Better Plants®
U.S. DEPARTMENT OF ENERGY

Trailblazers and Goal Achievers: How Better Plants Partners Achieved Ambitious Energy Goals

AUGUST 2021

DOE/EE-2485

U.S. DEPARTMENT OF ENERGY

Authors and Acknowledgements

"Trailblazers and Goal Achievers: How the Better Plants Partners Achieved Ambitious Energy Goals" was developed for the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) as part of the Better Buildings, Better Plants program. The guide was developed by staff at the Department of Energy (DOE) in collaboration with ICF.

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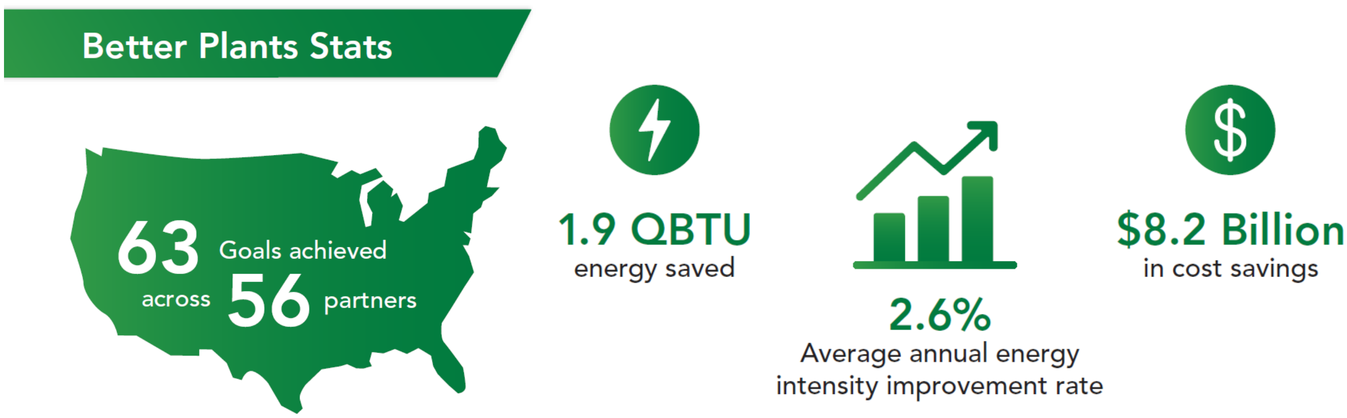
Report Number: DOE/EE-2485

Introduction

Since 2009, more than 250 U.S. manufacturers and industrial-scale energy-using organizations have established ambitious energy intensity reduction goals by joining DOE's Better Plants program. Having an ambitious goal that is approved and communicated by senior management gives these companies a target to reach and helps focus their efforts towards improving energy efficiency. However, setting an ambitious energy or sustainability goal can be a daunting proposition, particularly if personnel in such companies don't have enough resources or a coherent plan to achieve it. By working towards the Better Plants program goal, Better Plants partners have saved **1.9 Quadrillion BTUs** and almost **$8.2 billion** cumulatively since 2009.



As of 2019, **56 Better Plants partners** met the program goal a total of **63 times** (some partners met the goal more than once and then re-committed to the program goal and met it again – all in the past 12 years). In most cases this goal was a **25% improvement in energy intensity** to be achieved within ten years of joining Better Plants, with an **average annual energy intensity improvement rate of 2.6%**. This document seeks to serve as a high-level planning resource for new partners and interested manufacturers that seek to establish an ambitious energy efficiency goal. This document presents common strategies that were implemented by the partners that met the goal as well as best practices and estimates of energy savings potential for various industrial systems.

For partner organizations that have not yet undertaken a corporate energy-efficiency program, understanding how their peers were able to achieve an ambitious energy efficiency goal can provide more confidence as they seek to meet either the Better Plants goal or a similar corporate goal. As the U.S. industrial sector accounts for approximately 25% of U.S. GHG emissions[1], advances in energy performance, particularly reductions in consumption and intensity, are likely to yield reductions in emissions. In one example, 141 industrial plants that met EPA's Energy Star for Industry certification in 2015 achieved energy savings of 544 Trillion BTUs (on a source basis), which translated into CO_2e reductions of 36 million metric tons[2].

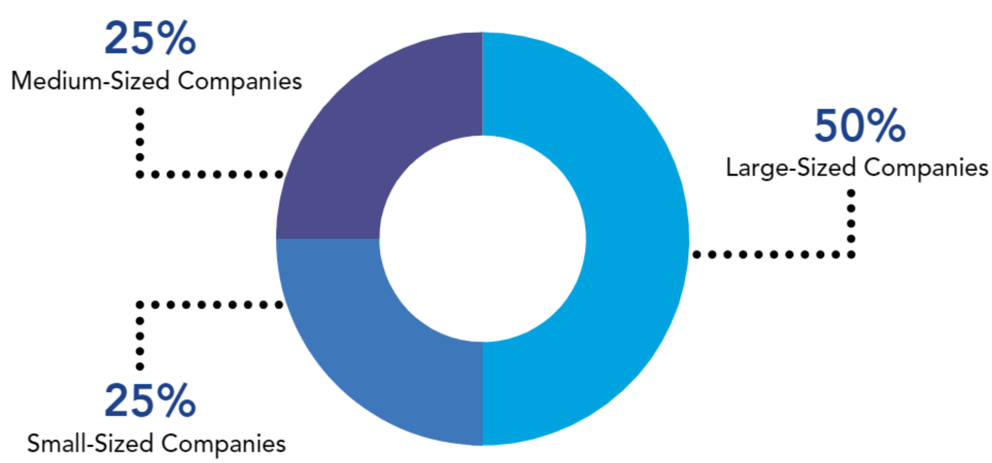
[1] EPA: Reducing Greenhouse Gases by Advancing Industrial Energy Efficiency, 2000-2015

[2] Ibid.

Characteristics of Goal Achievers

Based on some characteristics of the goal achieving partners, some interesting insights can be gleaned. Of the 56 organizations that met the goal, **28** (50%) **can be considered large**, industrial companies (more than 500 employees, 25 plants and $100 million in sales). In many cases, large companies have the resources to establish large EHS departments with highly trained staffs who can focus on energy efficiency and who can address having numerous plants and obtain employee buy-in. Another **14 partners could be classified as medium-sized companies** (more than a few plants, but not more than 20-25). There were **14 goal achievers that could be considered small companies**. This includes three wastewater treatment agencies that had each one plant. Each of these three wastewater treatment agencies installed a CHP system, which enabled them to meet the goal. As these smaller companies didn't have large EHS staffs they depended on highly motivated employees/managers who usually held other positions within their companies.

