In a recent survey of U.S. manufacturers, almost all—95%—reported that utilities and fuel costs increased on a per-unit basis in the past 12 months, with 67% reporting an increase of at least 6%. This creates an enormous challenge for the manufacturing sector, which consumes more energy than any other sector of the U.S. economy.

A limited supply of traditional sources and lengthy development cycles for alternatives make it certain that manufacturers will face an increasingly expensive and volatile energy market for the long term. This dilemma could inflate per-unit costs during a highly competitive period of global pricing pressure—not a good scenario for companies aiming to grow profits and market share.

Manufacturers use petroleum-based energy and products to run their machinery and plants, transport their products to market, and as an ingredient in finished goods and packaging. As with other companies, they face rising costs in many areas, such as employee benefits; but considering that manufacturers have limited alternatives to their core business activities, they must find a way to contain energy costs in order to protect profits.

The solution is adoption of a continuous improvement methodology that maximizes energy investment and eliminates energy waste. Energy LeanSigma® is a proven methodology that can do this and has the advantage of employing familiar tools that many manufacturers already use for process improvement. This paper defines Energy LeanSigma®, describes its benefits, and then describes how tools such as 5S, standard work, Total Productive Maintenance (TPM), visual management, and value chain mapping enable Energy LeanSigma® implementation.

Energy LeanSigma® can deliver:
- A way to identify, classify, and prioritize the financial impact of energy conservation.
- Improved environmental-emissions performance, customer satisfaction, and operating costs.
- A competitive advantage that will enable sales and profitability growth.
- A culture of involvement and mutual respect that encourages continuous improvement.

With this methodology, plant managers can come to understand the major energy consumers at their plants and the costs related to them; apply lean principles to identify opportunities for energy savings; change habits by increasing employee awareness; and maintain the gains over time by integrating standard work with energy-saving practices and using visual methods to track the progress. Additionally, by training associates to identify and eliminate wasted energy, an organization creates its own in-house league of environmental stewards and

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**How have the following costs changed in the past 12 months?** *(on a per-unit basis)*

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<thead>
<tr>
<th></th>
<th>Decreased</th>
<th>Increased</th>
<th>Stayed the Same</th>
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<tbody>
<tr>
<td>Utilities/fuel</td>
<td>5%</td>
<td>93%</td>
<td>Energy-intensive 2%</td>
</tr>
<tr>
<td>Employee benefits</td>
<td>1%</td>
<td>93%</td>
<td>6%</td>
</tr>
<tr>
<td>Logistics/transportation</td>
<td>4%</td>
<td>89%</td>
<td>Energy-intensive 7%</td>
</tr>
<tr>
<td>Employee wages</td>
<td>3%</td>
<td>87%</td>
<td>10%</td>
</tr>
<tr>
<td>Component/materials</td>
<td>10%</td>
<td>85%</td>
<td>Energy-intensive 5%</td>
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</table>
can quickly demonstrate the power of continuous improvement because cost savings are immediate.

**Using Lean Tools for Energy Management**

Manufacturers have enormous potential to cut costs by using common continuous improvement tools to manage energy consumption. According to the 2008 Census of Manufacturers, only one-third of U.S. plants have an energy-management program, although 88% report using at least one continuous-improvement methodology. Even among U.S. manufacturers that identify themselves as operating at or close to world-class status, fewer than half (46%) have an energy-management program despite their use of at least one improvement methodology at 99% of their plants.iv

Let’s take a look at some common continuous improvement tools and how they can be applied to eliminate energy waste, thus reducing costs substantially.

**5S: Workplace Cleanliness and Organization**

5S often is where continuous improvement in a particular area begins. The five terms, which all begin with S, describe an action used to create and maintain a safe, organized, clean, high-performance workplace: sort, set, shine, standardize, and sustain. These activities are the fundamentals of all improvement in the workplace and can be applied anywhere - work cells, warehouses, offices, delivery trucks, docks, etc.

From a management perspective, 5S is a valuable tool because it:

- Promotes safety.
- Creates a receptive environment for standard work.
- Is a prerequisite to perfect quality.
- Encourages visual control.
- Helps to identify waste.
- Promotes employee satisfaction.

5S is an ongoing cycle propelled by regularly scheduled audits that measure performance and encourage ongoing improvement through the five activities.

