OAK RIDGE NATIONAL LABORATORY

MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

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RESULTS FROM THE U.S. DOE 2008 *SAVE ENERGY NOW* ASSESSMENT INITIATIVE:

DOE's Partnership with U.S. Industry to Reduce Energy Consumption, Energy Costs, and Carbon Dioxide Emissions

DETAILED ASSESSMENT OPPORTUNITY DATA REPORT

July 2010

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Save ENERGY Now

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Energy and Transportation Science Division

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Prepared by
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1. INTRODUCTION

In October 2005, U.S. Department of Energy Secretary Bodman launched his *Easy Ways to Save Energy* campaign with a promise to provide energy assessments to 200 of the largest U.S. manufacturing plants. DOE's Industrial Technologies Program (ITP) responded to the Secretary's campaign with its *Save Energy Now* initiative, featuring a new and highly cost-effective form of energy savings assessment.

The approach for these assessments drew heavily on the existing resources of ITP's technology delivery component. Over the years, ITP Technology Delivery has worked with industry partners to assemble a suite of respected software tools, proven assessment protocols, training curricula, certified energy experts, and strong partnerships for deployment.

The *Save Energy Now* assessments conducted in calendar year 2006 focused on natural gas savings and targeted many of the nation's largest manufacturing plants – those that consume at least 1 TBtu of energy annually. The 2006 *Save Energy Now* assessments focused primarily on assessments of steam and process heating systems, which account for an estimated 74% of all natural gas use by U.S. manufacturing plants.

Because of the success of the *Save Energy Now* assessments conducted in 2006 and 2007, the program was expanded and enhanced in two major ways in 2008: 1) a new goal was set to perform at least 260 assessments; and 2) the assessment focus was expanded to include pumping, compressed air, and fan systems in addition to steam and process heating. DOE ITP has also developed software tools to assess energy efficiency improvement opportunities in pumping, compressed air, and fan systems.

The *Save Energy Now* assessments integrate a strong training component designed to teach industrial plant personnel how to use DOE's opportunity assessment software tools. This approach has the advantages of promoting strong buy-in of plant personnel for the assessment and its outcomes and preparing them better to independently replicate the assessment process at the company's other facilities.

Another important element of the *Save Energy Now* assessment process is the follow-up process used to identify how many of the recommended savings opportunities from individual assessments have been implemented in the industrial plants. Plant personnel involved with the *Save Energy Now* assessments are contacted 6 months, 12 months, and 24 months after the assessments are completed to determine implementation results.

A total of 260 *Save Energy Now* assessments were successfully completed in calendar year 2008. This means that a total of 718 assessments were completed in 2006, 2007, and 2008. As of July 2009, we have received a total of 239 summary reports from the ESAs that were conducted in year 2008. Hence, at the time that this report was prepared, 680 final assessment reports were completed (200 from year 2006, 241 from year 2007, and 239 from year 2008). The total identified potential cost savings from these 680 assessments is $1.1 billion per year, including natural gas savings of about 98

TBtu per year. These results, if fully implemented, could reduce CO_2 emissions by about 8.9 million metric tons annually.

When this report was prepared, data on implementation of recommended energy and cost savings measures from 488 *Save Energy Now* assessments were available. For these 488 plants, measures saving a total of $147 million per year have been implemented, measures that will save $169 million per year are in the process of being implemented, and plants are planning implementation of measures that will save another $239 million per year. The implemented recommendations are already achieving total CO_2 reductions of about 1.8 million metric tons per year.

This report provides detailed information on key results for all of the 2008 assessments of steam, process heating, pumping, compressed air, and fan systems. This report discusses the opportunities in the top 10 categories, and identified savings and payback summary for different system type assessments. A separate report (Wright et al. 2010) provides a summary of the key results of the *Save Energy Now* assessments completed in 2008, the 6-month, 12-month, and 24-month implementation results obtained to date, an evaluation of these implementation results, and key accomplishments, findings, and lessons learned from the *Save Energy Now* assessments completed to date.

Two prior reports (Wright et al. 2007 and Wright et al. 2009) detail the results from the 2006 and 2007 assessments and discuss the major components of the assessment process and improvements in the process made in 2007.

2. OVERVIEW OF THE 2008 *SAVE ENERGY NOW* ASSESSMENT PROCESS

2.1 A Unique Approach

The *Save Energy Now* in-plant energy efficiency assessments use a unique approach. Energy audits or assessments are typically done by energy experts who go into a plant, identify potential savings opportunities, and write reports that are left with plant personnel after the assessments are completed. *Save Energy Now* assessments, in contrast, have a training element. These assessments focus on hands-on demonstrations to industrial plant personnel specifically on how to use the DOE steam, process heating, pumping, compressed air, and fan software tools. Assessments are done in no more than three days, so, by necessity, they are very focused assessments. When making contact with a plant, the Energy Expert identifies a Plant Lead who has to agree to stay with the Energy Expert during the entire three-day assessment. The Energy Expert, Plant Lead, and other plant personnel who participate in the assessment identify some "target" opportunities to investigate using the DOE software. The target opportunities chosen are often those with the potential to achieve significant plant energy and cost savings. The Energy Expert and plant personnel identify any data requirements for assessing the target opportunity, obtain or measure data as necessary, and enter that data in the DOE software to quantify a specific energy savings opportunity. Often no more than three or four target opportunities are investigated during an assessment.

On the last day of the assessment, a required Closeout Meeting is held to review and discuss the opportunities identified in the assessment. Plant management personnel are invited to attend and participate. Prior to the Closeout Meeting, the Energy Expert and the Plant Lead agree on the opportunities that will be highlighted at the meeting and documented in the final assessment report. Only the opportunities approved by the Plant Lead are presented or discussed at the Closeout Meeting.

The positive effect of using this approach for conducting assessments is that: 1) plant personnel get hands-on experience in effectively using the DOE software tools and the opportunity to see the value of applying these tools to their operations; 2) plant personnel are willing to ***buy-in*** to the opportunities identified and evaluated during the assessment, which increases the likelihood that the identified opportunities will implemented ; and 3) opportunities are investigated that often can result in significant energy and cost savings for the plant.

A full discussion of the *Save Energy Now* assessment process is provided in the 2006 *Save Energy Now* Assessment Summary Report (Wright et al. 2007).

2.2 DOE ITP Decision Software Tools Used in 2008 *Save Energy Now* Assessments

The ITP program developed a suite of software-based decision tools to help industrial plant personnel identify energy efficiency improvements for plant process and utility systems. These tools use analytical models to evaluate process heating, steam, pumping, compressed air, fan, motor, and other plant utility systems. There is also a Quick Plant Energy Profiler, or "Quick PEP," online software tool that helps industrial plant personnel to quickly understand how energy is used at the plant and how they might save energy and reduce costs.

All of the software tools focus on energy efficiency "opportunity" assessments — quantifying the potential savings from specific improvements. For example, there are often potential savings from increasing condensate return in steam systems or reducing excess oxygen to furnaces for process heating.

DOE ITP has partnered with key trade associations and focused technical groups to develop the software tools. For example, DOE worked with the Hydraulics Institute to develop the pump tool, with the International Heating Equipment Association to develop the process heating tool, with the Compressed Air Challenge to develop the AirMaster+ tool, and with the Air Movement and Controls Association to develop the fan tool.

The DOE steam, process heating, pumping, compressed air, and fan system software tools, described below, were used for the2008 assessments.

More details about all of the DOE ITP decision software tools can be found at the following Web link: http://www1.eere.energy.gov/industry/bestpractices/software.html.

2.2.1 Steam System Scoping Tool (SSST), Steam System Assessment Tool (SSAT) and 3E-Plus

Three tools address steam systems. SSST is a pre-screening tool that allows plant personnel to develop a greater awareness of steam system improvement opportunities in their facilities. An SSST analysis was performed for each steam assessment. SSAT estimates the impacts of key improvements for models of representative steam systems. SSAT generates results detailing the energy, cost, and emissions savings that could be achieved by up to 18 different improvements. 3E-Plus calculates the most economical thickness of industrial insulation for operating conditions specified by the user.

2.2.2 Process Heating Assessment and Survey Tool (PHAST) and Process Heating Scorecard

PHAST is a tool for surveying process heating equipment that uses fuel, electricity, or steam (though modeling for only the direct-fuel-fired systems is presently developed) and identifying the most energy-intensive equipment. PHAST performs energy (heat) balances on furnaces to identify ways to improve efficiency. PHAST has several calculators that compare the performance of individual pieces of equipment under various operating conditions. The Process Heating Scorecard is a pre-screening tool.

2.2.3 Pump System Assessment Tool (PSAT)

PSAT uses data that are typically available or easily obtained in the field (e.g., pump head, flow rate, and motor power) to estimate potential energy and dollar savings in industrial pump systems. PSAT assesses current pump system operating efficiency by comparing field measurements of the power delivered to the motor with the fluid work (flow and head) required by the application. It estimates a system's achievable efficiency based on pump efficiencies and performance characteristics of pumps and motors. PSAT also provides a pre-screening filter to identify areas that are likely to offer the greatest savings.

2.2.4 AirMaster+ Compressed Air System Performance Software

AirMaster+ provides a systematic approach for assessing the supply-side performance of compressed air systems. Using plant-specific data, the software effectively evaluates supply-side operational costs for various equipment configurations and system profiles. It provides useful estimates of the potential savings to be gained from selected energy efficiency measures and calculates the associated simple payback periods for implementing these measures.

2.2.5 Fan System Assessment Tool (FSAT)

FSAT helps users quantify energy consumption and energy savings opportunities in industrial fan systems. With FSAT, users can calculate the amount of energy used by a fan system, determine system efficiency, and quantify the savings potential of an upgraded fan system. FSAT estimates the work done by the fan system and compares that to the estimated energy input to the system. The tool also provides a pre-screening filter to identify fan systems that are likely to offer optimization opportunities.

3. DETAILED ASSESSMENT OPPORTUNITY RESULTS FOR THE 2008 *SAVE ENERGY NOW* ASSESSMENTS

In 2008, 239 *Save Energy Now* assessments (assessments with summary reports submitted) were performed in large U.S. industrial plants. A total of 74 steam assessments, 51 process heating assessments, 60 compressed air assessments, 29 pumping assessments, 17 fan assessments, and 8 multi-system paper assessments were completed.

At the time this report was prepared, assessment reports for 134 of the plants visited in 2008 were available. The data from completed 2008 assessment reports is for 41 steam assessments, 34 process heating assessments, 37 compressed air assessments, 13 pumping assessments, and 9 fan system assessments.

Figure 1 is a color-coded U.S. map that illustrates how many of the 2006, 2007 and 2008 assessments have been performed in each state. The map shows that there are 24 states where at least 10 *Save Energy Now* assessments were completed. More than 20 assessments have been conducted in the states of Texas, Wisconsin, Michigan, Illinois, Indiana, Ohio, Pennsylvania, Tennessee, Louisiana, Alabama and Georgia, respectively.

Table 2 provides a summary of how many of each type of Save Energy Now assessments were conducted in each state. The states with the largest number of assessments of one or two type include Texas (28 steam assessments and 23 process heating assessments), Wisconsin (32 steam assessments), and Michigan (17 compressed air assessments and 17 steam assessments). Many of these states rank high in terms of industrial energy consumption.

Table 3 and Figure 2 show the industrial sectors in which the Save Energy Now assessments were performed. Of the 680 assessments that were finalized in 2006 through 2008, 582 were performed in chemical manufacturing, paper manufacturing, food, primary metals, transportation equipment, non-metallic mineral, petroleum and coal, and plastic and rubber product plants. The industries in which the most assessments were performed were:

- 73 steam and 26 process heating assessments in chemical manufacturing plants,
- 59 steam assessments in paper manufacturing plants,
- 59 steam assessments in food processing plants,
- 55 process heating assessments in primary metals plants,
- 28 compressed air and 24 steam assessments in transportation equipment plants, and
- 35 process heating assessments in non-metallic mineral product plants.

Figures 3 and 4 provide a broad comparison of results of the 2006 through 2008 assessments. The potential $284 million of annual energy cost savings and 43.3 TBtu of annual source-energy savings identified and recommended in the 2008 assessments were substantial. In general, however, the recommended cost and energy savings from the 2008 assessments were less than from the 2006 assessments. The total recommended cost savings from the 239 assessments from 2008 were about 55% of those from the 200 assessments from 2006; recommended source-energy savings from the 2008 assessments were about 75% of those from the 2006 assessments.

A major difference between the 2006, 2007, and 2008 assessments was the addition of pumping, compressed air, and fan assessments in 2007 and 2008. The potential annual cost savings identified by the 2008 assessments of 106 pumping, compressed air, and fan systems (where there is available data), is about $48.5 million (see Figure 3), much less than $195.4 million potential annual cost savings identified by 125 steam and process heating assessments from 2008. Much of the difference between 2006 and 2007-2008 assessment results is attributable to the greater identified savings opportunities in steam and process heating assessments than in pumping, compressed air, and fan system assessments.

In performing the *Save Energy Now* assessments, the Energy Experts used standard — or "pick-list" — wordings whenever possible to classify the identified opportunities. This was done so that the savings opportunity data could be analyzed using these pick-list categories. Tables 4 through 8 present the opportunity pick-list categories for steam, process heating, pumping, compressed air, and fan system assessments.

Tables 9 through 13 present detailed information on potential cost, energy, and CO_2 emissions reductions for all available 2006 through 2008 assessment results. Figures 5 through 10 illustrate the potential cost savings that could result from the "Top 10" energy savings opportunities — ranked by total recommended cost savings — for steam, process heating, pumping, compressed air, fan, and multi-system paper plant assessments. For each of the assessment areas, the Top 10 opportunities capture the majority of the energy cost savings identified from assessments completed in 2006 through 2008 (Table 1):

Table 1. Identified energy cost savings captured by Top 10 opportunities

System type assessed	Annual potential savings captured in Top 10	Percentage of total savings for system type
Steam	$514	84%
Process heating	$222	70%
Pumping	$16.2	99%
Compressed air	$18	93%
Fan	$40.7	100%
Multi-system paper	$40	100%

The Energy Experts estimated high and low values of the capital costs for implementing each identified savings opportunity and used the higher values to estimate payback periods. Savings payback period (in years) is defined as (cost to implement opportunity)/ (yearly savings for the opportunity). Most industrial plants will not consider implementing savings opportunities that have payback periods longer than two years.

Estimated payback results for the 2006 through 2008 *Save Energy Now* assessments are summarized in Table 14 and Figures 11 and 12. Some of the key results shown in the table and figures are summarized below:

- A total of 3,823 energy saving opportunities were identified for the 680 assessments, an average of 5.6 opportunities per assessment.
- When all results are averaged, almost 70% of all identified opportunities have estimated paybacks of 2 years or less.
- The estimated paybacks of about 70% of the identified steam, process heating, and compressed air opportunities had estimated paybacks of 2 years or less.
- The data for pumping and fan assessments is slightly different — about 40% to 50% of the identified opportunities had estimated paybacks of 2 years or less.

The available data can be analyzed to determine average percentages of plant energy cost and source-energy use represented by each pick-list category. Tables 15 through 19 present this data. Figures 13 through 18 show the “Top 10” identified opportunities for each assessment area, based on estimated average plant source-energy savings. The following are the key results presented in these tables and figures. It should be noted that this data is based on plant source-energy use, which in many cases is largely for fired systems at these large plants.

- The data for steam and process heating assessments show that many of the identified opportunities could save more than 1.5% of plant source-energy use.
- A number of the compressed air and fan opportunities could also save 1% or more of plant source-energy use.
- Potential source-energy-use savings for individual opportunities identified in pump system assessments are somewhat lower than for the other systems. Savings opportunities, however, are still substantial, in the range of 0.2% of plant source-energy use.

4. REFERENCES

Wright, Anthony, Michaela Martin, Sachin Nimbalkar, James Quinn, Sandy Glatt, and Bill Orthwein, 2010. Results from the U.S. DOE 2008 *Save Energy Now* Assessment Initiative: Summary and Lessons Learned. Oak Ridge National Laboratory, ORNL/TM-2010/145.

Wright, Anthony, Michaela Martin, Sachin Nimbalkar, James Quinn, Sandy Glatt, and Bill Orthwein, 2009. Results from the U.S. DOE 2007 *Save Energy Now* Assessment Initiative: Summary and Lessons Learned. Oak Ridge National Laboratory, ORNL/TM-2009/075.

Wright, Anthony, Michaela Martin, Bob Gemmer, Paul Scheihing, and James Quinn, 2007. Results from the U.S. DOE 2006 *Save Energy Now* Assessment Initiative. Oak Ridge National Laboratory, ORNL/TM-2007/138.