Company Size of Better Plants Goal Achievers

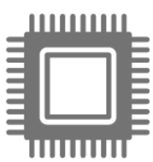


Another important aspect is that most goal achievers reached their goal within the 10-year period of the partnership. Four goal achievers took ten years to reach the 25% improvement, which signifies that 52 partners were able to meet it in less than the 10-year timeframe. The average amount of time to reach the goal was **5.72 years**. The table below shows many partners achieved their goals in how many years:

Years to Reach Goal	2	3	4	5	6	7	8	9	10	>10
# of Goal Achievers	4	3	10	11	6	3	2	6	4	2

How Long it Took Partners to Achieve their Goals

The partners that met the goal come from a wide variety of industrial sectors. The most frequently represented sectors are electronic equipment (NAICS code 335) and transportation equipment (NAICS code 336), which both have eight goal achievers, respectively. Common processes in this sector include process heating and machining, which is often served by compressed air systems. Next, is machinery manufacturing (NAICS code 333) with seven goal achievers. This includes manufacturers of industrial equipment, engines, and HVAC equipment.



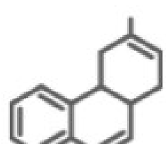
Electronic Equipment
8 Goal Achievers

Transportation Equipment
8 Goal Achievers

Machinery Manufacture
7 Goal Achievers

The next most represented sectors are forest/paper products (code 321), diversified manufacturing (code 339) and water and sewerage treatment (code 2213). The forest/paper products sector is very energy-intensive and depends on steam. The diversified manufacturing sector include consumer conglomerates that make a variety of chemicals, paper, and medical products. The water and sewerage sector depends on large pumping and aeration fan systems for which significant energy efficiency gains can be found. This sector also offers significant potential for goal achievement from cogeneration alone.

Paper Products
6 Goal Achievers



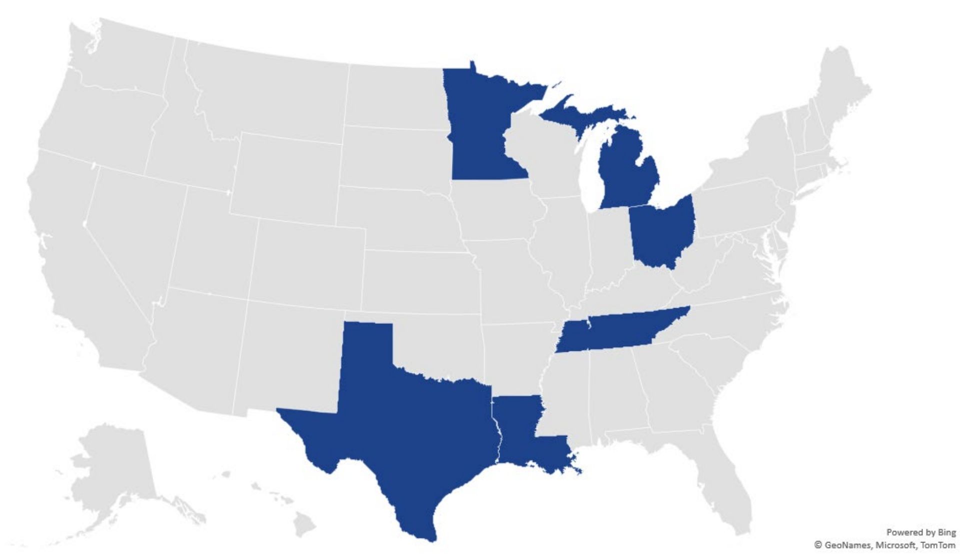
Diversified Manufacturing
6 Goal Achievers

Water and Sewerage
5 Goal Achievers

The next sectors in order of representation include non-metallic minerals (code 327) with four, chemicals (code 325), food processing (code 311) and fabricated metal products (code 332) with three goal achievers each. Companies in these sectors are often energy intensive and depend on steam, process heating and compressed air to support their production processes.

The remaining sectors include textiles (code 314) with 2 companies, paper making (code 322), plastic parts (code 326), fabricated metal products (code 331) and electronics (code 334) with one goal achiever each.

These goal achievers have plants across the U.S., but **many are in states with high numbers of industrial companies** such as Ohio, Indiana, Michigan, Tennessee, Minnesota, Louisiana, and Texas.



Better Plants Goal Achievers: Pathways to Ambitious Energy Goals

The partners that met the Better Plants goal leveraged many resources offered by both Better Plants and the DOE's Advanced Manufacturing Office (AMO). These resources include:

- Technical Account Manager (TAM) support
- In Plant trainings
- DOE software tools
- Better Plants diagnostic instruments
- Industrial Assessment Center (IAC) energy audits
- Energy management (SEP/50001 Ready)

TAM SUPPORT

When partners join Better Plants they are assigned a Technical Account Manager (TAM) to help the partners reach the goal. TAM can help with everything from establishing energy metrics and baselines, supporting training, using diagnostic tools, arranging for energy assessments from DOE's Industrial Assessment Centers and suggesting/making available any resources that they know of that can help the partners reach their goal. Support from Better Plants TAMs was instrumental for many goal achievers. Often, TAMs customized their support to each partner depending on their needs, level of energy management maturity and bandwidth. For most partners TAM support involved, at minimum, assistance in determining the appropriate energy metrics to gauge their energy intensity and in developing a robust energy baseline to compare results and measure cumulative savings. A good example concerns the partners in the water and wastewater treatment sector. Better Plants opened the partnership to this sector in 2014 and since then five partners from this sector have met the program goal. The TAMs working with these partners were instrumental in helping them develop energy metrics based on either flow (kWh/1000 gallons) or Biological Oxygen Demand (BOD).

TAM support also manifested itself in providing advice on how to leverage Better Plants and AMO resources. TAMs have helped partners identify large, energy using sites and systems and helped prioritize the partners' efforts.

One significant component of technical assistance delivered by TAMs is selecting which In Plant trainings would be valuable for partners to apply for and receive. TAMs have recommended many of the In Plant trainings that partners applied for based on high level reviews of the energy-using systems at the partners' plants. Some of the more frequently recommended systems to receive trainings include compressed air (often represents the most expensive utility for manufacturers), steam (one of the largest energy uses in industry) and energy treasure hunts (enable facility-level personnel to identify and quantify energy-saving opportunities).

What Partners are Saying About Better Plants TAM Support:

"By joining the Better Plants program and receiving the encouragement of DOE staff and our TAM it helped push towards the goal and make others realize that we were not pursuing this effort in a vacuum."