It is important to understand that 5S is not about just housekeeping. Rather, it is about organization and discipline. Frontline employees will not be able to effectively implement energy-management techniques without these characteristics. Through regular use, 5S trains minds and eyes to see waste and provides an easy-to-understand and universally applicable methodology to eliminate and prevent it. Its principles, activities, and outcomes (learning and discipline) create an environment that is receptive to ongoing continuous improvement.v

**Standard Work: Repeatability to Create Quality Processes**

Reducing variation improves quality, a truism that manufacturers usually apply to the goods they produce by enforcing product specification and/or investing in automation. But people cannot be automated, and variation in how they perform the same tasks can cause waste of motion, time, materials, machinery, and energy. Standardizing tasks using *standard work instructions* prevents this. Think of quality not just in

<table>
<thead>
<tr>
<th>How Does 5S Work?</th>
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<tbody>
<tr>
<td><strong>Key Principle</strong></td>
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<tr>
<td><strong>Sort</strong></td>
</tr>
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<td><strong>Set</strong></td>
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<tr>
<td><strong>Shine</strong></td>
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<tr>
<td><strong>Standardize</strong></td>
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<tr>
<td><strong>Sustain</strong></td>
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</table>
terms of goods produced but also in terms of the processes that produce them. High-quality processes use assets as efficiently as possible, thus consuming minimal assets (costs) to create maximum value (profits). In his book *Lean Product and Process Development*, Alan Ward confirms that the competitive advantage of being a lean producer comes not through designing and creating products but through designing and creating lean processes. Standardizing the day-to-day activities that comprise these processes is a key to eliminating and maintaining their quality, i.e., energy efficiency.

How does a plant, department, or cell begin using standard work? Define standard work for the tasks that propel processes by determining the best combination of people and equipment that uses the minimum amount of labor, space, inventory, energy, and equipment. Manufacturers commonly use a kaizen approach for this. “Best” refers to the best that can be achieved today, not some ideal, optimal condition. Standard work evolves and should be adjusted as learning and improvement expand. And as with 5S, standard work can be applied anywhere. That makes it an ideal tool to eliminate wasted energy because every function and location of a plant uses electricity.

Once a team identifies the best possible combination and establishes the standard work, it can create standard work instructions. Below is an example of standard work instructions for the process of closing an office at the end of the workday. It could be the outcome of a kaizen event to eliminate wasted energy. Note that the checklist uses simple language and a simple diagram to illustrate the standard work. This is important because standard work instructions need to be understood by anyone performing the task, and in a cross-functional plant, that could be everyone.

In addition to reducing waste by eliminating variation, standard work ensures that the gains from kaizen activities are sustained, and it provides a baseline for future kaizen activities. It also clearly defines ownership of activity and outcomes, and makes it easier to find root causes of problems.
Total Productive Maintenance (TPM) and Autonomous Maintenance

An obvious target for energy reduction in a manufacturing plant is machinery. Particularly in continuous process industries, the production floor consumes more energy than any other part of a plant. The ideal continuous improvement tool to attack plant-floor energy waste in machinery is TPM.

TPM is a system based on a partnership between plant floor and maintenance employees. Its goals are to keep equipment in optimal condition and support lean principles. True to lean philosophy, TPM solves problems. In this case, it addresses common production equipment problems such as these:

- No one monitors basic equipment conditions.
- Employees lack sufficient operating and maintenance skills.
- Equipment is poorly designed.
- Deterioration of equipment is not addressed until it causes a larger, more costly problem such as a stopped line or substandard product quality.

Without a TPM program, these problems are part of everyday life on the plant floor, and associates learn to respond with firefighting and bandage solutions. This negatively affects performance many ways, including wasting energy, because equipment that is not in peak condition runs inefficiently.

Equipment maintenance needs to become part of the standard work of machine operators to achieve optimal efficiency.

Specifically, machine operators can be trained to:

- Perform daily checks on equipment;
- Lubricate equipment as needed;
- Replace simple components;
- Perform minor repairs;
- And, assist in problem problem-solving alongside maintenance engineers, who perform more complicated repairs and tasks such as new-equipment design that require their specialized skills.

A plant might need to change how its operators and technicians work to set up the best system. For instance, a plant manager might find two levels of machine technicians a better way to address the plant’s needs — one level to perform routine work (operators), and one level to perform specialized and/or more high-tech work (maintenance group).

TPM is not a maintenance-driven program. It is driven by the partnership between machine operators and maintenance technicians, and their co-ownership of both the machinery and the process it supports.

As TPM implementation takes hold, maintenance practices (both operator- and technician-based) improve. The equipment will experience less performance variation, will run more efficiently, and can be scheduled more reliably.

Visual Management

Visual management refers to the concept of conveying pertinent knowledge of an environment’s processes and conditions to everyone working in that environment using visual signals. It enables employees to differentiate between a normal and an abnormal situation immediately.

Visual management “demystifies” many of the secret languages and metrics used in hierarchical management systems that trap decision-making at the top. By contrast, lean environments require transparency in order to disperse control of processes to those performing the work within those processes. Transparency supports lean by:

- Encouraging ongoing learning by observation and attentiveness;
• Putting control and ownership into the hands of front-line employees;
• Improving performance by making problems immediately apparent;
• Improving efficiency by making it easier to see waste;
• Connecting daily activities to strategic goals by focusing on and encouraging performance that supports these goals; and
• Developing ownership, accountability, and responsibility, which creates the potential to involve all levels of an organization in performance improvement.