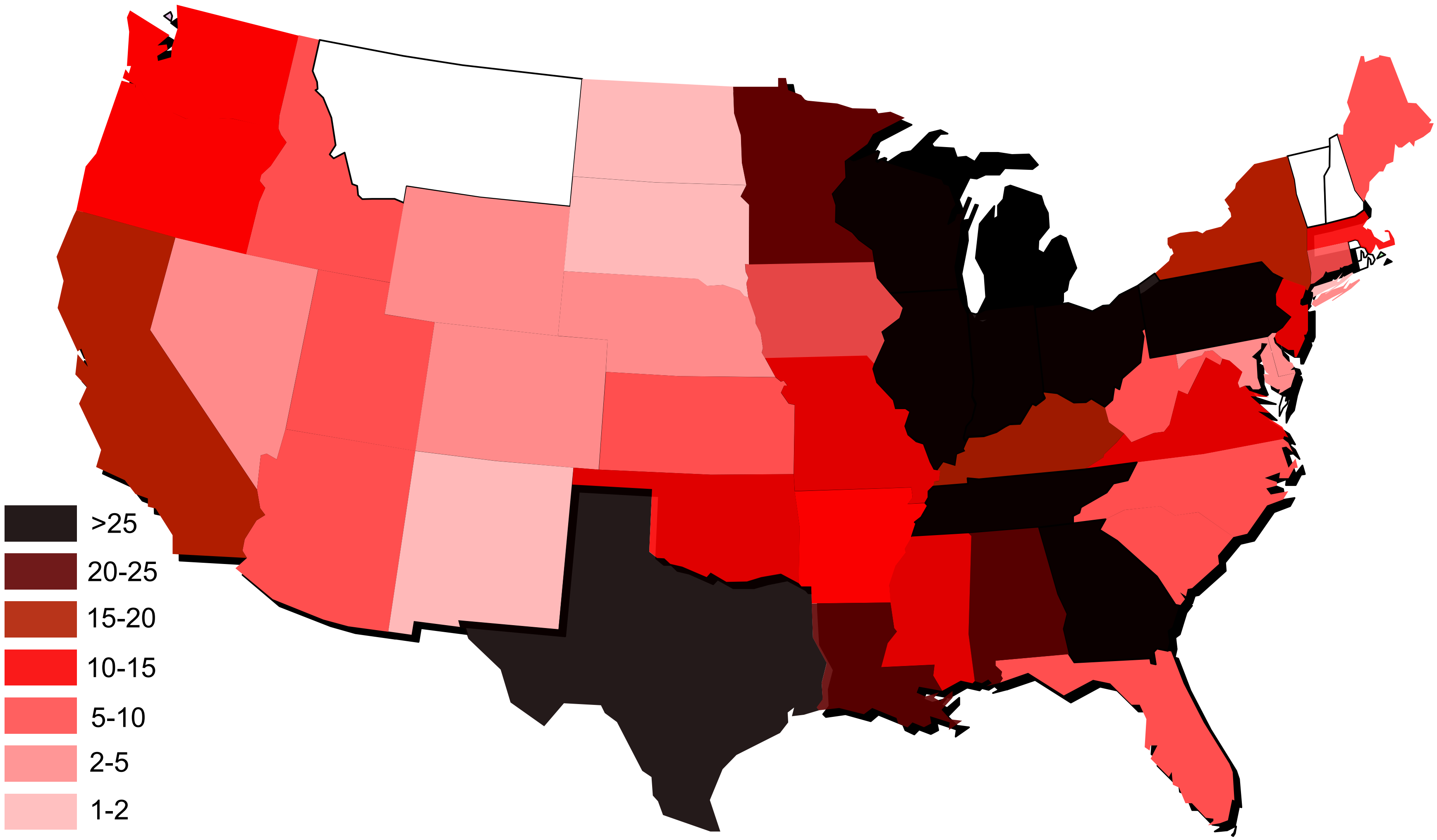

Figure 1. More than 25 *Save Energy Now* assessments were completed in Texas, Wisconsin, Michigan, Indiana, Illinois, Tennessee, Ohio, Pennsylvania and Georgia, respectively, in 2006, 2007 and 2008. (Based on 718 completed assessments (200 assessments in year 2006, 258 in year 2007 and 260 in year 2008). As of July 1, 2009, summary reports are available for 680 assessments.

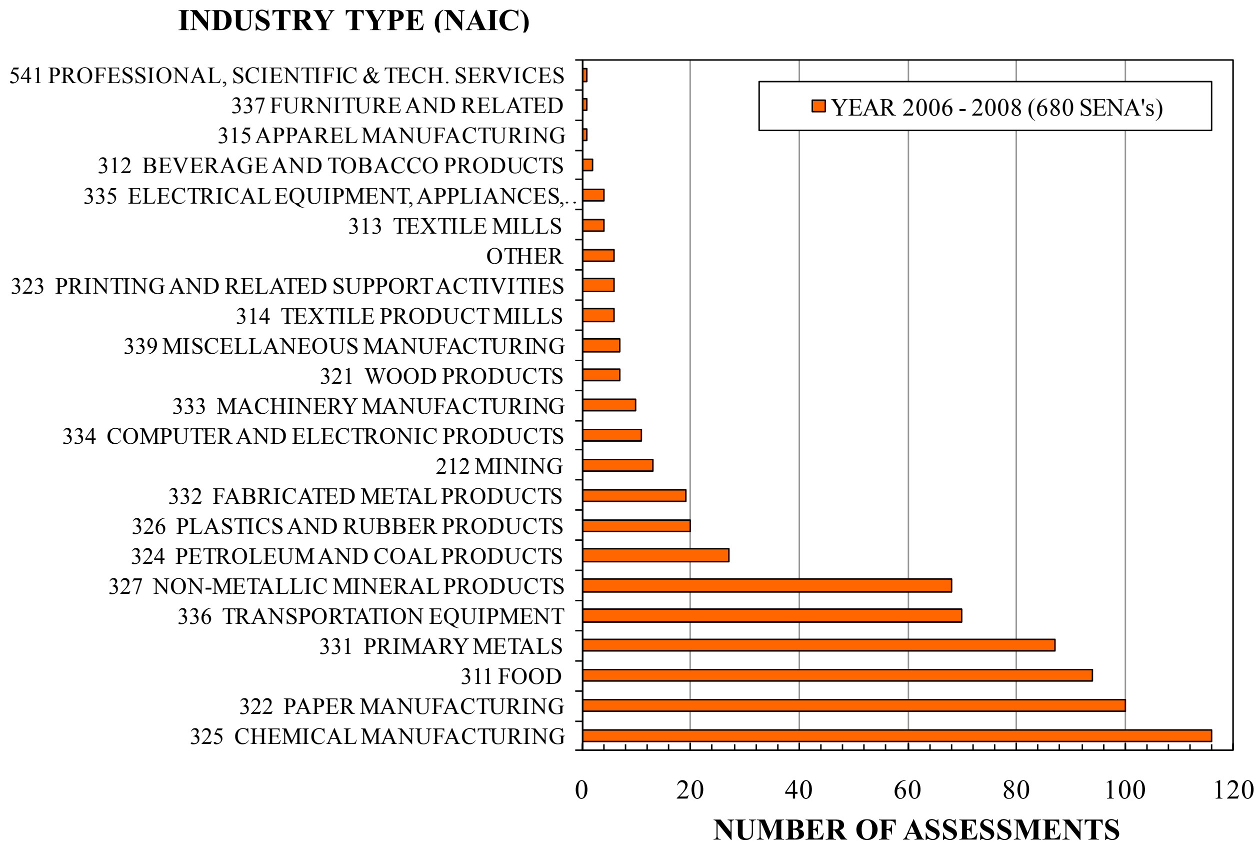

Figure 2. Of the 680 *Save Energy Now* assessments completed in 2006, 2007, and 2008, 535 were completed in the chemical, paper, food, primary metals, transportation equipment, and non-metallic mineral industries.

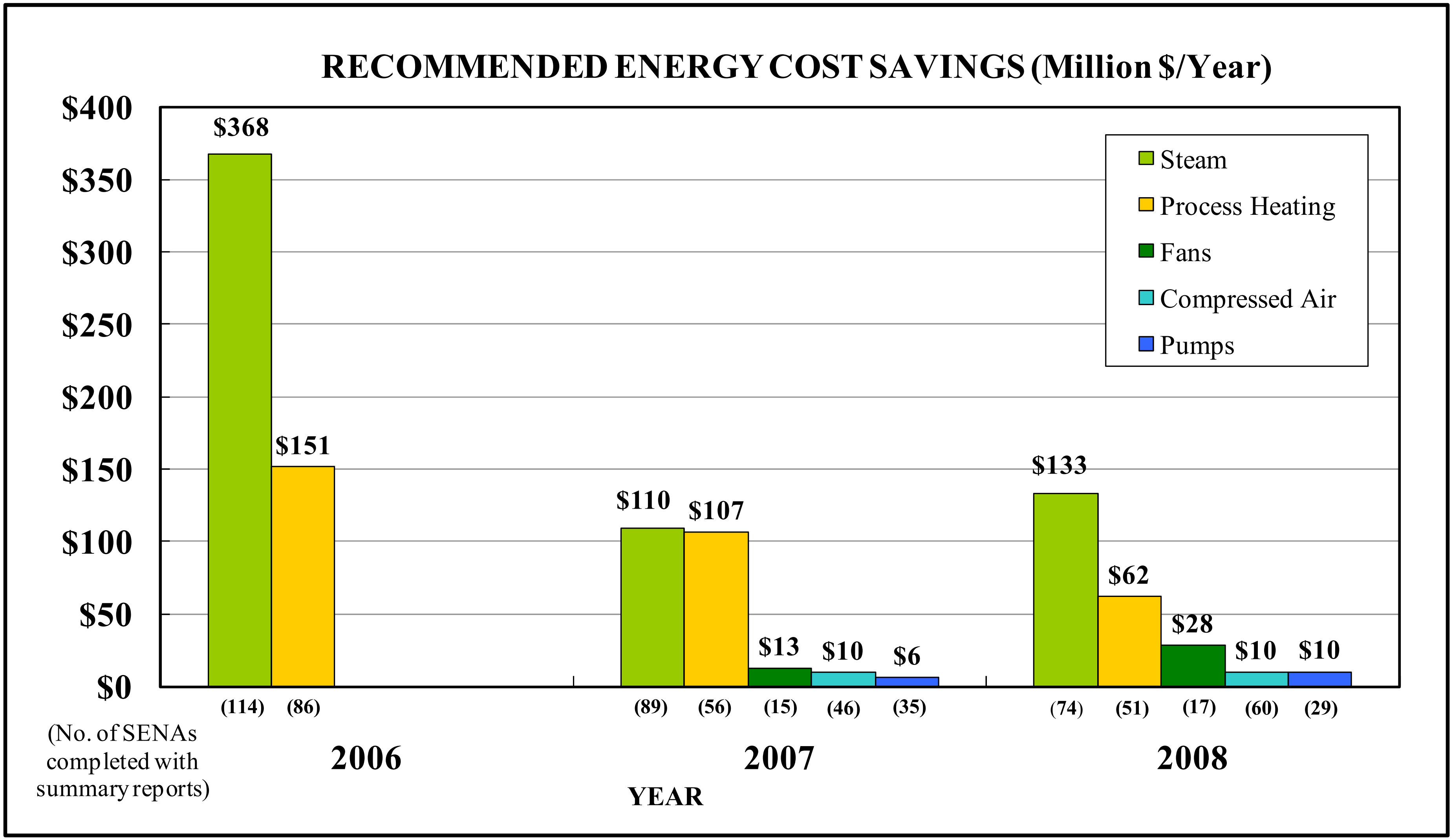

Figure 3. The total recommended energy cost savings from 241 *Save Energy Now* assessments (SENAs) completed in 2007 was $244 million per year, and $284 million per year for the 239 assessments completed in 2008. These are about 47% and 55% of the recommended cost savings from the 2006 assessments.

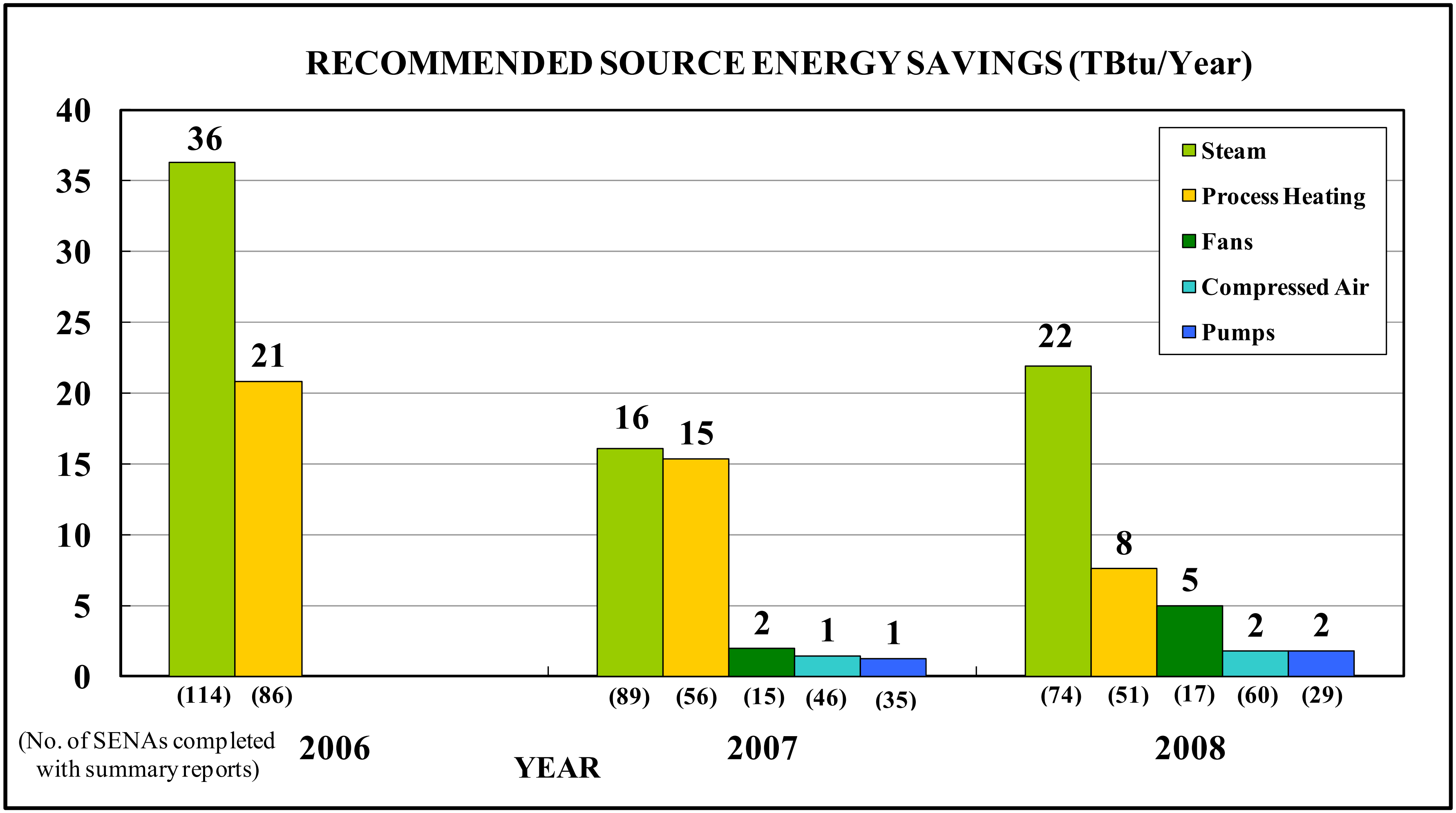

Figure 4. The total recommended source-energy savings from the 241 *Save Energy Now* assessments (SENAs) completed in 2007 was 36 TBtu per year, and from the 239 assessments completed in 2008 was 43.3 TBtu per year. These are about 60% and 75% of the recommended source energy savings from the 2006 assessments respectively.