- **Victor Valley Wastewater Reclamation Authority**

"Our TAM has been instrumental in identifying and communicating opportunities for DOE assistance and helping with the application process. He has also been very proactive in informing us about good practices he has seen at other manufacturing sites and in assisting with our annual reporting."

- **Volvo Group North America**

"Our TAM had been instrumental in identifying and communicating opportunities for DOE assistance and helping with the application process. He has also been very proactive in informing us about good practices he has seen at other manufacturing sites and in assisting with our annual reporting."

- **Lennox International**

"By knowing how DOE can help us track energy consumption amongst certain equipment, having a TAM that can provide further insight, and collaborating more with other partners down the road are certainly ways that we can leverage what we have available in order to be successful."

- **3M**

IN-PLANT TRAININGS

In-Plant trainings are the primary workforce development resource offered by the Better Plants program. Of the approximately 140 In Plant trainings that have been awarded between 2011 and 2019, 53 of which (38%) were awarded to goal achievers. Of the 56 goal achievers, 24 (42%) were awarded at least one In Plant training and 15 (~25%) goal achievers received more than one In Plant training prior to reaching the goal. Total estimated energy cost savings from opportunities identified across the 53 trainings were approximately $19 million.

Each In-Plant training includes education on one or more of DOE's system software platforms and TAMs were able to help partners access and use these software tools during and after the In-Plants were delivered. TAMs also brought diagnostic equipment and were able to help partners use these instruments to gather real-world, field data to analyze the systems in their plants.

What Partners are Saying About Better Plants INPLTs:

NISSAN

"The In-Plant trainings allowed industry experts to guide us in improving our process heating and compressed air systems. We were able to incorporate energy efficiency into the design of a new paint plant achieving a 30% reduction versus the old paint plant."

- **Nissan North America**

OWENS CORNING

"In-Plant Trainings have been instrumental in helping us identify opportunities and training people at the Plants on Energy conservation."

- **Owens Corning**

TE connectivity

"We have a small staff working on energy efficiency/sustainability and with as many plants and locations as we have making the sites aware of our commitment and how to reach the goal was a big lift. Fortunately, the educational resources (sourcebooks, case studies, tip cards) and the treasure hunt in plant training helped us spread the word and get site employees involved, which we previously could not do as well."

- **TE Connectivity**

INDUSTRIAL ASSESSMENT CENTERS (IAC) AND COMBINED HEAT AND POWER TECHNICAL ASSISTANCE PARTNERSHIPS (CHP TAPS)

In addition, TAMs facilitated access to IAC audits and CHP TAP assistance. The IAC audits have been crucial in helping partners understand both the types of energy efficiency opportunities and the magnitude of the energy savings that the opportunities could generate. Of the 56 goal achievers, 32 received at least one IAC audit. In addition, TAMs facilitated Better Plants partners' access to technical assistance on cogeneration or CHP. One goal achiever that benefited from this facilitation was Shaw Industries that was able to successfully install a 14.1 MW CHP system at one of their plants in Columbia, South Carolina.

The table below shows some DOE resources and how many of the goal achiever partners leveraged them:

DOE Programs and Resources Leveraged by Goal Achievers	Number
Received INPLT	24
Received IAC Audit	32

In addition, there were some partner goal achievers that leveraged other DOE resources such as Better Buildings financial allies for innovative funding mechanisms such as Energy as a Service arrangements.

Common Approaches to Reaching the Goal

Based on a review of goal achievers' experiences, two principal approaches for reaching the goal emerged: energy management and discrete project implementation.

ENERGY MANAGEMENT

Energy management is the implementation of a series of procedures, personnel assignments, internal policies, accountability mechanisms and managerial techniques that facilitate an organization's ability to improve its energy performance. In the case of Better Plants partners that met the goal, energy management systems (EnMS) aligned with the ISO 50001 Energy Management Standard have proven effective in supporting each respective organization's drive towards goal achievement. A few noteworthy facts emerge from these partners:

- Nine goal achievers have at least one plant that certified to SEP/50001
- Three goal achievers have at least one plant that attested to completing 50001 Ready
- Three of the SEP-certified goal achievers participated in voluntary pilot activities (SEP accelerator, SEP demonstrations). By participating in these activities these partners received free technical assistance from DOE in establishing their respective EnMSs.
- Several partners with ISO 50001-conformant EnMSs were able to meet the Better Plants goal early. This was the case with Volvo Trucks (4 years), Harbec (5 years), Schneider Electric (7 years), Comau (5 Years), and General Dynamics (3 years).

Each of the SEP-certified and 50001 Ready goal achievers implemented some common practices:

- Established an energy baseline normalized to production – this serves as the benchmark from which changes in energy performance are measured.
- Established Energy Performance Indicators (EnPIs) – these are the metrics used by the organization to understand current energy performance and gauge improvements over time.
- Established objectives, targets, and action plans – each partner performed an energy review which informs the development of the organization's objectives and targets, which support the organization's energy policy and strategic goals related to energy performance. The Better Plants program goal is an example of such an objective. This review also informs actions plans that specify what types of activities or projects the organization will undertake to meet its objectives and targets.
- Established operational controls/backsliding prevention measures – all these partners identified improvement opportunities that needed frequent implementation such as tagging and fixing compressed air leaks. By frequently addressing these types of energy losses that can occur or re-occur often, partners prevented energy losses from returning, thereby making the energy savings from those systems persistent.

Goal Achievers that Leveraged DOE Energy Management Programs	**Number**
SEP or 50001 Ready	12

INDIVIDUAL ENERGY-SAVING PROJECTS

Implementation of energy efficiency projects is how most of the goal achievers reached the Better Plants goal. Often, these projects were separate, energy-saving projects or tasks that were implemented at different points in time and spanned a variety of systems, technologies, and practices. A review of these projects shows that they can be further divided into three categories with the respective number of goal achievers in each category[3]:

1. One or a few large, capital-intensive projects (9 partners)
2. A combination of small, medium, and large projects (38 partners)
3. Many small- to medium-sized projects over time (8 partners)

The types of projects implemented by goal achievers that depended on one or a few large projects were most often projects that required large capital outlays exceeding $1 million each on specific technologies and were funded through capital budgets or, in some cases, municipal bond auctions for water/wastewater treatment agencies. Several of these projects involved installing Combined Heat and Power (CHP) systems. This was true for Victor Valley, New Water, Encina, Shaw Industries, and UTC. For many of these partners the CHP systems provided all or most of the improvement toward the goal. Other partners implemented large-scale renewable energy technologies. This was the case with Harbec Plastics, which implemented waste heat recovery (WHR) from injection molding machines, CHP, and wind turbines at their plant. The CHP system generated enough electricity that they were able to sell excess power into the grid. Proctor & Gamble developed a 50-megawatt biomass plant and CHP system that significantly increased the company's ability to come closer to its 2020 goal of obtaining 30 percent of its total energy from renewable sources. In a smaller number of cases, partners implemented whole system retrofits. This was the case with Martin Guitar that retrofitted the HVAC and chiller system serving their main plant. The project's energy savings propelled them to the goal and yielded better product quality due to improved consistency of humidity levels in the plant.

