offered through the Best Practices distribution channels. This would involve technical analysis of the recommendations to determine the savings possible if they are implemented.

Turning to the Plant-Wide Assessments, finding information on internal replications could be a quick way to boost the FY 2001 energy savings of the Best Practices Program. A telephone survey should be undertaken of the participating plants to determine the extent of internal replications made during 2001. In the current information base, replication data are available for only one plant out of 32 participating in both FY 2001 and FY 2002.

Appendix. Assumptions and Justifications: Preliminary Discussion

This appendix provides more details about the assumptions, limitations and qualifications concerning the preliminary estimates of the Best Practices Energy Management Program metrics presented in the main body of this report. Table A.1 documents the data sources for all the information used in the assessment. Table A.2 summarizes Best Practice Program products and services for the year 2001. Table A.3 presents our preliminary estimates for energy savings attributable to each product and service. Each table is discussed below.

The first column of Table A.1 presents our breakdown of all BP-EM Program products and services that could result in energy savings. This column also presents factors we used to adjust the impact that each product or service may have on energy savings estimates. The second column references each source of information used in this assessment. In many instances, we were able to base the estimate on published information. In many other instances, we need to develop estimates based on generalizations of the published information. The third column provides additional information on limitations and qualifications of the generalizations for our estimates. Also noted in the third column are our assumptions for two adjustment factors: the number of plants represented at training sessions or by users of software or callers for technical assistance or recipients of publications and newsletters; and estimates of the fraction of plants taking action based on using a software system or receiving some training, technical assistance or program materials. The only published information related to these adjustment factors is found in the Xenergy Motor Challenge Report (XMCR) and is only related to one technical areas, motors and pumps, and one product, newsletters. Notes in the third column explain how these estimates were generalized to the other technical areas and products.

Table A.2 gives estimates of the number of products distributed and services provided by the Best Practices Energy Management Program in 2001. These estimates were directly taken from activity reports and up-to-date program tracking databases.

Table A.3 presents energy savings associated with each product and service for each technical area. The numbers in bold are taken directly from evaluation reports such as those by Xenergy, IAC evaluation experience, and direct field reports. The numbers in italics were generalized from the numbers in bold. For example, in the absence of better information, it was assumed that energy savings attributed to CTAs could be used as a proxy for energy savings attributable to system-based software training (see pumps, steam and compressed air) and to distributed software directly (with a 50% downward adjustment factor, based on IAC Program experience that only half of recommended measures would be implemented). It was assumed that energy savings associated with tip sheets would be a reasonable proxy for technical assistance calls. Since there were no tip sheets for pumps, it was assumed that a good proxy for technical assistance in pumps would be the tip sheet for motors. It was not possible in this project to associate energy savings with every Best Practices Program publication, due to their sheer number and extremely wide range of content. As a proxy, we used a published energy savings estimate associated with the *Energy Matters* newsletter.

Table A.1. Best Practices Metrics Reference Sources, Limitations, and Qualifications