TOP "10" STEAM OPPORTUNITIES

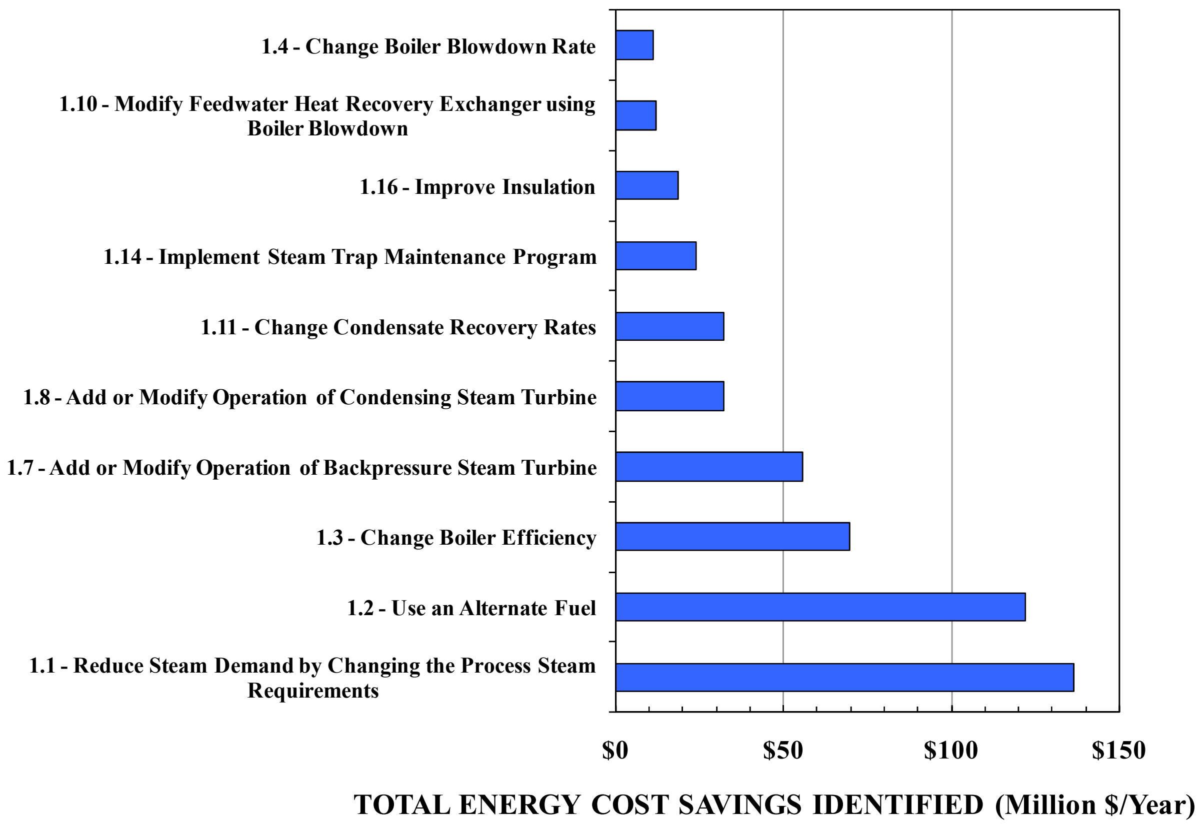

Figure 5. Opportunities in the top 10 steam categories for the 2006, 2007, and 2008 *Save Energy Now* assessments could result in plant energy savings of $514 million per year.

TOP "10" PROCESS HEATING OPPORTUNITIES

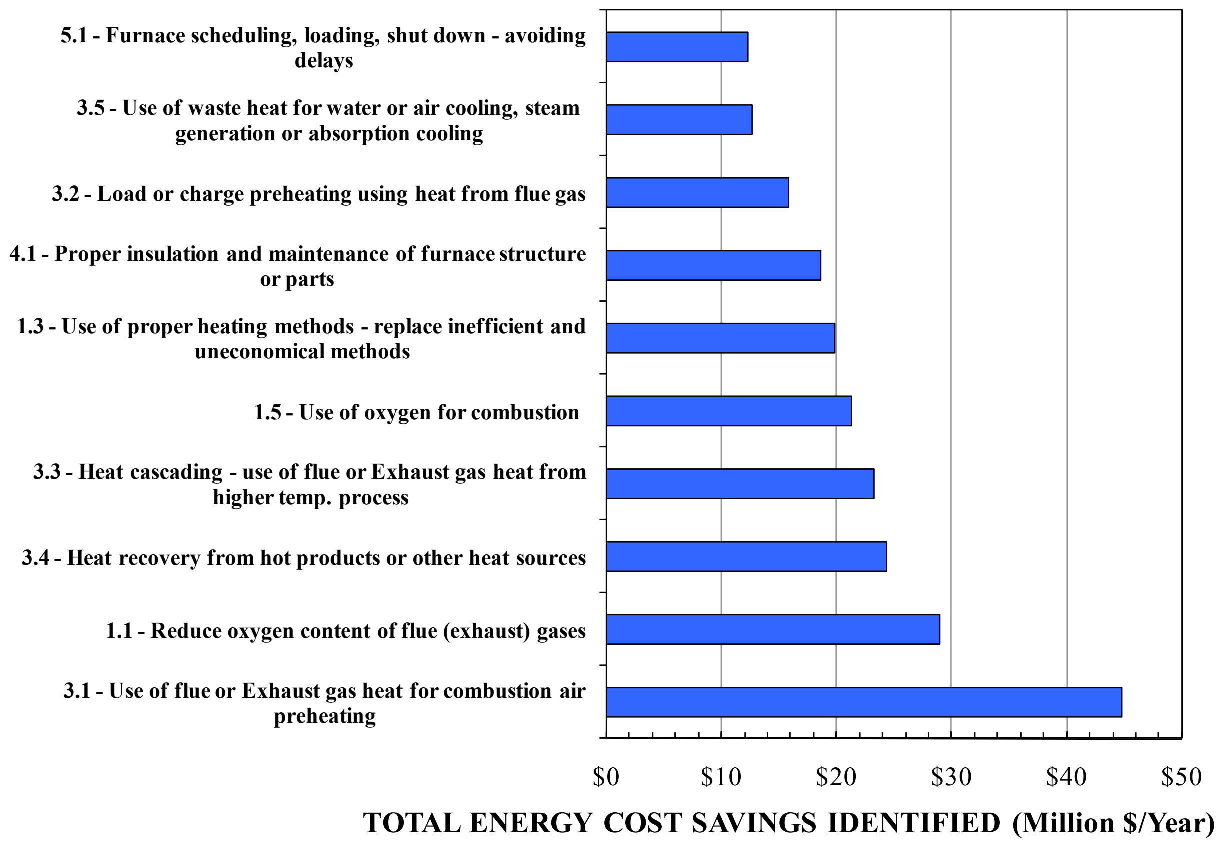

Figure 6. Opportunities in the top 10 process heating categories for the 2006, 2007, and 2008 *Save Energy Now* assessments could result in plant energy savings of $222 million per year.

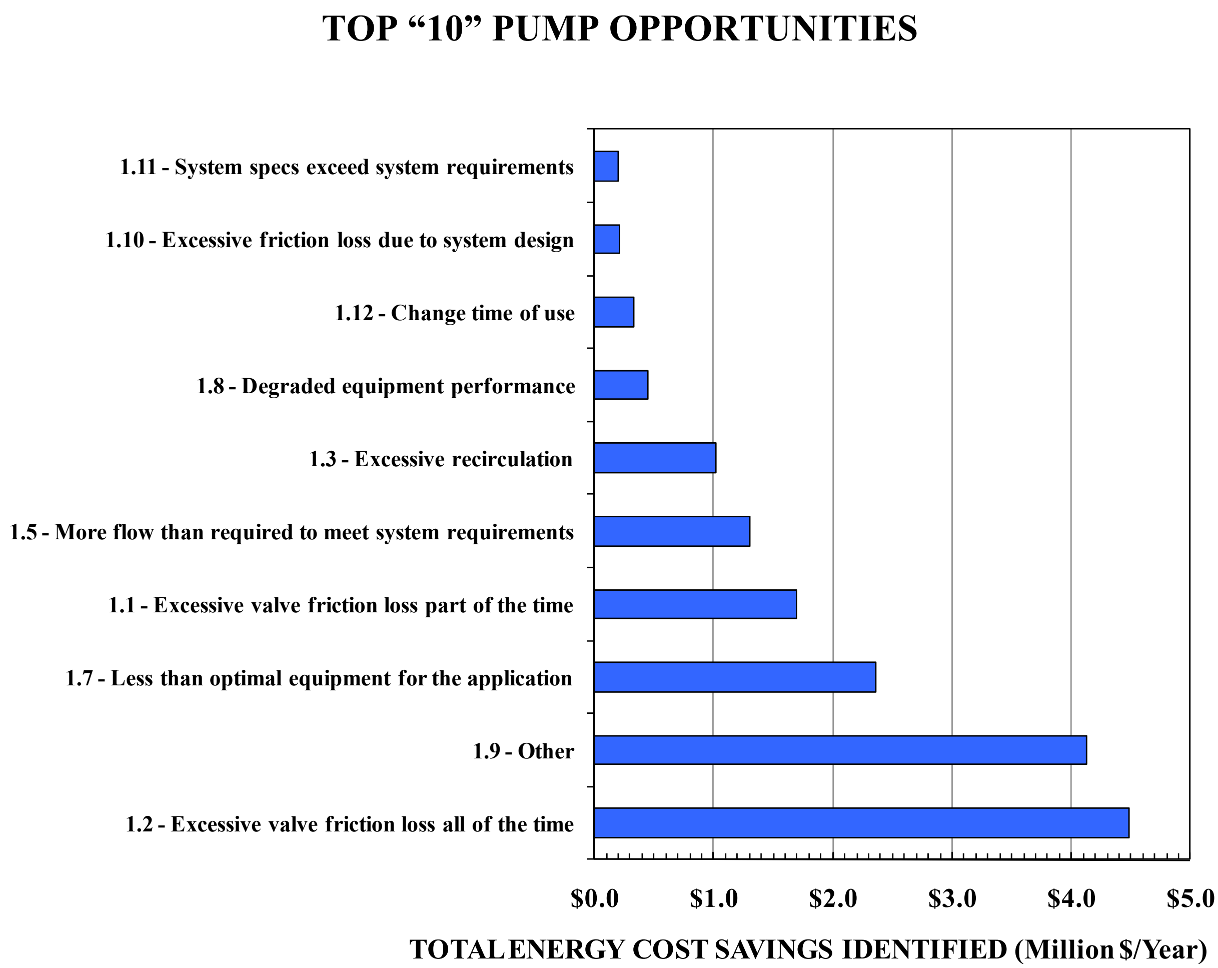

Figure 7. Opportunities in the top 10 pumping categories for the 2007 and 2008 *Save Energy Now* assessments could result in plant energy savings of $16.2 million per year.

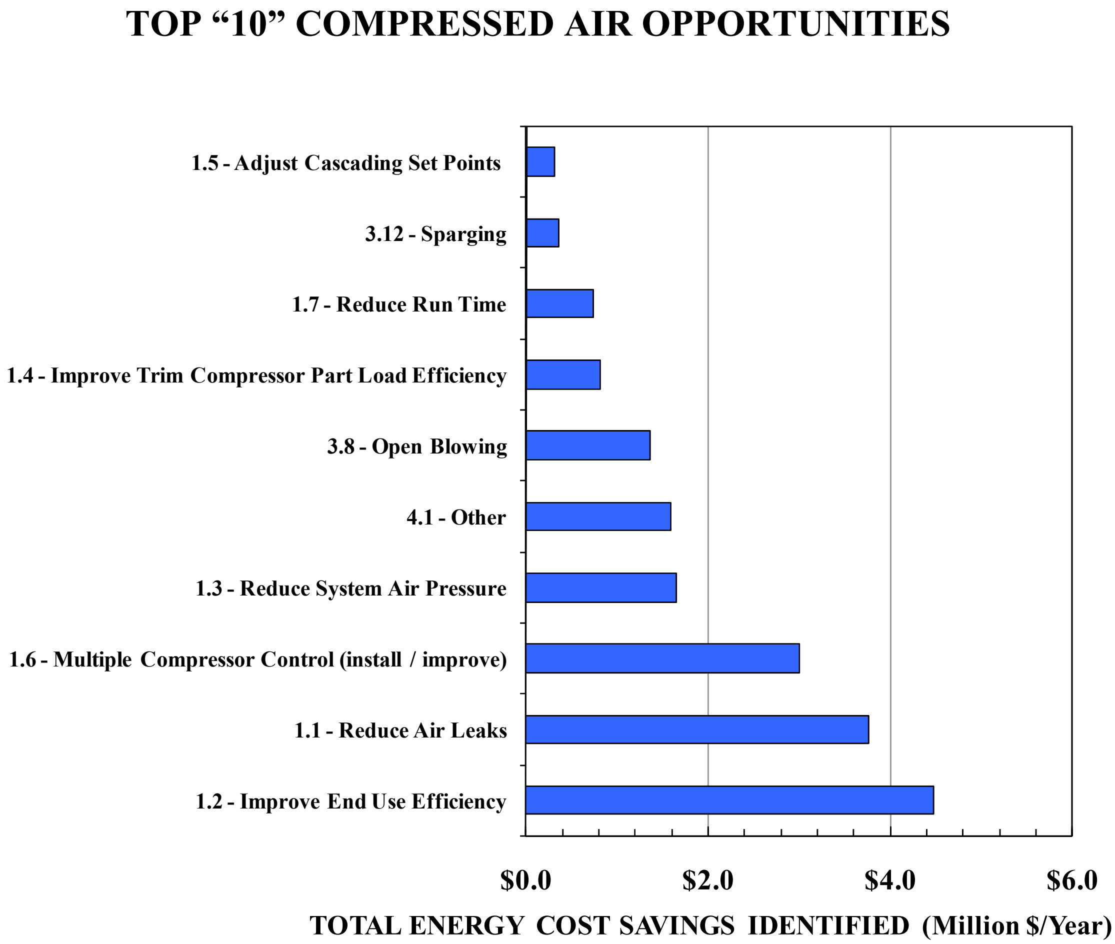

Figure 8. Opportunities identified in the top 10 compressed air categories for the 2007 and 2008 *Save Energy Now* assessments could result in $18 million per year of plant energy savings.

TOP "10" FAN OPPORTUNITIES

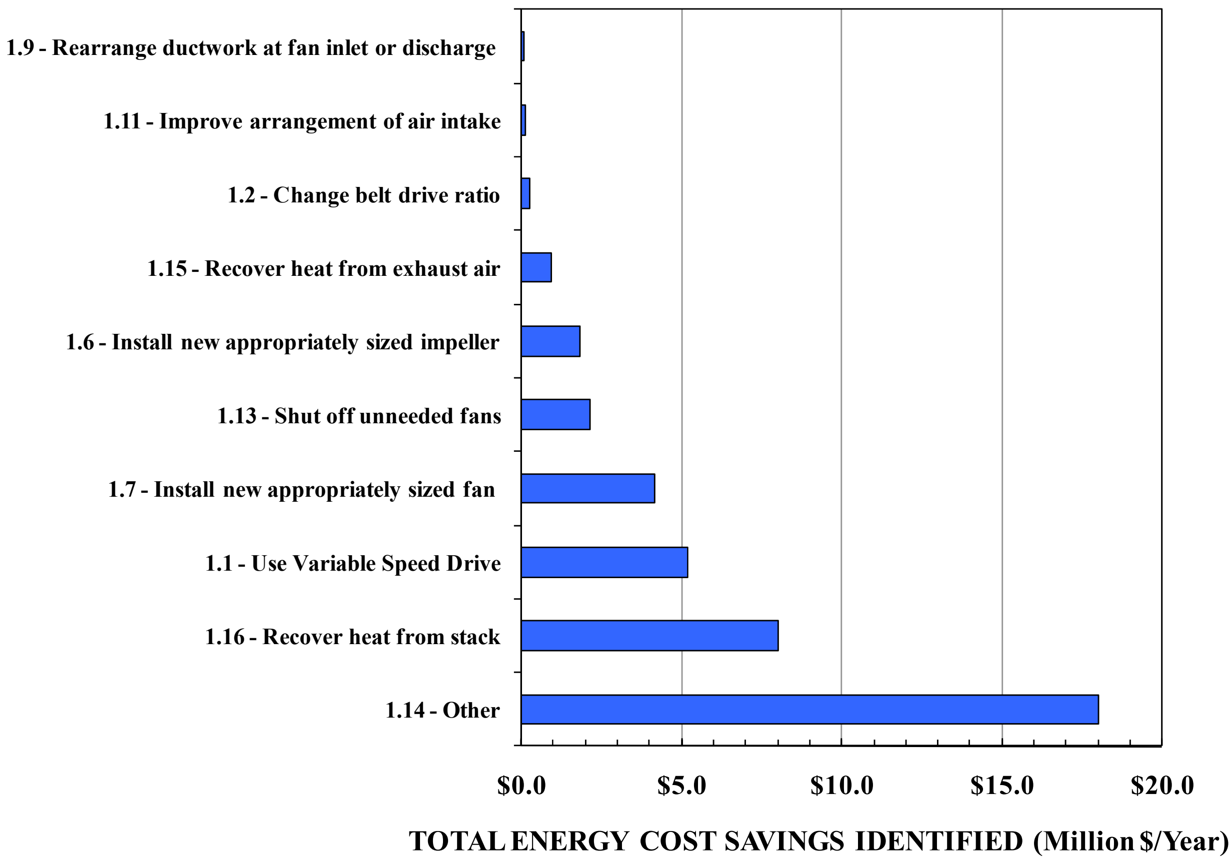

Figure 9. Opportunities identified in the top 10 fan categories for the 2007 and 2008 *Save Energy Now* assessments could result in $41 million per year of plant energy savings.