The types of projects that are in the combination of small, medium, and large projects are more varied. They spanned a wide spectrum of thermal and motor-driven systems as well as building envelope technologies and appliances. Some of the more common systems that were optimized included steam systems, lighting & HVAC, chiller systems, compressed air systems, pumping, fan and motor-driven systems, furnaces and process heating systems, and process improvements. Some of the more common optimization projects implemented include installing Variable Frequency Drives (VFD) on motor-driven systems, upgrading control systems and control schemes, steam trap replacement, sub-metering, regulating compressed air tools, replacing belts on fan systems with V-notched or cogged belts, adding/repairing mechanical insulation, upgrading motors, installing pressure/flow controllers with primary storage on compressed air systems, and lighting upgrades. Another important note is that some projects could be funded from maintenance or operating budgets while the more sophisticated ones needed capital funding.

The next category of project, small- to medium-sized projects, pertains to projects that could be funded out of operating budgets and be performed by plant-level personnel (outside vendors and consultants were not as necessary as for larger, capital-intensive projects). As with the preceding category, these projects cover a wide range of systems and applications including compressed air,

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[3] In the case of 1 goal achiever there was not sufficient information to determine what types of projects enabled them to reach the goal.

steam, pumping, building envelope and some processes. Another important aspect of these projects is that they often involve behavioral modifications such as turning off equipment when it is not needed. Some common examples of these projects include compressed air leak detection/repair, adjusting set points, applying vortex nozzles/regulators, fixing insulation/seals in furnaces, and equipment schedule adjustments and reconfiguration.

Some other salient statistics that emerged from the two latter categories of projects (small- to medium and combination of small, medium, and large) include:

- Of all the systems that were optimized, the most frequent projects reported involved compressed air systems. Twelve goal achievers identified compressed air system projects as part of their accomplishments that led them to meet the goal. In the case of Nissan's Smyrna, TN, plant a compressed air project that redesigned a compressed air operated paint plant achieved a 30% reduction in paint booth energy consumption versus the old paint.

- For many of the goal achievers in the small, medium, and large projects category that were new to energy efficiency, approximately 10 started with some small, low- or no-cost projects and moved onto more sophisticated, capital-intensive projects after achieving robust energy savings from the initial energy-saving efforts. This was the case for Eaton, Legrand, CYT, Navistar, Volvo, BPM, Comau, General Dynamics, JR Simplot, TE Connectivity. A good example is with Legrand, the company started by identifying low-tech, low-cost energy savings projects with attractive payback periods. Later on, the company was able to get the CEO's approval to buy and install a fuel cell that supplies 86% of the electricity needed for their headquarters and main plant.

- Many partners included best practices as part of their strategy, particularly as it pertained to system maintenance and operation. For example, in the case of TE Connectivity, compressed air leak detection/repair was often uncovered so often in their periodic energy treasure hunts that the company decided to make this activity a regular task, thereby preventing the leak load from returning to a previously higher level.

- Many partners sought to educate employees. This was most often done via the In Plant trainings as 23 of the 56 goal achievers received at least one In Plant training. In other cases, partners implemented their own educational campaigns informed by resources such as the DOE sourcebooks and the Better Plants Treasure Hunt toolkit. One significant example is with United Technologies (now part of Raytheon Technologies) in which the company created corporate guidance documents on energy and water efficiency and shared them across the enterprise.

- Many projects, whether they were small, medium, or large, were identified and recommended during In Plant trainings, IAC assessments and a couple Energy Savings Assessments (ESA) in the early days of the program. In some cases, the In-Plants and IAC assessments were able to confirm ideas generated by plant personnel who did not know how to quantify the savings. Some partners that credited IACs include Sherwin-Williams, Volvo Trucks, and Legrand. Partners that claimed to benefit from In Plant trainings include JR Simplot, Volvo Trucks, and Owens Corning. Two partners specifically referred to ESAs as having been helpful to them: Verso Paper and JR Simplot.

COMMON STRATEGIES

While discrete projects generated the energy savings that enabled many partners to reach the Better Plants program goal, many partners also implemented some common strategies and tasks that informed the projects and practices that they would take. Below, is a list of such strategies:

1. **Management Support and Funding –** partners elevated energy efficiency by either selecting a management representative to guide them or gaining senior management support to carry out the projects and practices needed to meet the goal. In the case of Schneider Electric, a management job title was created so that if the employee who held the title of energy manager left the company another management representative would need to fill the position. 3M had a longstanding energy program in which the employee responsible for energy management grew into a management role and kept his energy management responsibilities, thereby raising the prominence of energy management within the company.

2. **Data Collection –** almost all partners that met the goal decided to review their energy consumption to understand where energy is going in their plants and how it is being used. This enabled them to determine the best metrics to gauge their progress. A good example involves Legrand U.S., which installed submeters at all their facilities to gather real-time energy data and determine the energy flows within the plants. This enabled the company to understand what types of energy-saving projects would yield the greatest impacts such as compressed air leak repair and reducing system pressure, lighting upgrades, and using compressor exhaust for space heating in winter months.

3. **Identification of Energy –** using applications that can yield a) large savings or b) short paybacks on energy efficiency – many goal achiever partners used a strategic approach to determine how to maximize the impact of their efforts. This involved identifying the largest and/or least well performing plants and the systems that used the most energy and that would be susceptible to yielding significant energy savings. One example of this is with Cummins Engine. In 2009, Cummins established an Energy Champion Program to drive continuous improvement in energy performance at the plant level. The company trained facility energy leaders to identify top energy-consuming applications and operator-level improvements that could be done on them. This program is now required for the top energy consuming sites, representing 89% of the energy footprint of the company.

4. **Energy Action Plan –** once partners understood their energy flows and consumption, they knew where to focus efforts and many goal achievers developed short-, medium- and long-term projects that would enable them to meet their goals. 3M is one partner that applied this approach comprehensively across the enterprise. This company has had one of the longest running corporate energy management programs in the U.S. – since 1972. Over time they were able to train people in all plants to serve as energy managers in those plants. As these employees took steps to assess energy efficiency potential, they also categorized various energy-saving projects based on payback periods to determine which ones to implement. Since starting their program, the company has implemented more than 1,500 energy efficiency projects using this approach.