Examples of operational visual-management tools include:

• Metrics boards where real-time and trend performance data are displayed, such as actual-to-planned output, takt time, energy consumption, and quality yields.
• Color-coding systems that identify ownership of areas, tools, machinery, employees, materials, processes, etc. This supports 5S and makes it possible to immediately identify ownership and responsibility.
• Information centers that use charts, tables, lists, and other displays to convey performance by unit, function, system, process, etc. These centers often serve as meeting sites for these groups as well.
• Bins, shelves, carts, and other items that have meanings or functions beyond storage. For instance, an empty bin could signify a need to replenish inventory and be moved to a different location to signify it needs to be filled, or the location of a cart could signify the status of work-in-process.
• Gages, levels, pressures on machinery that allow “at-a-glace” recognition of normal or abnormal.

These tools enable operational efficiency, which in turn supports efficient use of energy.

From a leadership standpoint, visual management can reap big returns with minimal investment. For instance, most lean leaders use or have used value stream mapping to objectively identify problems and collectively envision solutions. Adding energy consumption data to every value stream map used in a plant and communicating that energy savings opportunities exist in every activity are inexpensive and fast ways to begin the energy reduction process.

Value stream maps have the advantage of being objective. Because solving problems in a manufacturing plant requires changing behaviors, this effort often meets resistance. Employees might view the requirement to change as a personal affront or see the potential benefits as inconsequential. Value stream maps help to break through this resistance and have the tools and knowledge to fully participate, they can lead energy-reduction efforts at individual points in the plant through kaizen. Begin by identifying the sources of energy in the plant, which could be: natural gas, compressed air, steam, water, electricity, and fuel. Make these systems — pipes, valves, controllers, trucks, and all other equipment — the focus of kaizen events.

These are some of the problems that may be found:

Gas and compressed air: Fixing leaks can return immediate and substantial savings. One company using Energy LeanSigma® saved $300,000 in one year by finding and repairing 400 gross air leaks. After fixing the leaks, they found they could stop using two compressors (450 HP and 200 HP) that ran across three shifts.

Steam: Undetected steam leaks are extremely expensive, as are uninsulated pipes and valves in steam systems. Fixing steam leaks dramatically reduces energy waste. At one plant, fixing 850 of 5,000 steam traps yielded more than $1 million in annual savings.

Water: Spillage from systems that use or supply heated water, such as boilers, is common. As with compressed air, water often is misused or overused in both the manufacturing processes and the sanitation routines associated with them.

Electrical equipment: Monitoring and documenting energy consumption of equipment discloses how efficiently the equipment is running. It is important to understand why the equipment is being used and if the equipment itself is masking an
inefficient process. For instance, can electronic-fund-transfers replace the non-value-adding task of cutting checks in the accounts payable department? Such a change would speed the payment process, eliminate the need for check-cutting equipment, and reduce the cost of check-cutting supplies.

**Vehicle fuel:** The most effective way to reduce vehicle fuel costs is to reduce the need for transportation and material handling. Dedicated transportation and logistics engineering is a worthy investment if it focuses on the most efficient way to serve customers. Strategies such as cross-docking and consolidated shipments can be used to do this. Inside the plant, keeping inventories as lean as possible can reduce the need for material-handling equipment, as can having supplies delivered directly to the production line rather than a warehouse.

Continuous improvement has become an everyday part of the daily culture of competitive manufacturing plants. Incorporating energy management into these cultures, or including it as a continuous improvement methodology is implemented, can yield substantial cost savings. This will become increasingly important in the near term, as energy prices will remain volatile. Energy LeanSigma® is a proven methodology that enables both.

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iv ibid.
v *Progressive 5S: We’re Not Talking Trash*, Mike Serena, TBM Consulting Group, Durham, N.C., 2008
About TBM Consulting Group
Headquartered in Durham, N.C., TBM Consulting Group is the leading provider of Lean Sigma® Consulting and Training Services globally. With more than 150 experienced consultants operating on five continents in multiple languages across the globe, TBM has grown to be the worldwide leader in “lean innovation” and business improvement in the manufacturing and service sectors. The company’s mission is to help discrete and continuous process production manufacturers and service companies create a competitive advantage to generate significant growth in sales and earnings. The company provides strategic direction and hands-on implementation to guide cultural and organizational transformation. TBM Consulting Group’s Lean Sigma® approach integrates Lean principles for market agility and responsiveness, and Six Sigma’s focus on quality. For more information, visit www.tbmcg.com.

The TBM Lean Energy Practice provides maintenance and sustainability initiatives for long-term savings. Its Total Productive Maintenance Services, a critical adjunct to lean manufacturing, is focused on waste elimination, preventing deterioration, and reducing equipment breakdowns—a proactive approach that prevents any kind of process interruption before maintenance is needed.

About Doug Kiss
Doug Kiss, a lean consultant at TBM with over 30 years’ manufacturing experience, leads the TBM Lean Energy Practice. He has been certified in Total Productive Maintenance by the Japan Institute of Plant Maintenance. Formerly a corporate quality consultant for United Technologies, he led the operation’s transformation initiative involving more than 50 facilities and the supply base. Trained in Japan in 3P and in kaizen, Doug has led lean programs for facilities worldwide.