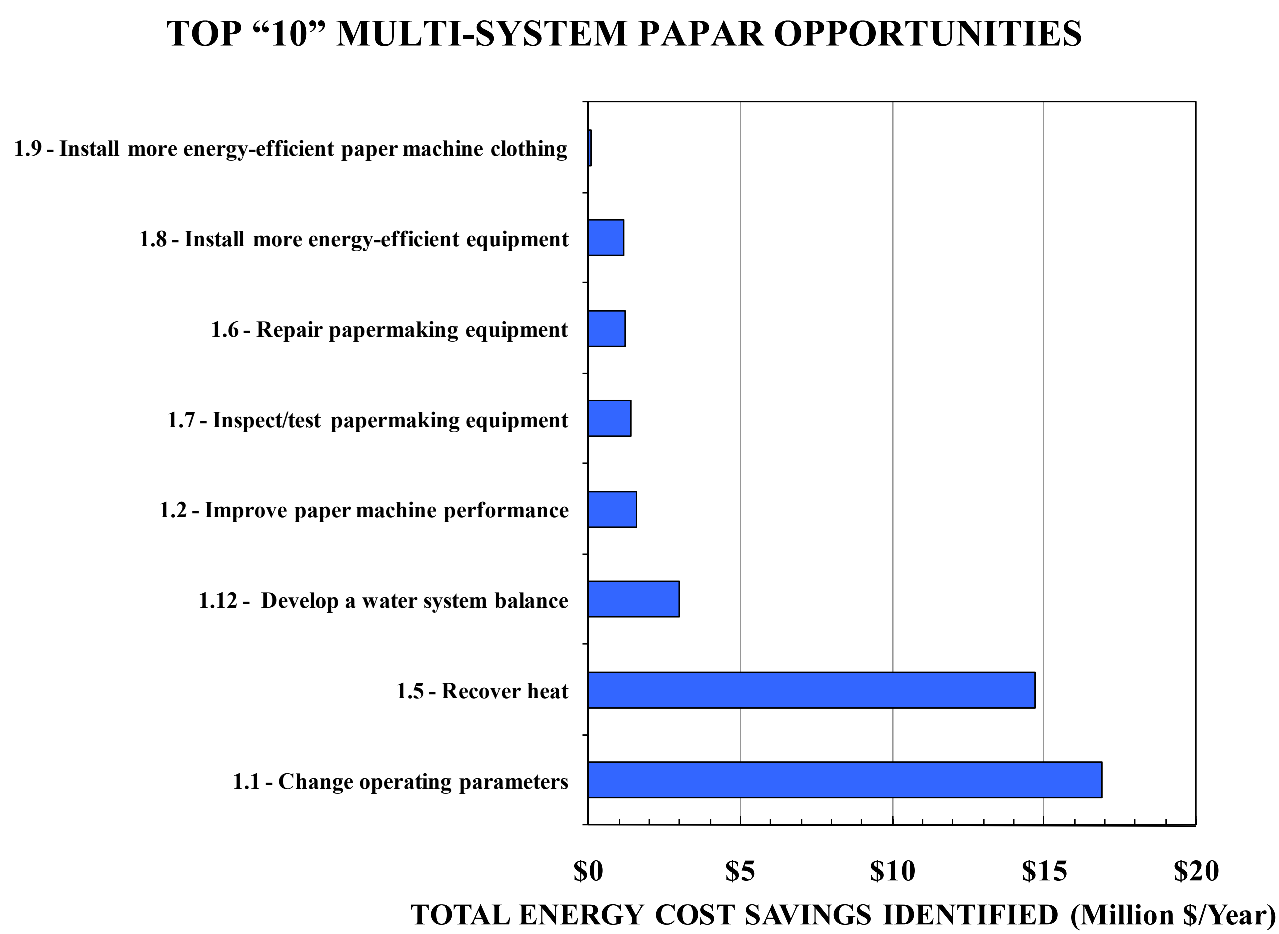

Figure 10. Opportunities identified in the top 10 multi-system paper categories for the 2007 and 2008 *Save Energy Now* assessments could result in $40 million per year of plant energy savings.

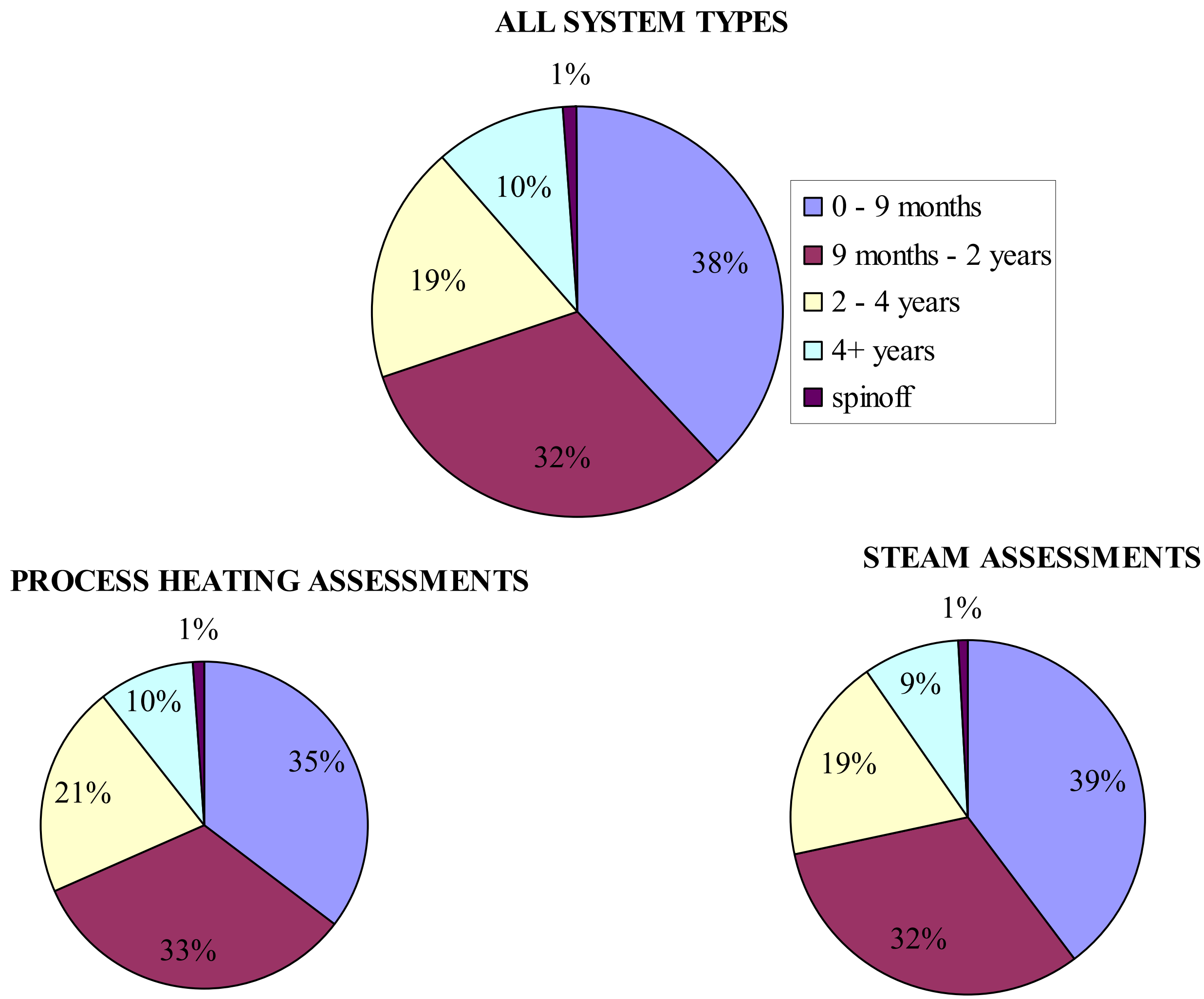

Figure 11. About 70% of all opportunities identified in 2006, 2007, and 2008 *Save Energy Now* assessments have estimated paybacks of less than 2 years.

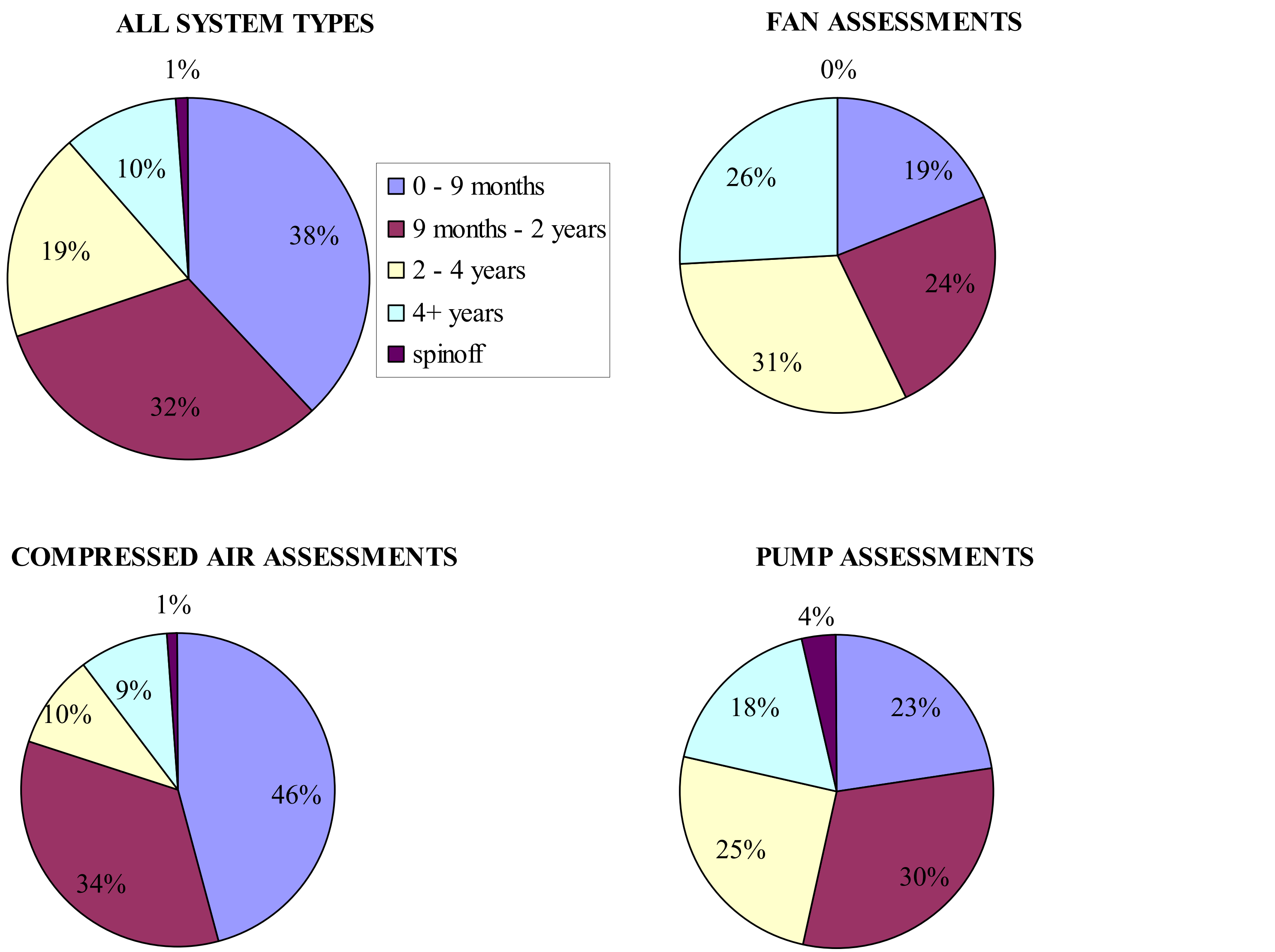

Figure 12. About 80% of the opportunities identified in compressed air assessments have estimated paybacks of less than 2 years. About 40 to 50% of the opportunities identified in the pumping and fan assessments have estimated paybacks of less than 2 years.

TOP "10" STEAM OPPORTUNITIES

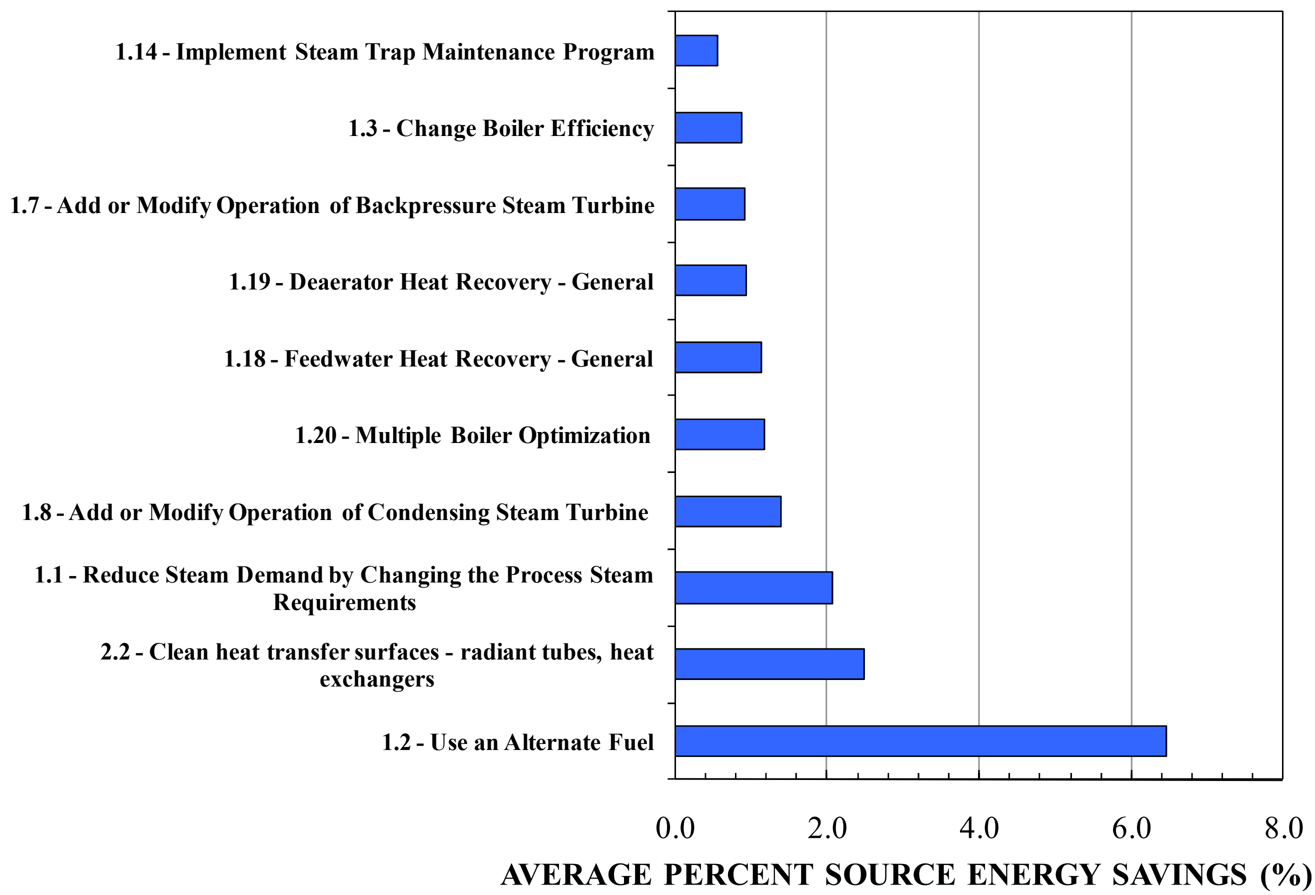

Figure 13. Each of the individual identified steam opportunities in eight categories, if implemented, could typically save industrial plants at least 1% of their total source-energy use.

TOP "10" PROCESS HEATING OPPORTUNITIES

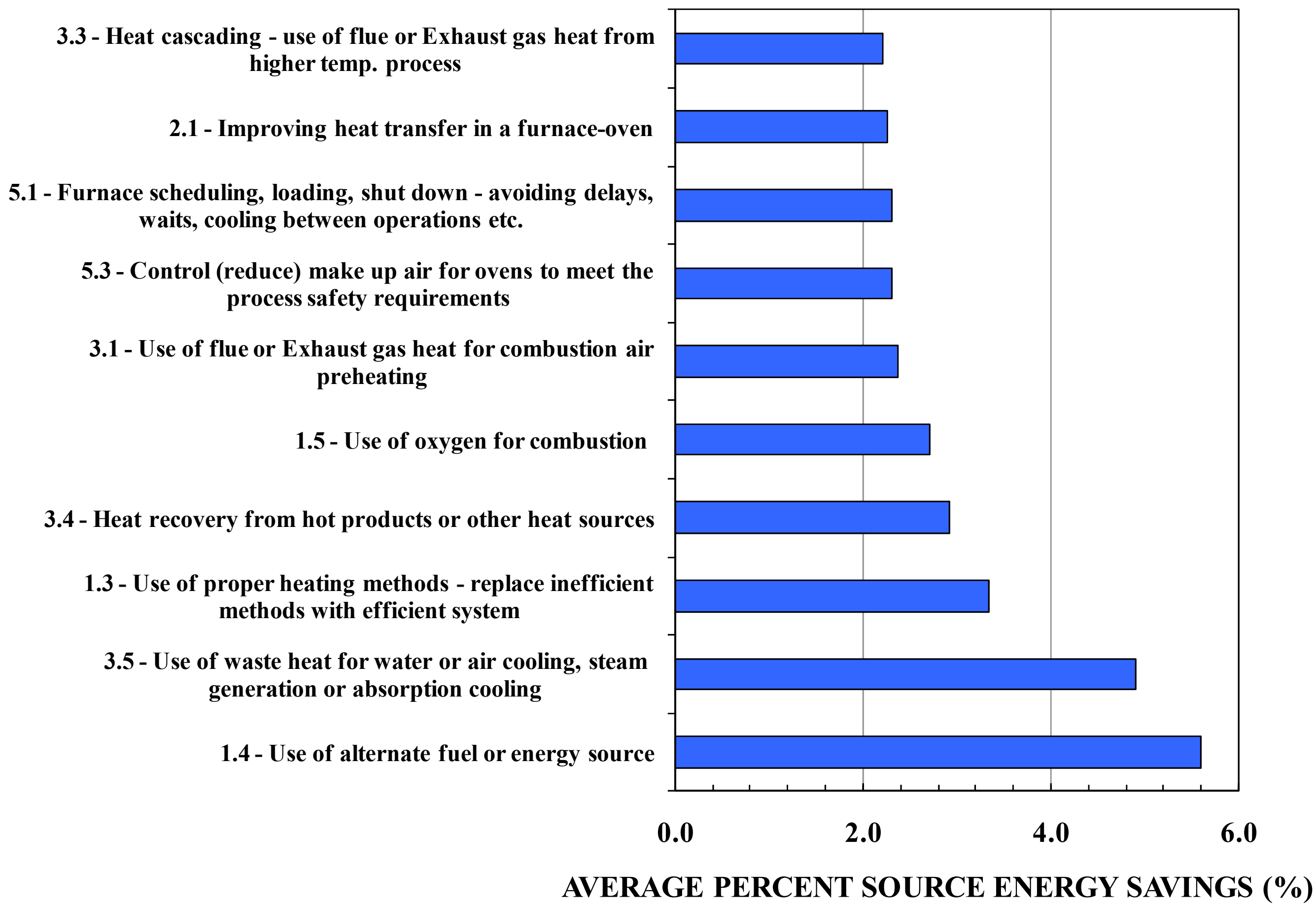

Figure 14. Many of the individual identified process heating opportunities, if implemented, could typically save industrial plants at least 2% of their total source-energy use.