Product/Service Area	Reference Source	Limitations and Qualifications
CTAs Number of CTAs in technical area Average energy savings per CTA	 - ORNL Activity Report 2001 - ORNL Activity Report 2001	CTAs were conducted in these technical areas: pumps, process heat, steam, compressed air
SOFTWARE TRAINING Software Training Attendees - By ORNL - By Allied Partners, Internal - By Allied Partners, External Software Training Sessions - By ORNL - By Allied Partners, Internal - By Allied Partners, External Number of Plants at Training Session - Fraction of external trainees from different plants (see Note A) Fraction of plants implementing actions (See Note B) Fraction of measures implemented Average energy savings per plant implementing actions	 - Best Practices Activity Report - ORNL Activity Report 2001 - Allied Partners Database - Allied Partners Database - Best Practices Activity Report - ORNL Activity Report 2001 - Allied Partners Database - Allied Partners Database - Xenergy Motor Challenge Report (XMCR)[1] - Xenergy Motor Challenge Report - Based on IAC database - Based on CTA energy savings	Software systems encompassed in this analysis: PSAT, STEAM, AirMaster, MotorMaster. Note A: Numbers taken directly from the Xenergy Motor Challenge Report (XMCR) for PSAT (.56) and MotorMaster (.8). Averages were derived from XMCR for STEAM and AirMaster (.6). Note B: Numbers taken directly from XMCR for PSAT (.48) and MotorMaster (.178). Averages were derived from XMCR for STEAM and AirMaster (.6).
REGIONAL TRAINING Attendees - By ORNL - By Allied Partners, Internal - By Allied Partners, External Number of Plants at Training Session - Fraction of external trainees from different plants (see Note A) Fraction of plants implementing actions (see Note B) Fraction of measures implemented Average energy savings per plant implementing actions	 - Best Practices Activity Report - Xenergy Motor Challenge Report - Xenergy Motor Challenge Report - Based on IAC database - Xenergy Compressed Air Challenge Report	Regional training sessions were held in only one technical area, compressed air. It was assumed that no software training was included in this training. Note A: Assumed to be analogous to MotorMaster training (.8). Note B: Assumed to be low, analogous to receiving a newsletter (.05).

Product/Service Area	**Reference Source**	**Limitations and Qualifications**
SOFTWARE DISTRIBUTED Downloaded from Web Sent individually by Clearinghouse Sent as part of Decision Tool CD Acquired in the DOE Reading Room Number of plants per software system distributed (See Note A) Fraction of plants implementing actions (See Note B) Fraction of measures implemented Average energy savings per plant implementing actions	 - Best Practices Activity Report - Clearinghouse Database - Best Practices Activity Report - N/A - Xenergy Motor Challenge Report - Xenergy Motor Challenge Report - Based on IAC database - Based on CTA energy savings	Software systems encompassed in this analysis: PSAT, STEAM, AirMaster, 3E+, MotorMaster. All five are included in the Decision Tool CD. Note A: Numbers taken directly from XMCR for PSAT (.56) and MotorMaster (.8). Averages were derived from XMCR for STEAM and AirMaster (.6). Note B: Numbers taken directly from XMCR for PSAT (.48) and MotorMaster (.178). Used MotorMaster number for Steam and AirMaster. Assumed 3E+ use to be low (.05).
TIP SHEETS Number of sheets in technical area Number distributed in each technical area Number of plants per tip sheet distributed (See Note A) Fraction of plants implementing actions (See Note B) Fraction of measures implemented Average energy savings per tip sheet	 - Best Practices Website - Best Practices Activity Report - Xenergy Motor Challenge Report - Xenergy Motor Challenge Report - Based on IAC database - Calculated from IAC database	Tips sheets have been prepared for the following technical areas: steam, compressed air, and motors. Energy savings per tip sheet were calculated using average energy savings for related measures found in the IAC database. Note A: Assumed analogous to MotorMaster software training for motors and steam areas (.8). Used average for compressed air area (.6). Note B: Assumed use of tip sheets would be low, like the use of a newsletter (.05).
TECHNICAL ASSISTANCE CALLS Number of calls in technical area Fraction of callers taking action (See Note A) Average energy savings per call	 - Clearinghouse database - Xenergy Motor Challenge Report - Based on tip sheet savings	Technical assistance calls fell into these four technical areas: pumps, steam, compressed air, and motors. Note A: Fraction of callers assumed to take action was based on averages from XMCR.