5. **Engage Other Departments/ Business Units –** for many goal achievers the energy managers understood that they needed other teams, divisions, and departments to participate in their corporate energy efficiency efforts. In the case of TE Connectivity, the energy manager leveraged the Better Plants Treasure Hunt In Plant training to engage employees that didn't typically focus on energy into the company's energy efficiency efforts. As part of the training's intent, TE assigned one employee to conduct energy treasure hunts and train other employees on how to perform them. In the four years since the initial treasure hunt In Plant, the company has performed more than 100 energy treasure hunts in its U.S. plants involving employees from multiple business units. Each time a treasure hunt is conducted the recommendations are added to a central database of energy-saving measures that the entire company can consult for ideas and implementation methodologies.

6. **Communicate Success –** Often, partners benefited from showing to both internal and external stakeholders how their energy efficiency accomplishments offered value. The communications materials served not only to showcase accomplishments but also to show how the energy efficiency accomplishments support the company's sustainability goals. In the case of Celanese, the partner leveraged DOE's communications capability to generate case studies each time they had a big energy-saving project or process upgrades that enhanced their ability to save energy. They also highlighted employees' accomplishments and global energy team meetings in internal newsletters.

7. **Training Employees –** many partners that met the goal encouraged employees to attend training offered by outside organizations such as AEE, the Compressed Air Challenge, and the Georgia Institute of Technology (particularly the ISO 50001 Certified Practitioner course). By gaining competence in energy efficiency, partner employees were able to identify opportunities and prevent situations that could lead to energy waste. In one example, General Motors convened employees from many plants in 2018 to an In Plant training on 50001 Ready to help educate them on energy management. Since then, 69 sites have completed the 25 steps in the 50001 Ready Navigator including 11 facilities belong to Better Plants partners.

8. **Internal Recognition of Employees –** some partners that met the goal recognized both energy management staffs as well as personnel from other teams such as production and engineering for their contributions. This was done to further engage employees and reward them for contributing to the organization's energy efficiency goal achievements. In one case, 3M established an internal recognition program that bestowed gift certificates to restaurants to employees that came up with energy-saving ideas/projects.

9. **Integrate Energy Efficiency into Procurement –** a few goal achievers decided to develop policies and mechanisms to ensure that energy efficiency is integrated into the corporate procurement process. A strong example of this involves Volvo Trucks. At the company's truck assembly plant in Dublin, Virginia, the plant's energy manager has oversight over procurement and if a piece of equipment that is proposed for purchase could increase the plant's energy intensity/consumption, the energy manager flags it for the plant manager who then decides whether to approve the purchase (instead of the procurement manager).

Concrete Steps that any Organization can Take

Based on the experiences of Better Plants goal achievers and best practices within the energy efficiency community, several steps and expected energy savings can be formulated into almost any industrial company's approach to reaching the Better Plants goal.

PERFORM AN ENERGY REVIEW

Conducting an energy review involves the following steps:

- Acquiring, analyzing, and tracking energy data
- Determining significant energy uses
- Identifying energy saving opportunities, and
- Prioritizing energy saving opportunities

1. Acquire, Analyze, and Track Data

A successful energy efficiency strategy relies on accurate and appropriate data. The energy review is a key component of this strategy as it enables an organization to identify and collect the appropriate data needed to provide an accurate profile of the organization's energy situation and to enable the organization to determine its energy performance and identify opportunities for improvement.

The DOE has several self-assessment tools that can help you perform an energy review. The Plant Energy Profiler (PEPEx) tool provides an overview of the amount of energy that your plant purchases, identifying the major industrial systems that consume that energy, describing your plant's savings potential, and pointing out specific measures you can take to realize savings. Many people who have used PEPEx were able to complete a plant profile in about one hour. Based on your responses, the tool can estimate potential savings in energy and costs and provide a simple list of the most common recommendations for your equipment.

A similar tool is available for specific analysis of steam systems. The Steam System Scoping Tool (SSST) is an Excel-based spreadsheet tool that walks you through several worksheets to gather information about your steam system. These include profiling your system, understanding your operating practices, and accounting for your steam end uses. Based on your overall score, you can determine the overall operating efficiency of your steam system.

2. Determine Significant Energy Uses

Designating a the most important industrial systems, equipment and associated processes as "significant", allows an organization to focus their limited resources on improving and maintaining optimum performance in a small number of systems that can yield the largest energy savings and ensure the best use of an organization's resources.

As with step 1, the DOE's PEPEx tool output can show you what systems and/or applications are using the most amount of energy in your plants.

Another tool that can be useful for acquiring energy data is DOE's Energy Footprint Tool. The footprint tool has a dedicated section for developing a list of Significant Energy Uses (SEU). You can create groups of energy-using equipment by location, type, or process and enter information about estimated operating hours, rated power, and loading. The goal is to balance the estimate of your energy consumption from the SEU list with the energy you are being charged for by your utilities. An accurate footprint can help prioritize efficiency projects and help utilize savings for future energy efficiency investment.

One method for identifying significant energy-using applications is by developing X-Y plots of energy use versus production or other parameters. This can reveal the relationships between energy use and other parameters and can explain variations in consumption and highlight potentials for interventions. For this task the DOE's [Energy Performance Indicator (EnPI)] regression analysis tool can be helpful. Regression analysis is a statistical technique that estimates the dependence of a variable (typically energy consumption for energy use and intensity tracking) on one or more independent variables, such as production and ambient temperature, while controlling for the influence of other variables simultaneously. Please see the newly revised Baseline Guidance document for more information.

An alternative approach is to generate an energy balance of your plants. In this approach, a certain threshold of energy consumption or a certain percentage of total consumption is used as a selection criterion for significance. Creating an energy balance for the organization and its main energy consuming processes provides a deep understanding of how energy is used and lost. A particularly effective way of communicating energy balance information is the development of Sankey diagrams. The DOE's interactive Dynamic Sankey Diagram Tool is a web-based tool that allow users to create custom Sankey displays of their energy consumption. Once generated the images can be saved for export.

3. Identify Energy Saving Opportunities

The best way to uncover energy-saving opportunities is to perform an assessment using real-world, field data of the significant energy-using systems. This has been done through Better Plants In Plant trainings and DOE's Industrial Assessment Centers. Industrial end users can also commission energy assessments from engineering consultants who have expertise and experience in performing such assessments. Users may want to consult resources such as the Compressed Air Challenge's Guidelines for Choosing a Compressed Air System Provider or the American Society of Mechanical Engineers System Assessment standards to understand what should be part of an appropriate energy assessment.