TOP "10" COMPRESSED AIR OPPORTUNITIES

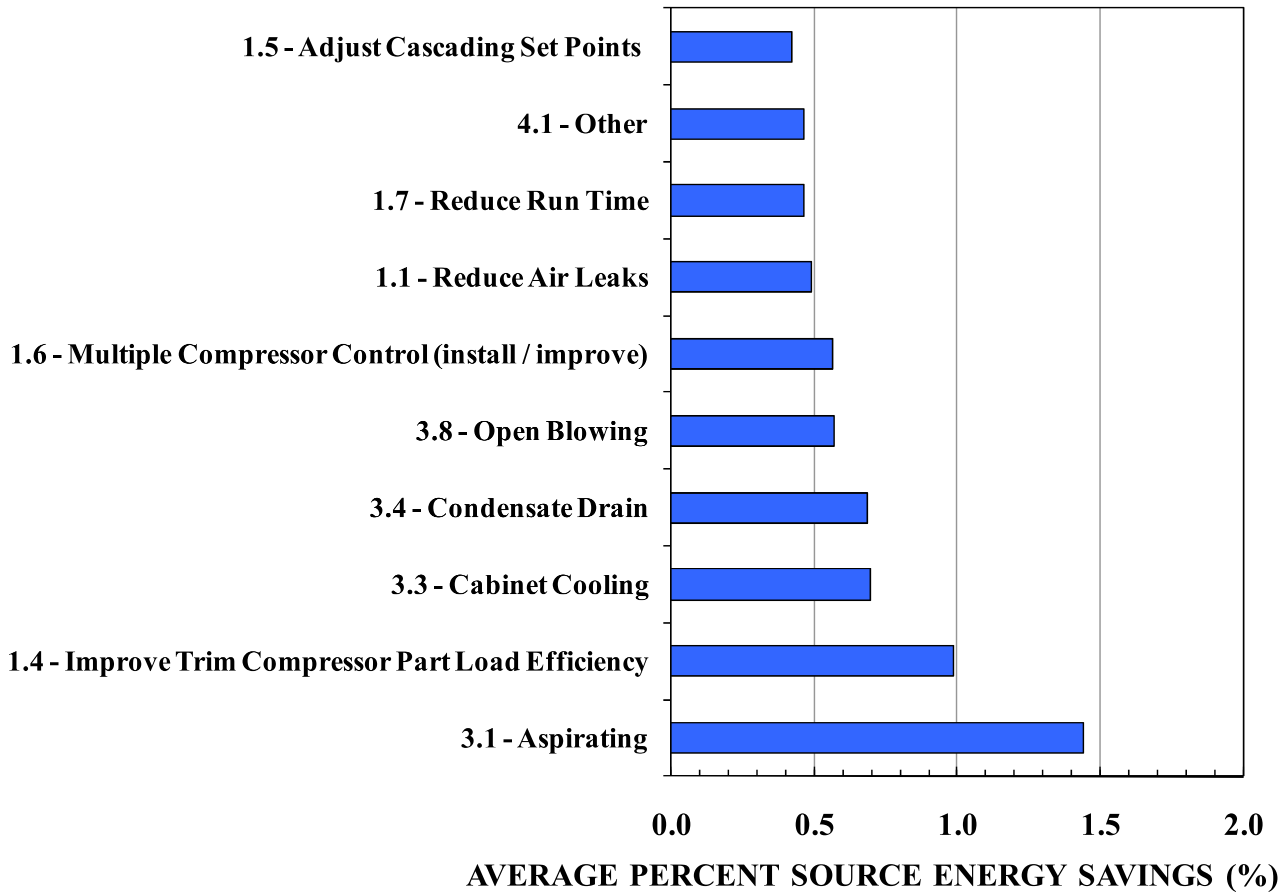

Figure 15. Each of the individual identified compressed air opportunities in six categories, if implemented, could typically save industrial plants at least 0.6% of their total source-energy use.

TOP "10" PUMP OPPORTUNITIES

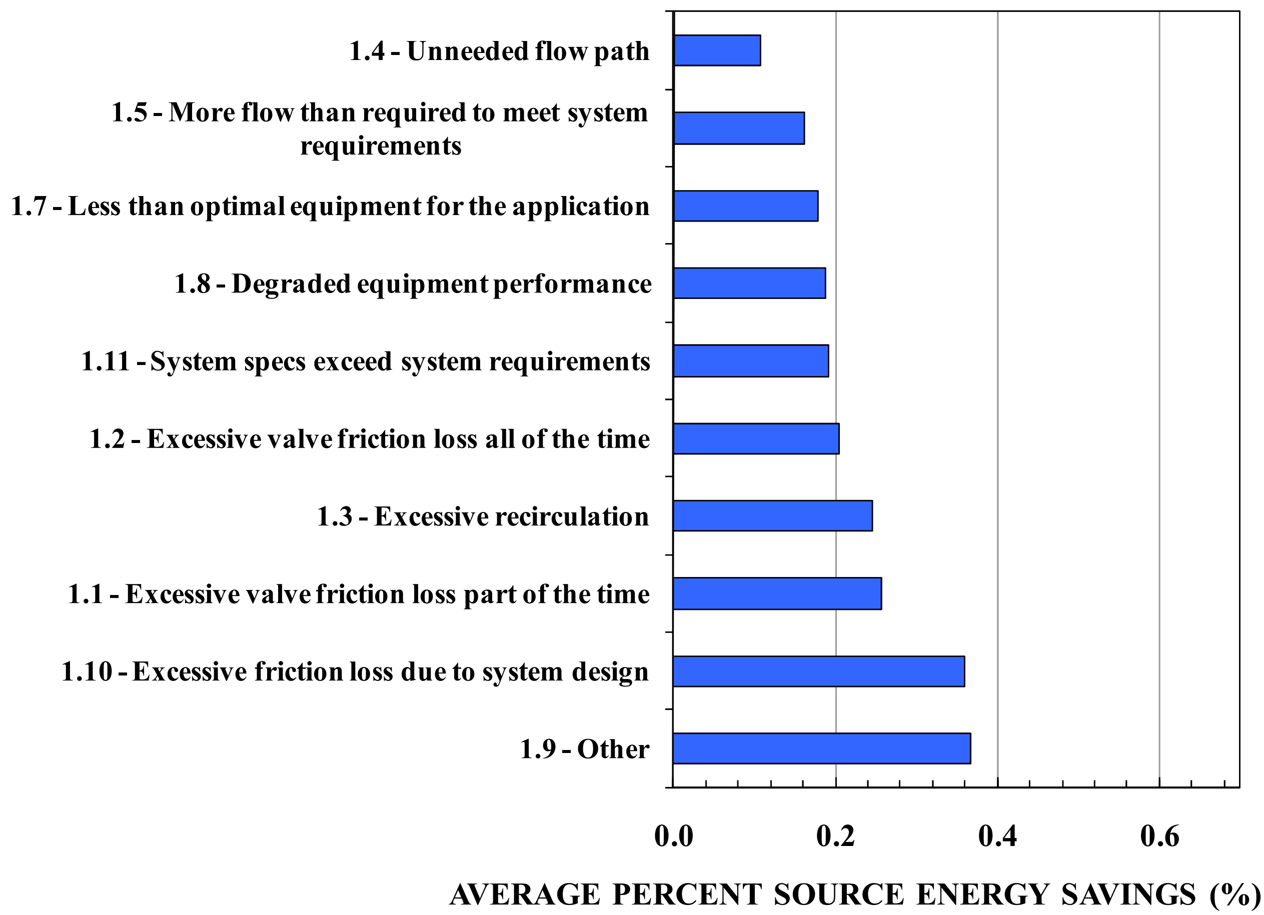

Figure 16. Each of the individual identified pumping opportunities in six categories, if implemented, could typically save industrial plants at least 0.2% of their total source-energy use.

TOP "10" FAN OPPORTUNITIES

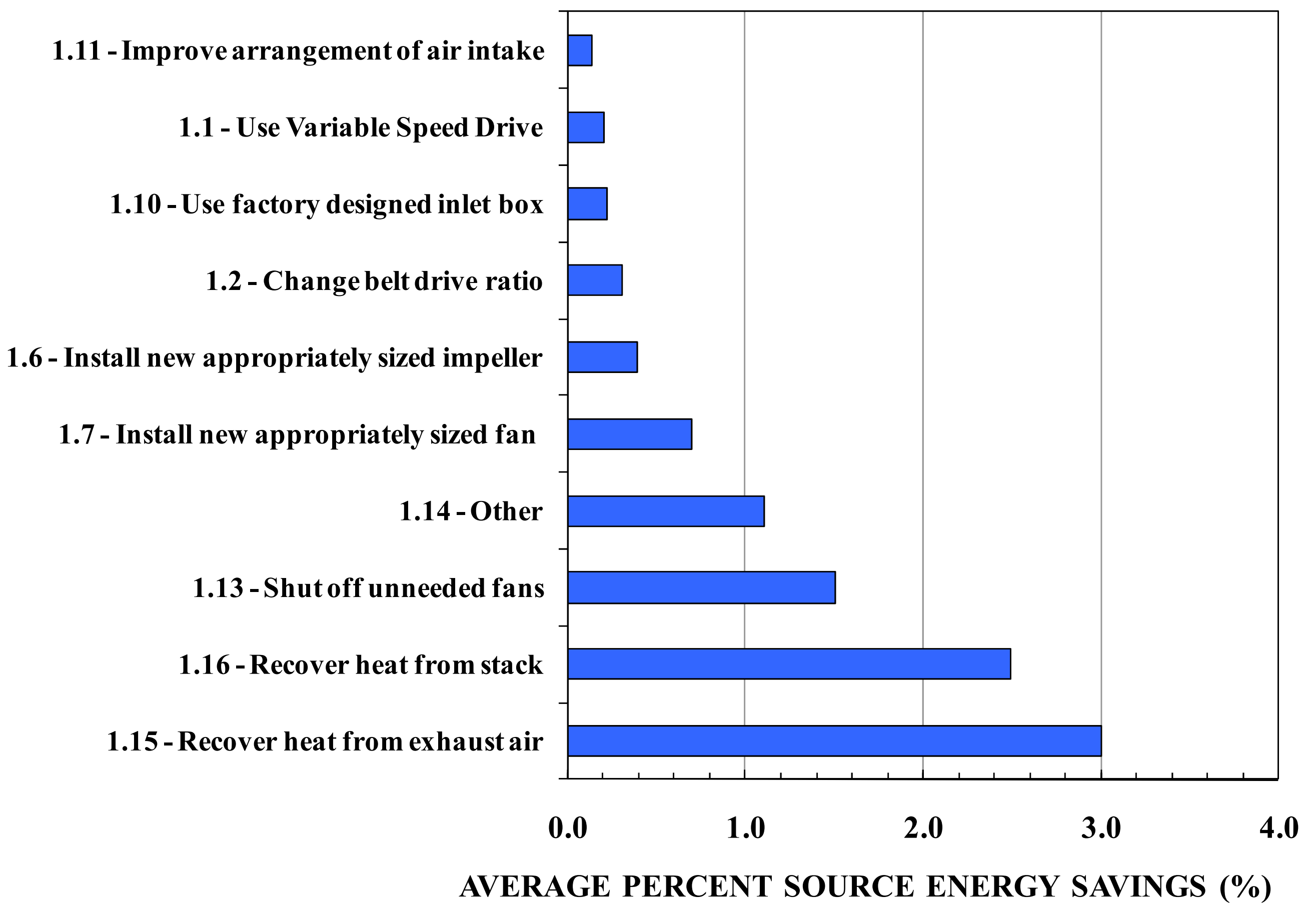

Figure 17. Each of the individual identified fan opportunities in six categories, if implemented, could typically save industrial plants at least 0.5% of their total source-energy use.

TOP "10" MULTI-SYSTEM PAPER OPPORTUNITIES

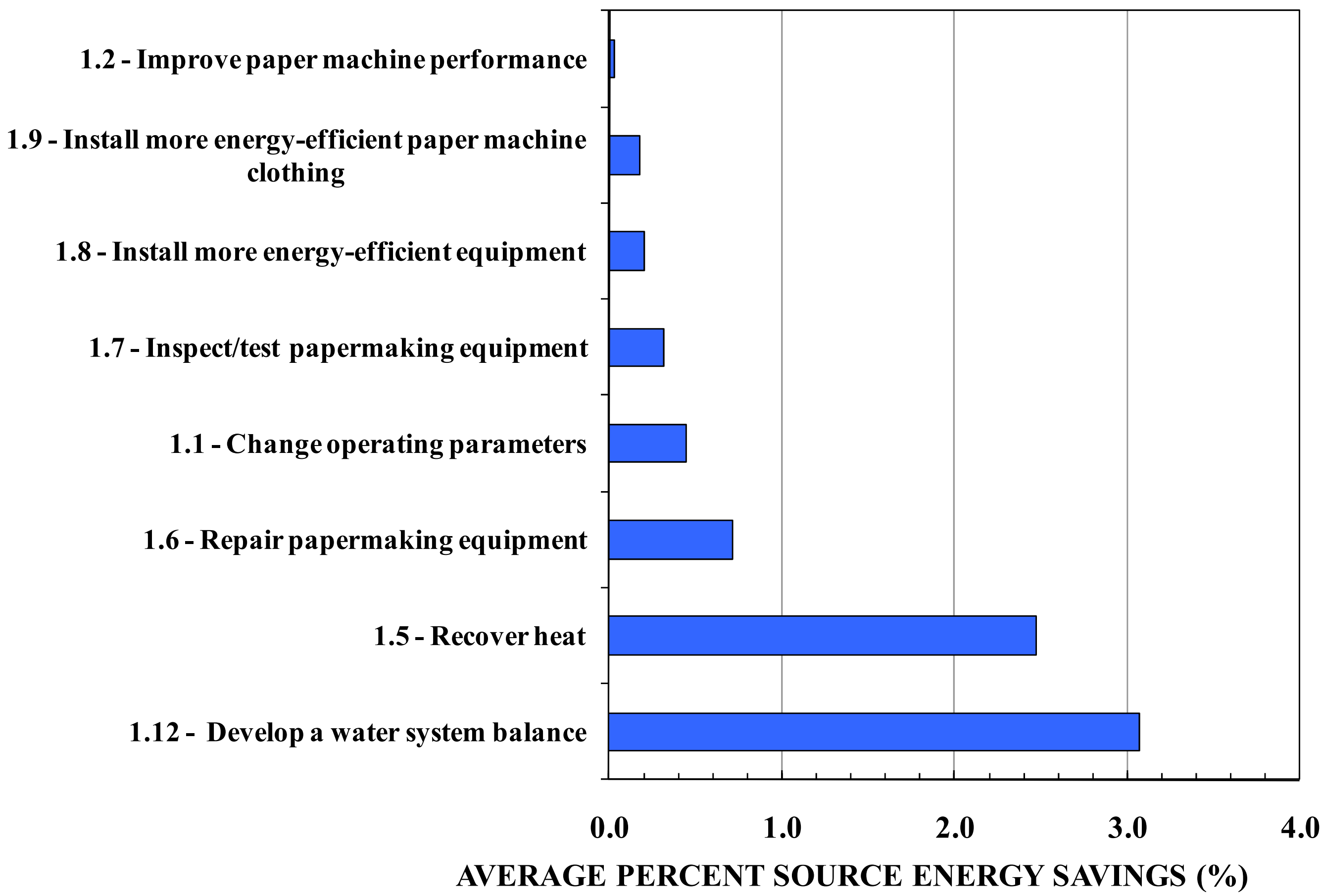

Figure 18. Each of the individual identified multi-system paper opportunities in six categories, if implemented, could typically save industrial plants at least 0.3% of their total source-energy use.