Product/Service Area	**Reference Source**	**Limitations and Qualifications**
PUBLICATION PACKAGES Number of packages distributed in technical area - By Clearinghouse - By DOE Reading Room - By Allied Partners Fraction of publication package recipients implementing actions (see Note A) Average energy savings per publication package	- Clearinghouse database - N/A - Allied Partners Database - Xenergy Motor Challenge Report - Based on tip sheet savings	Publications were distributed in all technical areas. Publications considered here include case studies, technical reports, manuals, and reference documents. Not included in this category are tip sheets and newsletters. Note A: Assumed to be even lower than newsletters (.025).
PLANT-WIDE ASSESSMENTS	- ORNL PWA 2001 Summary Report	PWA energy savings could not be attributed to individual technical areas. This estimate includes only a small fraction of the projected number of plant replications.
ENERGY MATTERS NEWSLETTER Number of newsletters distributed Number of plants receiving newsletter (see Note A) Fraction of newsletters recipients implementing actions (See Note B) Average energy savings per newsletter	- Best Practices Activity Report - Xenergy Motor Challenge Report - Xenergy Motor Challenge Report - Based on tip sheet savings	Newsletter savings could not be attributed to individual technical areas. Note A: Taken directly from XMCR (.36). Note B: Adjusted down from XMCR (.05).
CASE STUDIES Number of case studies Energy savings per case study	- from LBNL (via Aimee McKane, from Bruce Lung)	compressed air case studies only; report measures undertaken

Table A.2. Best Practice Program Activities by Technical Area, 2001

Technical Area/ Activity	Pumps	Process Heat	Steam	Compressed Air	Motors	Insulation	General
CTAs	13	8	14	14	0	0	-
Software Training Attendees	172	0	42	44	217	0	-
Regional Training	0	0	0	1343	0	0	-
Software Distributed	6599	0	7527	5175	9354	6966	-
Tip Sheets	0	0	9475	5775	4525	0	-
Technical Assistance Calls	14	0	198	136	478	0	-
Publication Packages	670	46	1000	1061	4034	45	-
Plant-wide Assessments	-	-	-	-	-	-	14
Newsletter	-	-	-	-	-	-	30000
Case Studies	-	-	-	20	-	-	-

Table A.3. Energy Savings per Selected Best Practices Activities by Technical Area (million Btu)

Technical Area/ Activity	Pumps	Process Heat	Steam	Compressed Air	Motors	Insulation	General
CTAs	**78009**	**284000**	**121249**	**46572**	-	-	-
Software Training	*78009*	-	*121249*	*46572*	**265**	-	-
Regional Training	-	-	-	*1876*	-	-	-
Software Distributed	*39005*	-	*121249*	*23286*	**265**	**147304**	-
Tip Sheets	-	-	**2081**	**2851**	**288**	-	-
Technical Assistance Calls	*288*	-	*2081*	*2851*	*288*	-	-
Publication Packages	*45*	*45*	*45*	*45*	*45*	*45*	-

Plant-wide Assessments	-	-	-	-	-	-	**211485**
Newsletter	-	-	-	-	-	-	**45**
Case Studies	-	-	-	**39957**	-	-	-

LIST OF ACRONYMS

BP	Best Practices Program
CTA	Collaborative Targeted Assessment
DOE	U.S. Department of Energy
IAC	Industrial Assessment Center Program
IOF	Industry of the Future
NEMA	National Electrical Manufacturers' Association
NREL	National Renewable Energy Laboratory
OIT	Office of Industrial Technologies
ORNL	Oak Ridge National Laboratory
PHAST	Process Heating Assessment Tool
PSAT	Pump System Analysis Tool
PWA	Plant-Wide Assessment
SEP	State Energy Program

INTERNAL DISTRIBUTION

1. M.A. Brown
2. T.R. Curlee
3. J.F. Eisenberg
4. E.C. Fox
5-6. K.M. Friedman
7. S.L. Glatt
8. A. Gluck
9. S.G. Hildebrand
10. P.J. Hughes
11-12. M.A. Martin
13-33. M. Olslowski
34. P. H. Salmon-Cox
35. M. Schweitzer
36. R.B. Shelton
37. A. Thomas
38-39. B.E. Tonn
40-32. ESD Library
33. ORNL Central Research Library
34. ORNL Laboratory Records-RC