In the absence of a robust energy assessment, the DOE's PEPEx tool can provide rough estimates of energy-saving opportunities based on the information that is inputted into the model. Two examples of such estimates are provided in figures 1 and 2 below:

Figure 1.

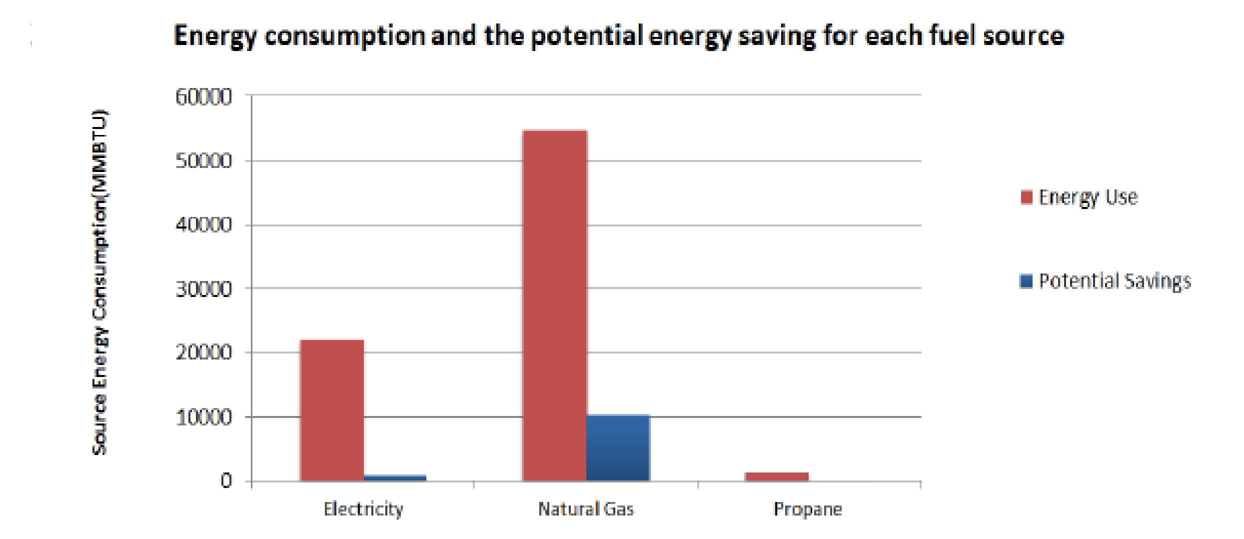
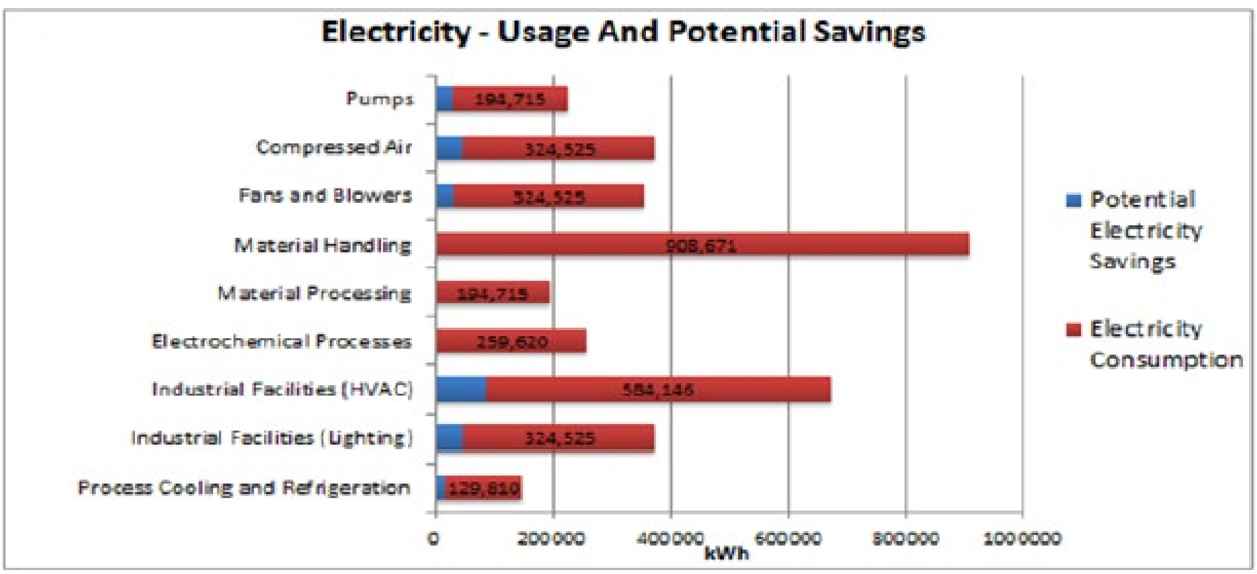


Figure 2.



4. Prioritize Energy-Saving Opportunities

The next step is to prioritize the energy-saving opportunities identified. Prioritizing ideas based on defined criteria helps focus resources on the most practical opportunities. Examples of criteria can include:

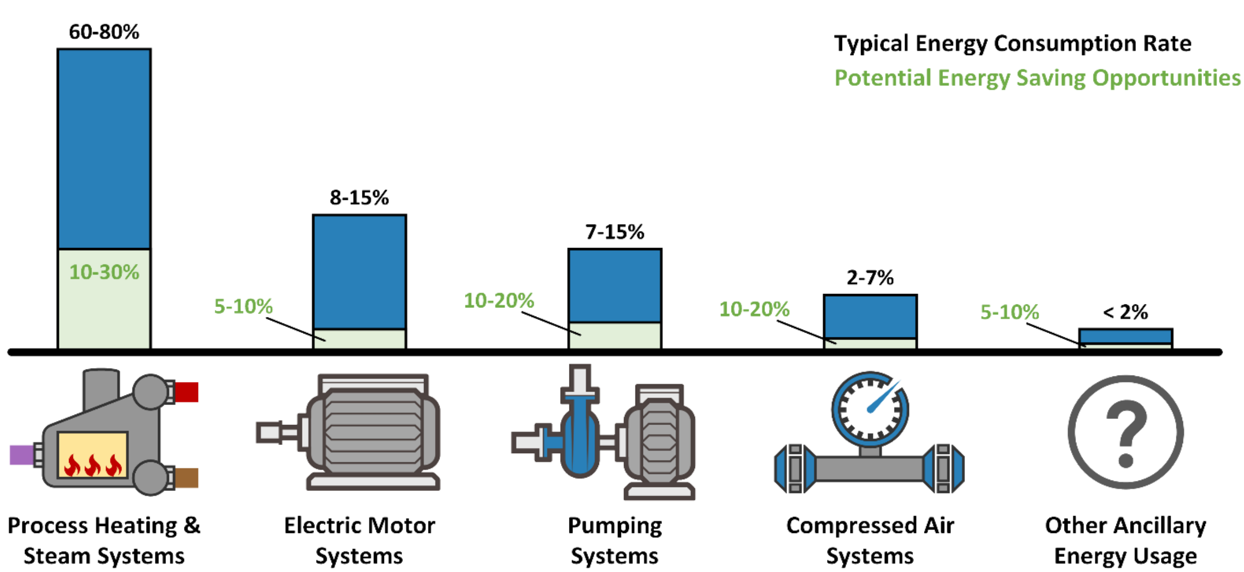
- Estimated energy or cost savings
- Financial cost of opportunity implementation
- Simple payback, return on investment, internal rate of return, or net present value
- Ease or difficulty of project implementation
- Length of implementation period
- Quantifiable co-benefits such as maintenance savings, productivity benefits, safety, health, and environmental benefits