Table 2. Total number of 2006, 2007, and 2008 assessments conducted per state

State	Compressed Air	Fans	Process Heating	Pumps	Steam	Multi-System Paper	Grand Total
TX	6	3	23	9	28		69
WI	3	4	8	11	32	2	60
MI	17	1	6	4	17		45
GA	6	2	11	1	12	1	33
IN	10	1	11	1	10		33
TN	6	1	12	4	7	1	31
OH	8	1	12	4	5		30
PA	2	1	14	4	7		28
IL	5	2	5	3	12		27
AL	2	1	7	2	9	1	22
LA			4		16	1	21
MN	2	4	7	1	7		21
CA	3	1	5	2	8		19
KY	6	1	7		4		18
NY	1		5	2	8		16
AR	1		3	1	8		13
VA	1	2	3	1	5		12
MO	2		2	1	7		12
MA	2		5		4		11
OR	1		4		6		11
OK	3		3	1	4		11
MS		1	4	2	4		11
WA		1	3	1	5		10
NJ	1		3		6		10
NC		1	3	1	2	1	8
WV	1		4		3		8
UT	1		4	1	2		8
SC	3		2	2	1		8
ME				1	6	1	8
KS	2		2	1	3		8
IA	2		4		1		7
AZ	3		1	1	2		7
FL		1	2		3		6
CT	2			1	3		6
ID	1				4		5
NE			2		2		4
DE	1				3		4
PR	1	1		1	1		4
WY			2		1		3
MD					3		3
RI					2		2
CO	1				1		2
NV		1			1		2
ND					1		1
SD					1		1
NM		1					1
Grand Total	**106**	**32**	**193**	**64**	**277**	**8**	**680**

Table 3. Number of *Save Energy Now* assessments completed in 20 major U.S. industry sectors in 2006, 2007, and 2008

Industry Sector	Compressed Air	Fans	Process Heating	Pumps	Steam	Multi-System	Grand Total
325 CHEMICAL MANUFACTURING	8	2	26	7	73		116
322 PAPER MANUFACTURING	4	5	10	15	59	7	100
311 FOOD	16	1	13	5	59		94
331 PRIMARY METALS	8	5	55	11	8		87
336 TRANSPORTATION EQUIPMENT	28	2	10	6	24		70
327 NON-METALLIC MINERAL PRODUCTS	17	7	35	9			68
324 PETROLEUM AND COAL PRODUCTS	3		10	1	13		27
326 PLASTICS AND RUBBER PRODUCTS	7		2	1	10		20
332 FABRICATED METAL PRODUCTS	1	1	11	2	4		19
212 MINING	1	3	5	2	2		13
334 COMPUTER AND ELECTRONIC PRODUCTS	2	2	2	1	4		11
333 MACHINERY MANUFACTURING	2	1	4		3		10
321 WOOD PRODUCTS	1	1	4		1		7
339 MISCELLANEOUS MANUFACTURING	2	1	1		3		7
314 TEXTILE PRODUCT MILLS					6		6
323 PRINTING AND RELATED SUPPORT ACTIVITIES	4		1	1			6
OTHER	1		1	1	2	1	6
313 TEXTILE MILLS			1	1	2		4
335 ELECTRICAL EQUIPMENT, APPLIANCES, COMPONENTS	1		2		1		4
312 BEVERAGE AND TOBACCO PRODUCTS		1			1		2
315 APPAREL MANUFACTURING					1		1
337 FURNITURE AND RELATED					1		1
541 PROFESSIONAL, SCIENTIFIC & TECHNICAL SERVICES				1			1
Grand Total	**106**	**32**	**193**	**64**	**277**	**8**	**680**

Table 4. The steam system "pick-list" recommendation classifications that streamline assessment and data analysis

Steam assessment "pick-list" savings projects	Description
1.1 - Reduce steam demand by changing the process steam requirements	Eliminating or optimizing the operation of steam-using process equipment reduces required steam generation rates which in turn reduces boiler fuel (and energy) consumption rates.
1.2 - Use an alternate fuel	When switching from a fuel with a lower theoretical combustion efficiency (e.g. natural gas) to a fuel with a higher efficiency (e.g. fuel oil with a lower hydrogen content), a lower boiler fuel (and energy) consumption rate results. Switching to a less costly fuel (on an energy basis) will reduce operating costs.
1.3 - Change boiler efficiency	Energy is saved if boiler efficiency is improved since boiler losses are reduced, and less fuel (and energy) is needed to achieve a desired steam production rate.
1.4 - Change boiler blowdown rate	Boiler blowdown constitutes a pressurized, hot water loss from a boiler (energy loss). Actions (e.g. improved boiler water treatment) which allow a reduction in this loss improve boiler efficiency.
1.5 - Install blowdown flash to low pressure steam	Blowdown water (superheated liquid) flashes to steam when pressure is lowered in the exit stream. Flash steam directed to a low pressure header reduces needed boiler steam generation rate. This in turn reduces boiler fuel (and energy) use rate.
1.6 - Change steam generation conditions	For boilers producing superheated steam, reducing output temperature (e.g. by removing a superheater) will reduce boiler fuel (and energy) use. For boilers producing saturated steam, improving steam quality (decreasing wetness) improves downstream process
1.7 - Add or modify operation of backpressure steam turbine	If a backpressure turbine is taken out-of-service, steam usage, boiler load and fuel (and energy) consumption rate are reduced. If a new backpressure turbine is added to reduce steam flow through pressure reducing valves, steam flows through pressure reducing valves will be reduced but total steam usage will increase. This action will reduce total energy costs if the electricity savings (related to the turbine drive) are greater than the increased boiler fuel consumption rate.
1.8 - Add or modify operation of condensing steam turbine (high pressure to condensing)	If the isentropic efficiency of a utilized condensing turbine is improved (e.g. by rebuilding), a lower steam flow is required to drive the turbine load. This in turn reduces boiler load and fuel (and energy) consumption rates. If a condensing turbine is taken out-of-service, steam usage is reduced, boiler load decreases and boiler fuel (and energy) consumption is lowered.
1.9 - Modify feedwater heat recovery exchanger using condensate tank vent	The main condensate receiver is typically vented to atmosphere when flash steam forms at the reduced receiver pressure. Flash steam passed through a heat exchanger can be used for boiler feedwater heating. The addition of hotter water to the feedwater system reduces boiler fuel (and energy) consumption rate.
1.10 - Modify feedwater heat recovery exchanger using boiler blowdown	When superheated blowdown water undergoes a pressure reduction after leaving the boiler, some water flashes to steam and a hot water fraction remains. This hot water may be passed through a heat exchanger to heat feedwater or process fluids thereby reducing steam use for heating.

Table 4 (continued)

Steam assessment "pick-list" savings projects	Description
1.11 - Change condensate recovery rates	If the amount of formed condensate returned to the boiler is increased, hotter water is fed back into the boiler feedwater system, lowering feedwater heating requirements and feedwater chemical treatment needs.
1.12 - Modify the medium pressure condensate flash system	When the pressure of condensate formed in a high-pressure system is reduced, flash steam forms. When this steam is supplied to the medium-pressure steam header, an amount of boiler-produced steam is displaced and boiler load and fuel (and energy) consumption rates are reduced.
1.13 - Modify low pressure condensate flash system	When the pressure of condensate formed at a given pressure is reduced flash steam forms. When this steam is supplied to the low-pressure steam header, an amount of boiler-produced steam is displaced and boiler load and fuel (and energy) consumption rates are reduced.
1.14 - Implement steam trap maintenance program	An improved steam trap maintenance program results in a reduced number of traps failed in the leaking steam mode. If trap steam leaks are reduced, less steam energy is lost in the condensate system and boiler load and fuel (and energy) consumption rates are reduced.
1.15 - Implement steam leak maintenance program	An improved steam leak maintenance program reduces the number of steam leaks (lost energy). Less steam must be generated in the boiler to satisfy process loads and boiler fuel (and energy) consumption rates are reduced.
1.16 - Improve insulation	Improving insulation quality (e.g. replacing ineffective wet insulation or increasing insulation thickness) and insulating uninsulated components will reduce energy loss from hot steam components.
1.17 – Other	Miscellaneous projects may minimize or eliminate the need for boiler-generated steam. These projects save energy by reducing the use of process energy or by improving the efficiency of converting fuel energy to process heating (e.g. steam) energy.
1.18 - Feedwater heat recovery - general	Available process waste heat other than condensate tank vent energy or liquid blowdown heat can be used in a heat exchanger to heat boiler feedwater. Hotter water fed back into the boiler feedwater system lowers feedwater heating requirements.
1.19 - Deaerator heat recovery - general	Boiler water deaerators are often vented to atmosphere. The installation of a heat exchanger can recover heat for feedwater or process heating. This heating reduces needed boiler output.
1.20 - Multiple boiler optimization	Optimization of overall steam generation efficiency in multi-boiler systems requires selection of individual boiler loads to maximize their efficiencies and minimize total boiler fuel use while meeting total steam production requirements.
1.21 - Reduce or recover vented steam	Steam is vented from steam headers when steam supplied by backpressure turbines exceeds downstream process needs. Steam is also vented from some plant processes (e.g. furnace decoking). If steam venting is reduced or vented steam is recovered (for process heating) boiler steam load and fuel (and energy) consumption rates are reduced.

Table 5. The process heating system "pick-list" recommendation classifications that streamline assessments and data analysis

Process Heating assessment "pick-list" savings projects	Description
1.1 - Reduce oxygen content of flue (exhaust) gases	Reduced oxygen reflects a reduction in excess air entering the heating equipment. This raises the available heat, and consequently, the efficiency. Excess air can be lowered by adjusting burner air-fuel ratios, closing off air leaks into the equipment or maintaining a slightly positive chamber pressure to exclude outside air.
1.2 - Eliminate excess unburned hydrocarbons (CO, H2, CH4, soot in the exhaust gases)	Unburned hydrocarbons represent unburned or partially-burned fuel. They can be lowered by improving the thoroughness of air-fuel mixing in burners or avoiding operating burners fuel-rich or with insufficient excess air.
1.3 - Use of proper heating methods - replace inefficient and uneconomical methods with economical/efficient system	Some heating equipment is either obsolete or poorly matched to the needs of the process. Replace it with modern equipment which takes the unique needs of the process into account.
1.4 - Use of alternate fuel or energy source	In certain situations, fuels like by-product gases may be available at lower cost than the primary fuel. Waste energy from other nearby operations might be able to be used in the process under consideration.
1.5 - Use of oxygen for combustion	Using oxygen to enrich or replace combustion air lowers the weight flow of nitrogen in the exhaust gases, increasing available heat and efficiency. Flame temperatures will also increase, and this may enhance radiation heat transfer to the furnace and its load.
1.6 - Use of process or exhaust air for combustion	If this air contains sufficient oxygen (usually 18% or more) and is at elevated temperature, it can be used as a combustion air source. Its heat content will raise the available heat of the combustion process.
1.7 - Use of outdoor air for combustion or make-up air	In a closed building with space heating in use, drawing combustion air from inside and then exhausting it through the stack wastes the energy that air contains. Heated replacement air will be needed. Drawing combustion air from outdoors bypasses the building heating system, reducing the burden on it.
2.1 – Improving heat transfer in a furnace-oven	The work load must be exposed as effectively as possible to the source of radiant or convective heat. This will entail steps like changing loading patterns, increasing burner or hot air nozzle velocities or relocating heat sources so they "see" more of the furnace load.
2.2 - Clean heat transfer surfaces - radiant tubes, heat exchangers, heater tubes, electrical heating elements	Buildups of scale, soot and dirt reduce the thermal conductivity of tubes, heating elements and heat exchangers. Heat turned back by these deposits short-circuits out the exhaust, increasing losses, slowing the process and lowering efficiency.

Table 5 (continued)

Process Heating assessment "pick-list" savings projects	Description
3.1 - Use of flue or Exhaust gas heat for combustion air preheating	This is one of the most effective ways to recycle waste heat. Incoming ambient combustion air is routed through a heat exchanger and preheated with energy extracted from the outgoing exhaust gases. Every unit of energy transferred to the air is one less that must be provided by burning fuel.
3.2 - Load or charge preheating using heat from flue or exhaust gas or other source of waste heat	Instead of exhausting flue gases from the process at high temperatures, they are passed over incoming cold charge materials. This raises the load partway to its processing temperature and lowers the amount of energy need to support the process.
3.3 - Heat cascading - use of flue or exhaust gas heat from higher temp. process to supply heat to lower temperature processes	Waste gases from one process can be used to heat a lower temperature process.
3.4 - Heat recovery from hot products or other heat sources (i.e. from walls) from a furnace - oven	Products are often removed from ovens or furnaces at elevated temperatures and allowed to cool in the open air. Cooling them with forced air in an enclosure will heat the air, which might be useful for heating another process.
3.5 - Use of waste heat for water or air cooling, steam generation or absorption cooling	Heated exhaust gases can be routed through waste heat boilers, hot water generators or absorption chillers to perform a variety of heating or cooling roles.
4.1 - Proper insulation and maintenance of furnace structure or parts	Maintain furnace and oven insulation to avoid localized losses through the walls, roof and floor. Consider increasing the thickness or efficiency of the existing insulation to further lower wall losses.
4.2 - Reduce-eliminate internal cooling	Some furnaces contain components protected from overheating with cooling water and air. Make sure excessive amounts of cooling media aren't used.
4.3 - Reduce-eliminate openings and air leakage in the furnace	Openings allow radiant energy to escape and ambient air to leak in. As much as possible, seal those openings and leaks. As an added measure, maintain the furnace or oven at a slightly positive internal pressure to prevent in-leakage.
5.1 - Furnace scheduling, loading, shut down - avoiding delays, waits, cooling between operations etc.	Heating equipment efficiency is highest at 100% of design capacity. Underloaded or overloaded equipment will consume more energy per unit of production.
5.2 – Reducing weight of fixtures, trays, baskets etc.	If fixtures, baskets and conveyors leave the heating process at higher temperatures than they entered, they contribute to wasted heat. Lowering their mass causes a corresponding decrease in the amount of energy they extract from the process.
5.3 - Control (reduce) make up air for ovens to meet the process safety requirements	Ovens handling flammable solvents or vapors must have sufficient fresh air ventilation to dilute those combustible materials well below their lower flammable limit. Any ventilation in excess of the safe required amount wastes energy.
5.4 - Eliminate use of continuous flame curtains, pilots where possible	Flame curtains and door pilots insure burnoff of flammable prepared atmospheres escaping around furnace doors and out vents. If the process atmosphere has been changed to a non-flammable mixture, these ignition sources are no longer necessary.

Table 6. The pump system "pick-list" recommendation classifications that streamline assessments and data analysis

Pump assessment "pick-list" savings projects	Description
1.1 – Excessive valve friction loss part of the time	Throttled valve losses incurred periodically when system flow requirement has to be reduced.
1.10 - Excessive friction loss due to system design	Can be caused by unnecessary flow paths, excessive numbers of fittings, poor suction geometry, etc.
1.11 - System specs exceed system requirements	Often the result of excessive conservatism during the design phase of a project or a change in process conditions/system function after the original design was implemented.
1.12 - Change time of use	Systems that are not required to operate continuously may be operated during a time of day when the cost of electricity is lower.
1.2 – Excessive valve friction loss all of the time	Often occurs when system capacity exceeds the current operating requirement or an undersized motor has been used.
1.3 – Excessive recirculation	Use of recirculation as a method of flow control rather than turning off pumps or throttling flow.
1.4 – Unneeded flow path	Flow supplied to non-operating equipment to avoid changing valve alignment.
1.5 - More flow than required to meet system requirements	System oversized, either by having a pump that is too large or operating multiple parallel pumps necessarily. Usually used with multiple parallel pumps. Use 1.11 for oversized pump.
1.6 - Suction-related problems	Inadequate suction head, poor suction geometry, or obstructions.
1.7 - Less than optimal equipment for the application	Installed pump is the wrong size or type for current operating requirements.
1.8 – Degraded equipment performance	Equipment wear/degradation (impeller damage, erosion, corrosion, wear rings, etc.) that prevents operation at design conditions.

Table 7. The compressed air system "pick-list" recommendation classifications that streamline assessments and data analysis

Compressed Air assessment "pick-list" savings projects	Description
1.1 - Reduce air leaks	Eliminate compressed air waste to leakage.
1.10 - Improve compressor intake condition	Conditions that increase air density at the compressor intake will increase the delivered airflow and improve specific power (kw / 100 scfm). This measure includes reducing pressure loss at the compressor intake and providing lower.
1.11 - Heat recovery	As much as 85% of the input energy to an air compressor is rejected as heat that can potentially be recovered and used to offset another energy use. To the extent that the alternate energy use is reduced, a system energy reduction is possible.
1.2 - Improve end use efficiency	The measure can cover a wide range of end use improvements that reduce or eliminate the use of compressed air. See also items 3.1 through 3.9 which further classify the type of end use that is being improved.
1.3 - Reduce system air pressure	Reducing system air pressure provides two potential benefits. The energy of positive displacement compressors is reduced at lower working pressure. Also at reduced pressure unregulated air demands and leaks consume less compressed air. See also items 2.2, 2.3 and 2.4 for individual pressure reduction of supply or demand side pressure.
1.4 - Improve trim compressor part load efficiency	Various compressor capacity control methods provide different power reduction characteristics at reduced capacity. Changing the control method of a single trim compressor can improve generation efficiency reducing specific power (kw / 100 scfm).
1.5 - Adjust cascading set points	Adjusting cascade set point can improve system efficiency by eliminating the part load operation of multiple compressors.
1.6 - Multiple compressor control (install / improve)	Multiple compressor control can improve system efficiency by eliminating part load operation of multiple compressors. The more sophisticated controls can also respond to changes in system air demand selecting the optimum mix of various size compressors and compressor control types to improve overall generation efficiency.
1.7 - Reduce run time	Reduce run time can result from system changes reducing air demand to a point that a compressor can simply be shut off during certain periods of time.
1.8 - Add primary receiver volume	Primary storage installed for the purpose of reducing load / unload cycle rate of lubricant injected rotary screw compressors. Longer unload time can reduce energy use by reducing part load power consumption.
1.9 - Optimize air treatment	Optimizing air treatment can reduce energy use by two means. First by reducing irrecoverable pressure drop through treatment equipment, system pressure might be reduced with the associated energy savings. Second, if the air is presently being treated to a greater level of contaminate removal than necessary, reducing the amount of air treatment can reduce system energy use. For example changing from regenerative style to refrigerated style air dryers.
2.1 - Stabilize control pressure signal	Control pressure variations caused by system dynamics are corrected to provide a stable control signal improving compressor efficiency.
2.2 - Reduce supply side pressure	Reducing supply side operating pressure and the resulting lower compressor discharge pressure will decrease power consumption of positive displacement compressors.
2.3 - Install flow pressure control	Install a flow / pressure control to optimize compressed air storage and / or eliminate artificial demand. By maintaining a recoverable pressure differential storage of compressed air energy can be optimized. To the extent that artificial demand is reduced, or stored energy prevents the start-up of an air compressor in response to peak air demand, system energy reduction is possible.
2.4 - Reduce demand side pressure	Reducing demand side pressure to eliminate artificial demand. All unregulated air demand and leakage consumes less compressed air at reduced demand side operating pressure.

Table 7 (continued)

Compressed Air assessment "pick-list" savings projects	Description
2.5 - Install primary storage for peak air demand	Primary Storage to address peak air demand or permissive start-up event loads. Peak air demand may cause an air compressor to operate, where-as application of storage may allow the compressor to be shutdown.
2.6 - Install secondary storage	Application of Secondary Storage may allow savings through reduced system pressure, improved compressor control, or other energy reduction measures made possible through the used of Secondary Storage.
2.7 - Reduce distribution piping pressure gradient	Excessive piping resistance in distribution piping can lead to irrecoverable pressure loss, or excessive pressure decay during peak airflow events. Eliminating piping pressure gradient can allow reduced system pressure with associated energy savings.
2.8 - Reduce component pressure drop	Pressure loss through a discrete component or group of components i.e. "filter pressure drop", "pressure drop through treatment", etc.
2.9 - Resolve high pressure demand	Perceived high pressure demands are modified or corrected to operate at normal working pressure. Valid high pressure demands are served by other means. The resultant system pressure reduction can save energy.
3.1 – Aspirating	Using compressed air to introduce the flow of another gas (such as flue gas). As an alternative the application of a fan or blower can provide a net energy reduction.
3.10 – Padding	Using compressed air to transport liquids and light solids. By pumping or using a low pressure blower as the energy source, a net energy reduction is possible.
3.11 - Personal cooling	Comfort cooling with air, replacing compressed air use with a fan or air conditioner can be a net energy reduction.
3.12 – Sparging	Aerating, agitation, oxygenating, or percolating liquid with compressed air. Alternatives include pumping, mechanical agitation, or a low pressure blower as the energy source. Alternatives can provide a net energy reduction.
3.13 - Vacuum generation	Using air with venturi effect to create vacuum can be replaced by an electrically driven vacuum pump with net energy reduction.
3.2 – Atomizing	Delivering a liquid as an aerosol using compressed air may alternatively be accomplished with high pressure liquid pump and suitable spray nozzle. Alternatives can provide net energy reduction.
3.3 - Cabinet cooling	Cooling of electrical panels with open tubes that expand compressed air to create a cooling affect can alternatively be accomplished with ventilation fans, heat tubes, or small mechanical refrigeration units.
3.4 - Condensate drain	Open blowing drain, failed automatic drain, solenoid timer drain will waste compressed air. Appropriate maintenance actions and / or replacement with zero air loss style condensate drains can reduce waste.
3.5 - Dense phase transport	Compressed air is used to transport solids in a batch format. Alternatives such as mechanical conveyors or other material handling methods can reduce energy use.
3.6 - Diaphragm pumps	Diaphragm pumps are commonly found installed without regulators and speed control valves. By properly controlling the pump air demand can be reduced. Alternatives may also include electrically driven pumps which provide.
3.7 - Dilute phase transport	Dilute phase transporting solids such as powdery material in a diluted format using compressed air. Alternatives might include mechanical conveyors, or lower the use of lower pressure blowers or fans as the energy source.
3.8 - Open blowing	Compressed air blowing for cooling, drying, clean-up, etc. Alternatively a low pressure blower, vacuum, or something a simple a using a broom to sweep the floor can result in a net energy reduction.
3.9 - Open hand held blow guns or lances	Any unregulated hand held blowing is a variation of blowing described in item 3.8 with the same alternatives and energy reduction.
4.1 – Other	

Table 8. The fan system “pick-list” recommendation classifications that streamline assessments and data analysis

Fan assessment "pick-list" savings projects	Description
1.1 - Use variable speed drive	Fans normally are driven by constant-speed motors. When the process load varies, the electronic Variable Speed drive varies the speed of the motor to change the capacity of the fan in order to match the load. Also known as adjustable speed, variable frequency, or adjustable frequency drives.
1.10 - Use factory designed inlet box	If a 90 degree turn at the fan inlet is unavoidable, then a factory-designed inlet box is the best way to minimize those losses.
1.11 - Improve arrangement of air intake	Sharp-edged intakes can have significantly higher losses than flared or bell-mouth entrances.
1.12 - Replace motor	Newer motors are usually more efficient than the older motors found in some plants.
1.13 - Shut off unneeded fans	If more fans are operating than the process needs, some fans can be shut off
1.14 – Other	Sometimes it is possible to do other things to improve the fans than the items on this list
1.15 – Recover heat from exhaust air	If fan is handling hot exhaust air, it may be possible to recover heat (or cooling) from the air stream
1.16 – Recover heat from stack	If the fan is handling hot boiler exhaust gasses it may be possible to recover some of the heat
1.17 - Reconfigure pollution control equipment	Sometimes older pollution control equipment my have a very high pressure drop or may be configured inefficiently by today’s best practices
1.2 - Change belt drive ratio	When fans that are oversized are belt-driven, the fan capacity can be de-rated to match the process needs by changing the pulley ratio to slow the fan down.
1.3 - De-tip fan blades	When fans that are oversized are direct-driven, the fan capacity can be de-rated to match the process needs by carefully taking a little bit off the end of each blade on the impeller wheel.
1.4 - Convert to belt drive	When fans that are oversized are direct-driven, sometimes they can be converted to a belt drive in order de-rate the capacity to match process needs.
1.5 - Use high-efficiency belt drive	Older style V-Belts can be upgraded to newer, more efficient belts made with modern materials and designs
1.6 - Install new appropriately sized impeller	Sometimes the impeller can be changed out to a more efficient configuration, or a different type in order to improve performance
1.7 - Install new appropriately sized fan	If the fan is the wrong type, performing poorly, or is too big or too small, then sometimes a new fan is the best option.
1.8 - Replace outlet damper with variable inlet vanes	Outlet Dampers are the least efficient means of controlling the fans. Variable inlet vanes usually have lower losses, although they too should be applied very carefully, and should not be used less than 70% open.
1.9 - Rearrange ductwork at fan inlet or discharge	Poor ductwork arrangements such as abrupt turns or abrupt changes in size immediately at the inlet or the outlet of the fan can adversely performance.

Table 9. Potential cost savings, energy savings, and reduction in CO_2 emissions from identified steam opportunities in pick-list categories

Year 2006 - 08 Steam Savings Opportunity Recommendations	Cost savings ($/year)	Source energy savings (MMBtu/year)	Natural gas savings (MMBtu/year)	CO_2 savings (metric tons CO_2/year)	No. of times the opportunity applied
1.1 - Reduce Steam Demand by Changing the Process Steam Requirements	$136,369,000	23,393,000	12,191,000	1,718,000	253
1.2 - Use an Alternate Fuel	$122,198,000	5,908,000	23,105,000	937,000	42
1.3 - Change Boiler Efficiency	$69,516,000	9,655,000	6,513,000	642,000	335
1.7 - Add or Modify Operation of Backpressure Steam Turbine	$55,550,000	7,793,000	-1,155,000	331,000	105
1.17 - Other and 6.2 - Other - Misc.	$51,260,000	5,975,000	1,005,000	299,000	159
1.8 - Add or Modify Operation of Condensing Steam Turbine	$32,350,000	3,149,000	5,691,000	270,000	27
1.11 - Change Condensate Recovery Rates	$32,185,000	3,568,000	2,725,000	220,000	123
1.14 - Implement Steam Trap Maintenance Program	$24,066,000	3,232,000	2,768,000	215,000	133
1.16 - Improve Insulation	$18,560,000	2,456,000	1,805,000	158,000	197
1.10 - Modify Feedwater Heat Recovery Exchanger using Boiler Blowdown	$11,884,000	1,693,000	1,452,000	97,000	101
1.4 - Change Boiler Blowdown Rate	$11,245,000	1,263,000	1,032,000	73,000	87
1.21 - Reduce or Recover Vented Steam	$9,132,000	1,338,000	858,000	84,000	64
1.20 - Multiple Boiler Optimization	$8,209,000	199,000	614,000	81,000	19
1.18 - Feedwater Heat Recovery - General	$8,051,000	1,191,000	1,145,000	64,000	27
1.15 - Implement Steam Leak Maintenance Program	$7,871,000	1,580,000	755,000	59,000	100
1.13 - Modify Low Pressure Condensate Flash System	$3,986,000	532,000	550,000	27,000	22
1.12 - Modify the Medium Pressure Condensate Flash System	$2,002,000	225,000	225,000	12,000	8
1.5 - Install Blowdown Flash to Low Pressure Steam	$1,913,000	415,000	245,000	27,000	25
1.6 - Change Steam Generation Conditions	$1,419,000	260,000	24,000	18,000	19
1.19 - Deaerator Heat Recovery - General	$1,021,000	138,000	90,000	8,000	6
1.9 - Modify Feedwater Heat Recovery Exchanger using Condensate Tank Vent	$684,000	77,000	82,000	4,000	10
3.1 - Use of flue or Exhaust gas heat for combustion air preheating	$302,000	38,000	27,000	2,000	2
2.2 - Clean heat transfer surfaces - radiant tubes, heat exchangers, heater tubes, electrical heating elements	$233,000	32,000	32,000	2,000	1
3.5 - Use of waste heat for water or air cooling, steam generation	$230,000	24,000	24,000	1,000	2
1.1 - Reduce oxygen content of flue (exhaust) gases	$202,000	28,000	28,000	1,000	2
5.1 - Furnace scheduling, loading, shut down - avoiding delays, waits, cooling between operations etc.	$74,000	0	0	0	1
Grand Total	**$610,511,000**	**74,163,000**	**61,831,000**	**5,349,000**	**1870**

Table 10. Potential cost savings, energy savings, and reduction in CO_2 emissions from identified process heating opportunities in pick-list categories

Year 2006 - 08 Process Heating Savings Opportunity Recommendations	Cost savings ($/year)	Source energy savings (MMBtu/year)	Natural gas savings (MMBtu/year)	CO_2 savings (metric tons CO_2/year)	No. of times the opportunity applied
3.1 - Use of flue or Exhaust gas heat for combustion air preheating	$44,808,000	5,871,000	5,495,000	320,000	99
6.2 - Other - Misc.	$36,426,000	4,428,000	3,677,000	244,000	84
1.1 - Reduce oxygen content of flue (exhaust) gases	$28,963,000	4,114,000	3,092,000	246,000	164
3.4 - Heat recovery from hot products or other heat sources	$24,382,000	3,633,000	1,869,000	207,000	42
3.3 - Heat cascading - use of flue or Exhaust gas heat from higher temp. process to supply heat to lower temperature processes	$23,214,000	3,223,000	1,843,000	164,000	56
1.5 - Use of oxygen for combustion	$21,315,000	3,153,000	2,588,000	190,000	35
1.3 - Use of proper heating methods - replace inefficient and uneconomical methods with economical/efficient system	$19,821,000	2,352,000	2,163,000	130,000	46
4.1 - Proper insulation and maintenance of furnace structure/parts	$18,677,000	2,778,000	2,039,000	164,000	106
3.2 - Load or charge preheating using heat from flue or exhaust gas	$15,874,000	1,966,000	1,876,000	106,000	63
3.5 - Use of waste heat for water or air cooling, steam generation	$12,658,000	2,075,000	531,000	119,000	20
5.1 - Furnace scheduling, loading, shut down - avoiding delays	$12,330,000	1,331,000	1,298,000	71,000	36
4.3 - Reduce-eliminate openings and air leakage in the furnace	$11,040,000	1,463,000	1,298,000	83,000	67
1.6 - Use of process or exhaust air for combustion	$8,104,000	845,000	845,000	45,000	16
6.1 - Other - Measures not directly related to process heating	$7,814,000	966,000	-268,500	58,000	33
1.4 - Use of alternate fuel or energy source	$7,438,000	2,457,000	1,038,000	198,000	11
4.2 - Reduce-eliminate internal cooling	$6,671,000	592,000	536,000	29,000	10
1.2 - Eliminate excess unburned hydrocarbons (CO, H2, CH4, soot in the exhaust gases)	$6,593,000	831,000	831,000	44,000	11
2.1 - Improving heat transfer in a furnace-oven	$5,428,000	713,000	380,000	40,000	15
5.3 - Control (reduce) make up air for ovens to meet the process safety requirements	$2,705,000	303,000	318,000	16,000	14
2.2 - Clean heat transfer surfaces - radiant tubes, heat exchangers, heater tubes, electrical heating elements	$2,224,000	288,000	209,000	11,000	9
1.16 - Improve Insulation	$1,920,000	237,000	223,000	12,000	7
1.7 - Use of outdoor air for combustion or make-up air	$544,000	54,000	54,000	3,000	4
5.4 - Eliminate use of continuous flame curtains, pilots	$181,000	25,000	25,000	1,000	3
1.3 - Change Boiler Efficiency	$176,000	18,000	18,000	1,000	8
1.1 - Reduce Steam Demand by Changing the Process Steam Requirements	$81,000	8,000	8,000	0	3
5.2 - Reducing weight of fixtures, trays, baskets etc.	$72,000	7,000	7,000	0	3
1.20 - Multiple Boiler Optimization	$12,000	2,000	2,000	0	1
Grand Total	**$319,469,000**	**43,733,000**	**31,994,000**	**2,502,000**	**967**

Table 11. Potential cost savings, energy savings, and reduction in CO_2 emissions from identified pumping opportunities in pick-list categories

Year 2007 - 08 Pump Savings Opportunity Recommendations	Cost savings ($/year)	Source energy savings (MMBtu/year)	Electricity savings (MWh/year)	CO_2 savings (metric tons CO_2/year)	No. of times the opportunity applied
1.2 - Excessive valve friction loss all of the time	$4,481,000	938,000	275000	55,000	71
1.9 - Other	$4,127,000	761,000	223000	44,000	36
1.7 - Less than optimal equipment for the application	$2,359,000	426,000	125000	25,000	53
1.1 - Excessive valve friction loss part of the time	$1,697,000	304,000	89000	18,000	25
1.5 - More flow than required to meet system requirements	$1,298,000	224,000	66000	13,000	30
1.3 - Excessive recirculation	$1,016,000	175,000	51000	10,000	22
1.8 - Degraded equipment performance	$448,000	68,000	20000	4,000	12
1.12 - Change time of use	$334,000	46,000	13000	3,000	6
1.10 - Excessive friction loss due to system design	$206,000	34,000	10000	2,000	3
1.11 - System specs exceed system requirements	$200,000	30,000	9000	2,000	3
1.4 - Unneeded flow path	$178,000	27,000	8000	2,000	8
1.6 - Suction-related problems	$15,000	2,000	1000	0	1
1.1 - Use Variable Speed Drive	$10,000	2,000	1000	0	2
Grand Total	**$16,368,000**	**3,038,000**	**890,000**	**177,000**	**272**