The fourth and final input sheet in the PEPEx application allows users to define the potential energy savings opportunities for each system. The is done by choosing between High/Medium and Low priority from the drop-down list in rows 17 – 28. A high-level guideline to determine the existing potential can be found in the instructions above the table. Tool users also have the option to use a more rigorous approach to determine energy savings potential associated with a system by making use of the scorecards that are in the tool.

ESTIMATE ENERGY SAVINGS

Once the energy review is complete your organization will have a strong idea of where to pursue energy-saving efforts, both best practices and projects. Figure 3 below provides a high-level overview of major energy-using applications and processes that are common to industrial plants. It gives typical aggregate energy consumption rates and potential savings opportunities for each system or set of systems.

Figure 3.



Conclusion

There is no single or one-size-fits-all approach for industrial energy end users to achieve an ambitious energy efficiency goal. In the case of DOE's Better Plants program, 56 partners representing approximately 25% of the partnership met the program goal between 2009 and 2019. These partners used multiple strategies and leveraged various DOE resources in reaching their goals. In some cases, partners adopted energy management aligned with ISO 50001. For others, discrete energy-saving projects in three separate categories (capital-intensive projects, a combination of operational and capital-intensive projects, and operational projects) enabled them to reach the objective. In both approaches (energy management and discrete projects), the inclusion of best practices facilitated partners' ability to get to the goal.

One additional takeaway is that the preponderance of this data shows that in many cases it is not necessary to incur large expenditures on new or sophisticated technologies to reach an ambitious goal. One hypothesis for this is that many manufacturing plants in the United States tend to be older, existing facilities in which energy efficiency may not have been understood at the time they were designed and built. As a result, energy-saving opportunities that can be considered "operational" or not requiring large capital expenditures can be easy to find and can yield significant savings. Another insight for partners that received IAC assessments and In Plant trainings, is that the recommendations generated during those events by the subject matter experts who led them, are consistent with a system-level approach toward optimizing/replacing industrial equipment. In essence, this means that in any given system the impact(s) of all the equipment in that system – from the controls and fuel intakes all the way to end use applications and the operating practices – are considered. In contrast to approaches that favor replacing prime mover types of equipment such as motors, this approach considers the condition and efficiency of prime mover equipment as well as all components and practices that can affect the prime movers' energy consumption. Projects based on this approach tend to generate robust energy savings along with co-benefits such as improved reliability and lower maintenance needs.

Manufacturers and industrial-scale energy-using organizations that establish ambitious energy goals can gain important insights from their peers that achieved similar goals. By leveraging the technical assistance resources offered by DOE's Better Plants and other DOE resources, many Better Plants partners identified and implemented energy efficiency measures that enabled them to meet the program goal. While each organization is different, some common measures can be applied by many industrial organizations to establish a pathway that can enable them to meet the Better Plants goal or a similarly ambitious corporate goal.

Appendix: Energy Efficiency Measures and Potential Savings

A more comprehensive and specific list of opportunities broken out by type and system is provided below. Once an organization determines the projects it can implement it is possible to derive a rough estimate of what will yield a cumulative improvement of approximately 20 to 25%. Note: The savings provided are averages based on previously implemented projects. Individual results may vary.

ENERGY MANAGEMENT

- Implement ISO 50001 to establish a transparent energy efficiency policy and permanent energy management system. Plants and buildings can certify to the standard. If they wish, they can also certify to the energy savings achieved during the process of establishing an ISO 50001-conformant energy management system, via DOE's 50001/Superior Energy Performance program.
- Use the DOE's 50001 Ready Navigator – completing the 25 steps in this online tool will provide ~90% of the infrastructure that organizations have once they've certified to ISO 50001 without the need for an external certification audit.
- Utilize the ASME system assessment standards (steam, pumping, compressed air, and process heating) for both internal, operator-level assessments and when working with outside energy experts. Assessments conducted in accordance with these standards support ISO 50001-based energy management systems.

STEAM/BOILER SYSTEMS

- Check steam lines to fix steam traps and repair leaks - savings from 3% to 6%[4]
- Capture energy from boiler blowdown – savings up to 7% depending on site-specific steam conditions[5]
- Insulate steam lines – savings of 1% to 2% depending on length of pipe and steam temperature[6]
- Tune Boiler - (minimize excess air, clean boiler heat transfer surfaces, improve fuel/air ratio control) – savings between 1% to 10% – savings of between 1.5% to 3%[7][8][9]
- Install combustion air pre-heaters – savings up to 6% for every 300°F decrease in gas temperature[10]
- Install economizer on boilers – savings of up to 4% of boiler energy use[11]

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[4] EPA "Steam Systems in Industry: Energy Use and Energy Efficiency Potentials," 2001 (http://eetd.lbl.gov/node/49826)

[5] EPA "AVAILABLE AND EMERGING TECHNOLOGIES FOR REDUCING GREENHOUSE GAS EMISSIONS FROM INDUSTRIAL, COMMERCIAL, AND INSTITUTIONAL BOILERS," 2010

[6] NWFPA "Opportunities in Boiler Efficiency," 2010 (http://www.nwfpa.org/nwfpa.info/component/content/article/37-boiler/57-opportunities-in-industrial-boiler-efficiency)

[7] EPA "AVAILABLE AND EMERGING TECHNOLOGIES FOR REDUCING GREENHOUSE GAS EMISSIONS FROM INDUSTRIAL, COMMERCIAL, AND INSTITUTIONAL BOILERS," 2010

[8] EPA "AVAILABLE AND EMERGING TECHNOLOGIES FOR REDUCING GREENHOUSE GAS EMISSIONS FROM INDUSTRIAL, COMMERCIAL, AND INSTITUTIONAL BOILERS," 2010

[9] CED "Improving Energy Efficiency of Boiler Systems," 2011

[10] EPA "AVAILABLE AND EMERGING TECHNOLOGIES FOR REDUCING GREENHOUSE GAS EMISSIONS FROM INDUSTRIAL, COMMERCIAL, AND INSTITUTIONAL BOILERS," 2010

[11] IIP"A2A Energy Assessment and Management Study," 2013

- Upgrade instrumentation and controls – savings range from between 0.5% to 3%[12]
- Consider oxygen trim controls (in addition to minimizing excess air) – savings up to 0.5% for every 1% decrease in excess oxygen from the stack[13]
- Consider parallel positioning (separate motor actuators for air and fuel) to improve fuel to air ratio – savings up to 2%[14]
- Install high efficiency motor on boiler feedwater and condensate tank pumps – savings range from 3% to 15% depending on age and type of motor[15]
- Replace/upgrade worn burners – savings up to between 4% to 5%[16]

COMPRESSED AIR SYSTEMS

- Repair fixed leaks in plant header, regulators, quick fittings, and tubing (after leak load is reduced, reduce compressor discharge pressure) – savings range from 15% to 25% of compressed air energy costs[17]
- Minimize vented compressed air – savings of up to 12%[18]
- Eliminate wasteful uses/switch to non-pneumatic methods. Savings up to 20% in compressed air energy costs.[19]
- Upgrade compressed air system controls – savings range from 2% to 15% of compressed air energy costs depending on type of upgrade (installing part-load controls, microprocessors, or system master controls).[20]

PROCESS HEATING/FURNACE SYSTEMS

- Check and maintain proper burner air to fuel ratios – savings range from 5% to 25%[21]
- Improve heat transfer (clean and maintain heat transfer surfaces) within a furnace – savings can range from 1% to 10%[22]
- Check and maintain furnace insulation – savings range from 5% to 10%[23]
- Reduce air leakage and infiltration in furnace (maintain seals, avoid excessive door openings) – savings can be up to 5%[24]
- Install waste heat recovery systems to:

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[12] EPA "AVAILABLE AND EMERGING TECHNOLOGIES FOR REDUCING GREENHOUSE GAS EMISSIONS FROM INDUSTRIAL, COMMERCIAL, AND INSTITUTIONAL BOILERS," 2010

[13] CED Engineering, "Improving Energy Efficiency of Boiler Systems," 2011

[14] NWFPA "Opportunities in Boiler Efficiency," 2010 (http://www.nwfpa.org/nwfpa.info/component/content/article/37-boiler/57-opportunities-in-industrial-boiler-efficiency)

[15] DOE Motor & Fan sourcebook

[16] EPA "AVAILABLE AND EMERGING TECHNOLOGIES FOR REDUCING GREENHOUSE GAS EMISSIONS FROM INDUSTRIAL, COMMERCIAL, AND INSTITUTIONAL BOILERS," 2010

[17] DOE "Motor System Market Opportunities Assessment," 2002

[18] DOE case study on Southeastern Container (http://www.compressedairchallenge.org/library/casestudies/southeasterncontainer.pdf)

[19] DOE "Motor System Market Opportunities Assessment," 2002

[20] DOE "Motor System Market Opportunities Assessment," 2002

[21] DOE Process Heating sourcebook

[22] Ibid

[23] Ibid

[24] Ibid

- Preheat combustion air – average energy cost savings ~$239,000, average payback 1 year; savings range from 15% to 30%[25]
- Preheat loads/materials before entering process – savings range from 5% to 25%[26]
- Provide heat to external processes (steam, water heating, HVAC, absorption cooling) – savings range from 5% to 20%[27]
- Improve heat transfer with advanced burners & burner controls – savings range from 5% to 10%[28]
- Use oxygen-enriched combustion air – savings range from 5% to 25%[29]
- Install furnace pressure controllers (prevent ambient air from leaking into furnace) – savings range from 5% to 10%[30]

PUMPING SYSTEMS

- Trim impellers on pumps instead of using bypass/throttling valves in cases of excess flow/oversized pumps – savings up to 15% of pumping system energy use[31]
- Install variable speed drives – savings up to 50%[32]
- Optimize pipe size to reduce head and frictional losses – savings range from 5% to 20% of pumping system energy use[33]

FAN SYSTEMS

- Install variable speed drives – savings can range from 10% to up to 50%[34]
- Replace V-belts with cogged or synchronous belt drives which can save 2% to 5%[35]
- Upgrade fan system controls

MOTOR AND OTHER SYSTEMS

- Optimize motor control[36]
- Replace worn motors with NEMA premium efficiency motors - savings range from 1% to 4% above EPact levels depending on speed and type of motor[37]

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[25] Ibid

[26] Ibid

[27] Ibid

[28] Ibid

[29] Ibid

[30] Ibid

[31] IIP "A2A Energy Assessment and Management Study," 2013

[32] DOE: Guidebook "Variable Speed Pumping"

[33] DOE "Motor System Market Opportunities Assessment," 2002

[34] DOE Motor sourcebook

[35] DOE motor sourcebook

[36] IIP"A2A Energy Assessment and Management Study," 2013

[37] DOE motor sourcebook, appendix C

- Implement a motor management program (repair/replace & purchasing policies, spares inventory, motor maintenance, motor selection) – savings of up to 20%[38]
- Chiller systems: consider using waste heat recovery with absorption or adsorption chillers – savings up to 50% of chilled water energy costs[39][40]

BUILDING ENVELOPE:

- Install radiant heaters – savings up to 25% of HVAC energy use[41]
- Install high efficiency furnaces with condensing heat exchangers – savings range from 12% to 16% of furnace energy use[42]
- Install variable speed drives on chiller compressors, saving up to 50% of chiller energy use[43]
- Replace lighting with LED lighting – savings between 50% to 80% of lighting energy use depending on wattage of replaced lighting technology[44]

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[38] Ibid

[39] ACEEE "Best Practices for Data Centers: Lessons Learned from Benchmarking 22 Data Centers," 2006

[40] Minimum Energy Performance Standards: Chillers, Australian National Appliance & Equipment Energy Efficiency Program http://www.energyrating.gov.au/wp-content/uploads/Energy_Rating_Documents/Library/Cooling/Chillers/200415-mepschillers.pdf

[41] IIP"A2A Energy Assessment and Management Study," 2013

[42] EPA "Energy Star Building Upgrade Manual," 2008

[43] IIP "A2A Energy Assessment and Management Study," 2013

[44] Australian Government "Energy Efficiency Opportunities in Commercial Buildings, Aldi Foods Audit" 2010