Table 12. Potential cost savings, energy savings, and reduction in CO_2 emissions from identified compressed air opportunities in pick-list categories

Year 2007 - 08 Compressed Air Savings Opportunity Recommendations	Cost savings ($/year)	Source energy savings (MMBtu/year)	Electricity savings (MMBtu/year)	CO_2 savings (metric tons CO_2/year)	Number of times the opportunity applied
1.2 - Improve End Use Efficiency	$4,469,000	551,000	161,000	32,000	100
1.1 - Reduce Air Leaks	$3,763,000	714,000	209,000	42,000	92
1.6 - Multiple Compressor Control (install / improve)	$2,997,000	546,000	160,000	32,000	59
1.3 - Reduce System Air Pressure	$1,656,000	294,000	86,000	17,000	62
4.1 - Other	$1,582,000	287,000	84,000	17,000	34
3.8 - Open Blowing	$1,355,000	233,000	68,000	14,000	23
1.4 - Improve Trim Compressor Part Load Efficiency	$806,000	146,000	43,000	9,000	20
1.7 - Reduce Run Time	$730,000	140,000	41,000	8,000	24
3.12 - Sparging	$359,000	9,000	3,000	1,000	3
1.5 - Adjust Cascading Set Points	$319,000	44,000	13,000	3,000	10
3.1 - Aspirating	$194,000	35,000	10,000	2,000	1
1.9 - Optimize Air Treatment	$189,000	23,000	7,000	1,000	2
3.6 - Diaphragm Pumps	$164,000	31,000	9,000	2,000	8
2.2 - Reduce Supply Side Pressure	$154,000	31,000	9,000	2,000	9
1.11 - Heat Recovery	$143,000	26,000	8,000	1,000	3
1.10 - Improve Compressor Intake Condition	$122,000	26,000	8,000	2,000	9
2.4 - Reduce Demand Side Pressure	$78,000	19,000	6,000	1,000	3
2.3 - Install Flow Pressure Control	$68,000	13,000	4,000	800	4
3.5 - Dense Phase Transport	$62,000	12,000	4,000	700	1
3.4 - Condensate Drain	$57,000	7,000	2,000	500	4
3.3 - Cabinet Cooling	$37,000	7,000	2,000	500	3
1.8 - Add Primary Receiver Volume	$33,000	6,000	2,000	400	5
2.7 - Reduce Distribution Piping Pressure Gradient	$18,000	4,000	1,000	250	2
2.8 - Reduce Component Pressure Drop	$10,000	2,000	1,000	120	2
2.6 - Install Secondary Storage	$9,000	2,000	1,000	120	1
2.5 - Install Primary Storage for Peak Air Demand	$9,000	1,000	0	100	1
3.13 - Vacuum Generation	$7,000	1,000	0	100	1
3.7 - Dilute Phase Transport	$4,000	800	0	50	1
3.9 - Open hand held blow guns or lances	$3,000	300	0	20	1
Grand Total	**$19,398,000**	**3,213,000**	**942,000**	**188,000**	**488**

Table 13. Potential cost savings, energy savings, and reduction in CO_2 emissions from identified fan opportunities in pick-list categories

Year 2007 - 08 Fan Savings Opportunity Recommendations	Cost savings ($/year)	Source energy savings (MMBtu/year)	Natural gas savings (MMBtu/year)	CO_2 savings (metric tons CO_2/year)	Number of times the opportunity applied
1.14 - Other	$18,034,000	3,044,000	892,000	81,000	23
1.16 - Recover heat from stack	$8,000,000	1,320,000	387,000	77,000	1
1.1 - Use Variable Speed Drive	$5,176,000	925,000	271,000	54,000	65
1.7 - Install new appropriately sized fan	$4,172,000	670,000	196,000	39,000	32
1.13 - Shut off unneeded fans	$2,124,000	326,000	96,000	18,000	13
1.6 - Install new appropriately sized impeller	$1,811,000	379,000	111,000	22,000	14
1.15 - Recover heat from exhaust air	$931,000	151,000	44,000	9,000	1
1.2 - Change belt drive ratio	$271,000	50,000	15,000	3,000	17
1.11 - Improve arrangement of air intake	$121,000	17,000	5,000	1,000	4
1.9 - Rearrange ductwork at fan inlet or discharge	$91,000	10,000	3,000	600	1
1.10 - Use factory designed inlet box	$40,000	6,000	2,000	400	1
1.3 - De-tip fan blades	$21,000	4,000	1,000	250	2
1.4 - Convert to belt drive	$15,000	2,000	1,000	150	1
Grand Total	**$40,805,000**	**6,903,000**	**2,023,000**	**306,000**	**175**

Table 14. Estimated payback periods for energy savings opportunities identified in the 2006, 2007, and 2008 *Save Energy Now* assessments

Payback category	Number of identified opportunities	Potential cost savings ($/year)	Potential total source energy savings (MMBtu/year)	Potential total CO_2 emission reduction (metric tons/year)
Payback data summary for all assessment completed in 2006 - 08				
0 - 9 months	1456	$363,595,000	55,394,000	3,365,000
9 months - 2 years	1211	$340,858,000	40,071,000	2,325,000
2 - 4 years	720	$221,865,000	24,301,000	1,929,000
4+ years	395	$87,231,000	13,569,000	1,061,000
spinoff	41	$31,467,000	3,000,000	160,000
Totals	**3,823**	**$1,045,015,000**	**136,335,000**	**8,839,000**
Payback data summary for steam assessment completed in 2006 - 08				
0 - 9 months	736	$207,885,000	33,510,000	2,063,000
9 months - 2 years	596	$195,153,000	20,276,000	1,212,000
2 - 4 years	345	$143,433,000	12,016,000	1,320,000
4+ years	166	$50,569,000	7,434,000	706,000
spinoff	15	$12,318,000	907,000	48,000
Totals	**1,858**	**$609,359,000**	**74,143,000**	**5,348,000**
Payback data summary for process heating assessment completed in 2006 - 08				
0 - 9 months	336	$100,949,000	13,823,000	826,000
9 months - 2 years	316	$123,631,000	16,400,000	916,000
2 - 4 years	202	$57,666,000	8,265,000	468,000
4+ years	92	$19,443,000	3,205,000	184,000
spinoff	10	$17,380,000	2,035,000	108,000
Totals	**956**	**$319,069,000**	**43,728,000**	**2,502,000**
Payback data summary for fan assessment completed in 2007 - 08				
0 - 9 months	33	$2,794,000	441,000	25,000
9 months - 2 years	42	$9,132,000	1,219,000	68,000
2 - 4 years	55	$15,059,000	2,930,000	78,000
4+ years	45	$13,820,000	2,313,000	135,000
spinoff	0	$0	0	0
Totals	**175**	**$40,805,000**	**6,903,000**	**306,000**

Payback category	Number of identified opportunities	Potential cost savings ($/year)	Potential total source energy savings (MMBtu/year)	Potential total CO_2 emission reduction (metric tons/year)
Payback data summary for compressed air assessment completed in 2007 - 08				
0 - 9 months	224	$8,573,000	1,524,000	89,000
9 months - 2 years	166	$6,604,000	1,150,000	67,000
2 - 4 years	48	$1,837,000	370,000	22,000
4+ years	44	$810,000	149,000	9,000
spinoff	6	$1,573,000	20,000	1,000
Totals	**488**	**$19,398,000**	**3,213,000**	**188,000**
Payback data summary for pump assessment completed in 2007 - 08				
0 - 9 months	62	$4,340,000	901,000	53,000
9 months - 2 years	83	$5,398,000	911,000	53,000
2 - 4 years	69	$3,845,000	718,000	42,000
4+ years	48	$2,589,000	469,000	27,000
spinoff	10	$196,000	38,000	2,000
Totals	**272**	**$16,368,000**	**3,038,000**	**177,000**

Table 15. Steam assessments — potential percentage savings in plant energy costs and source-energy use from all identified opportunities, by pick-list category

Pick-list category of identified savings opportunities	Frequency	Average energy cost savings (%)	Average source-energy savings (%)
1.2 - Use an Alternate Fuel	42	15.2*	6.5
2.2 - Clean heat transfer surfaces - radiant tubes, heat exchangers	1	2.6	2.5
1.1 - Reduce Steam Demand by Changing the Process Steam Requirements	253	2.8	2.1
1.8 - Add or Modify Operation of Condensing Steam Turbine	27	2.9	1.4
1.20 - Multiple Boiler Optimization	19	2.2	1.2
1.18 - Feedwater Heat Recovery - General	27	1.5	1.1
1.19 - Deaerator Heat Recovery - General	6	1.0	0.9
1.7 - Add or Modify Operation of Backpressure Steam Turbine	105	2.2	0.9
1.3 - Change Boiler Efficiency	335	1.3	0.9
1.14 - Implement Steam Trap Maintenance Program	133	0.8	0.6
1.1 - Reduce oxygen content of flue (exhaust) gases	2	0.8	0.8
1.21 - Reduce or Recover Vented Steam	64	1.0	0.7
1.12 - Modify the Medium Pressure Condensate Flash System	8	1.3	0.7
1.13 - Modify Low Pressure Condensate Flash System	22	1.0	0.7
1.11 - Change Condensate Recovery Rates	123	0.9	0.6
1.14 - Implement Steam Trap Maintenance Program	133	0.8	0.6
1.9 - Modify Feedwater Heat Recovery Exchanger using Condensate Tank Vent	10	0.6	0.5
3.5 - Use of waste heat for water or air cooling, steam generation or absorption cooling	2	0.7	0.5
1.6 - Change Steam Generation Conditions	19	0.5	0.4
1.16 - Improve Insulation	197	0.6	0.4
1.10 - Modify Feedwater Heat Recovery Exchanger using Boiler Blowdown	101	0.5	0.4
1.5 - Install Blowdown Flash to Low Pressure Steam	25	0.5	0.3
3.1 - Use of flue or Exhaust gas heat for combustion air preheating	2	0.4	0.3
1.15 - Implement Steam Leak Maintenance Program	100	0.4	0.3
1.4 - Change Boiler Blowdown Rate	87	0.4	0.2
6.2 - Other - Misc.	1	0.2	0.1
5.1 - Furnace scheduling, loading, shut down - avoiding delays, waits, cooling between operations	1	0.4	0.0

* Includes energy savings from switching to an opportunity fuel.

Table 16. Process heating assessments — potential percentage savings in plant energy costs and source-energy use from all identified opportunities, by pick-list category

Pick-list category of identified savings opportunities	Frequency	Average energy cost savings (%)	Average source-energy savings (%)
1.4 - Use of alternate fuel or energy source	11	6.6*	5.6
3.5 - Use of waste heat for water or air cooling, steam generation or absorption cooling	20	6.0	4.9
1.3 - Use of proper heating methods - replace inefficient methods with efficient system	46	3.7	3.3
3.4 - Heat recovery from hot products or other heat sources	42	3.4	2.9
1.5 - Use of oxygen for combustion	35	3.3	2.7
3.1 - Use of flue or Exhaust gas heat for combustion air preheating	99	2.5	2.4
5.3 - Control (reduce) make up air for ovens to meet the process safety requirements	14	2.7	2.3
5.1 - Furnace scheduling, loading, shut down - avoiding delays, waits, etc.	36	3.1	2.3
2.1 - Improving heat transfer in a furnace-oven	15	2.1	2.3
3.3 - Heat cascading - use of flue or Exhaust gas heat from higher temp. process	56	2.5	2.2
3.2 - Load or charge preheating using heat from flue or exhaust gas or other source of waste heat	63	1.7	1.4
1.1 - Reduce oxygen content of flue (exhaust) gases	164	1.3	1.2
4.3 - Reduce-eliminate openings and air leakage in the furnace	67	1.4	1.1
6.1 - Other - Measures not directly related to process heating	33	1.8	1.1
4.1 - Proper insulation and maintenance of furnace structure or parts	106	1.2	1.0
2.2 - Clean heat transfer surfaces - radiant tubes, heat exchangers, heater tubes	9	0.8	0.9
1.16 - Improve Insulation	7	0.7	0.9
4.2 - Reduce-eliminate internal cooling	10	1.5	0.8
1.7 - Use of outdoor air for combustion or make-up air	4	0.9	0.8
1.6 - Use of process or exhaust air for combustion	16	1.1	0.7
1.3 - Change Boiler Efficiency	8	0.8	0.7
1.1 - Reduce Steam Demand by Changing the Process Steam Requirements	3	0.8	0.6
1.2 - Eliminate excess unburned hydrocarbons (CO, H2, CH4, soot in the exhaust gases)	11	0.7	0.5
5.4 - Eliminate use of continuous flame curtains, pilots where possible	3	0.3	0.3
5.2 - Reducing weight of fixtures, trays, baskets etc.	3	0.2	0.2
1.20 - Multiple Boiler Optimization	1	0.01	0.01
6.2 - Other - Misc.	84	3.1	2.9

* Includes energy savings from switching to an opportunity fuel.

Table 17. Compressed air assessments — potential percentage savings in plant energy costs and source-energy use from all identified opportunities, by pick-list category

Pick-list category of identified savings opportunities	Frequency	Average energy cost savings (%)	Average source-energy savings (%)
3.1 - Aspirating	1	1.3	1.4
1.4 - Improve Trim Compressor Part Load Efficiency	20	1.0	1.0
3.3 - Cabinet Cooling	3	0.6	0.7
3.4 - Condensate Drain	4	0.7	0.7
3.8 - Open Blowing	23	0.5	0.6
1.6 - Multiple Compressor Control (install / improve)	59	0.5	0.6
1.1 - Reduce Air Leaks	92	0.5	0.5
1.7 - Reduce Run Time	24	0.5	0.5
4.1 - Other	34	0.5	0.5
1.5 - Adjust Cascading Set Points	10	0.4	0.4
1.11 - Heat Recovery	3	0.3	0.3
3.5 - Dense Phase Transport	1	0.6	0.3
3.6 - Diaphragm Pumps	8	0.3	0.3
1.2 - Improve End Use Efficiency	100	0.5	0.3
1.9 - Optimize Air Treatment	2	0.6	0.3
2.6 - Install Secondary Storage	1	0.3	0.3
1.3 - Reduce System Air Pressure	62	0.3	0.3
2.8 - Reduce Component Pressure Drop	2	0.2	0.2
2.4 - Reduce Demand Side Pressure	3	0.3	0.2
3.12 - Sparging	3	0.4	0.2
2.7 - Reduce Distribution Piping Pressure Gradient	2	0.2	0.2
2.3 - Install Flow Pressure Control	4	0.2	0.2
1.10 - Improve Compressor Intake Condition	9	0.1	0.1
1.8 - Add Primary Receiver Volume	5	0.2	0.1
2.2 - Reduce Supply Side Pressure	9	0.2	0.1
2.5 - Install Primary Storage for Peak Air Demand	1	0.1	0.1
3.13 - Vacuum Generation	1	0.05	0.08
3.7 - Dilute Phase Transport	1	0.04	0.02
3.9 - Open hand held blow guns or lances	1	0.02	0.01

Table 18. Pumping assessments — potential percentage savings in plant energy costs and source-energy use from all identified opportunities, by pick-list category

Pick-list category of identified savings opportunities	Frequency	Average energy cost savings (%)	Average source-energy savings (%)
1.9 - Other	36	0.4	0.4
1.10 - Excessive friction loss due to system design	3	0.3	0.4
1.1 - Excessive valve friction loss part of the time	25	0.4	0.3
1.3 - Excessive recirculation	22	0.3	0.2
1.2 - Excessive valve friction loss all of the time	71	0.3	0.2
1.11 - System specs exceed system requirements	3	0.2	0.2
1.8 - Degraded equipment performance	12	0.2	0.2
1.7 - Less than optimal equipment for the application	53	0.2	0.2
1.5 - More flow than required to meet system requirements	30	0.2	0.2
1.4 - Unneeded flow path	8	0.1	0.1
1.12 - Change time of use	6	0.2	0.1
1.1 - Use Variable Speed Drive	2	0.1	0.1
1.6 - Suction-related problems	1	0.03	0.04

Table 19. Fan assessments — potential percentage savings in plant energy costs and source-energy use from all identified opportunities, by pick-list category

Pick-list category of identified savings opportunities	Frequency	Average energy cost savings (%)	Average source-energy savings (%)
1.15 - Recover heat from exhaust air	1	5.5	3.0
1.16 - Recover heat from stack	1	2.2	2.5
1.13 - Shut off unneeded fans	13	1.1	1.5
1.14 - Other	23	2.4	1.1
1.7 - Install new appropriately sized fan	32	0.7	0.7
1.6 - Install new appropriately sized impeller	14	0.5	0.4
1.2 - Change belt drive ratio	17	0.3	0.3
1.10 - Use factory designed inlet box	1	0.3	0.2
1.1 - Use Variable Speed Drive	65	0.2	0.2
1.11 - Improve arrangement of air intake	4	0.1	0.1
1.9 - Rearrange ductwork at fan inlet or discharge	1	0.7	0.1
1.4 - Convert to belt drive	1	0.1	0.1
1.3 - De-tip fan blades	2	0.1	0.1