solutions

From Shop Floor to Top Floor: Best Business Practices in Energy Efficiency

by

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CASE STUDY

Toyota Motor Engineering & Manufacturing North America, Inc.
Internal Operations

Headquarters:	Erlanger, KY
President/COO:	Tetsuo Agata
Revenues (2008):	$94 billion
Energy Costs (2008):	$155 million
Energy Savings Target:	29 percent reduction in energy consumption per vehicle produced. Goal set in 2002 to be achieved by 2011.
Key Efficiency Strategy Successes:	• Engaging people across multiple levels and job functions to implement the energy efficiency strategy and sustain results; • Moving beyond supplying energy efficiently to production shops, to engaging shop staff in rethinking operating practices to drive down energy needs.

Toyota-TMMK—Internal Operations

On a wall in an open bay in the middle of the Toyota Motor Manufacturing Kentucky (TMMK) plant hangs a mockup of a NASCAR racetrack. Instead of mile-markers, the track is marked off in months. To its magnetic surfaces cling model cars, most—but not all—Toyotas. Taped on top of each car is a tiny face—the shop captains from Paint, Assembly, Power Train, Body Welding… 10 in all. In the pit area at the center of the track are pictures of each shop's "pit crews."

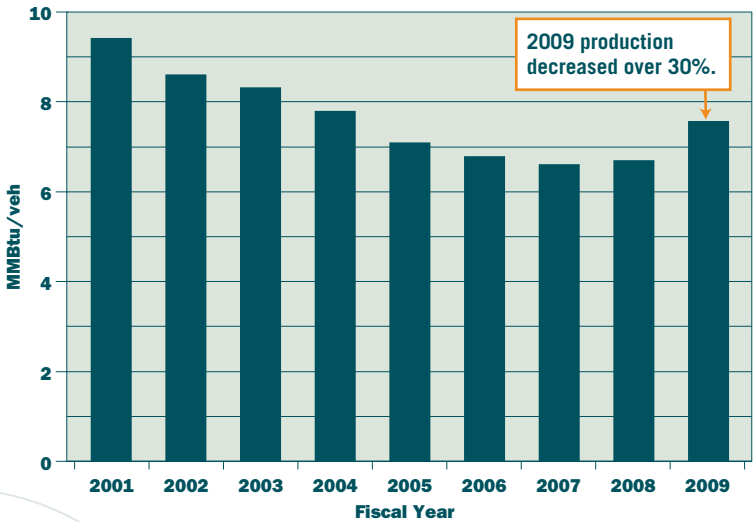
On a Wednesday morning in July, some 40 people gather in front of the magnetic track-board, from TMMK President Steve St. Angelo to the site's Energy Management Organization (EMO) lead, Roger Wallin, to shop captains and other team members. This meeting marks the start of the 2009 "Race for the Greenest." Roger places the tiny cars in order on the track-board, based on the points they earned in the previous month and year to date from energy, water, compressed air, and steam efficiency. Now in its third year, this friendly competition (earlier years used a horse-racing theme called "Greenland Stakes," based on the nearby Keeneland racetrack) not only gets good attendance, it appears to be getting results. TMMK beat the Toyota goal of using less than 6.3 million British Thermal Units (BTUs) per vehicle produced, having driven its usage down below six million.

The Race for the Greenest competition epitomizes Toyota's energy efficiency strategy. Energy is a key performance indicator that is measured and reported regularly, and the process engages the whole organization, from senior management to individual shop staff. But beyond the mechanics of the process, energy performance is part of the company's culture. There's a certain amount of fun that is palpable in these monthly gatherings: so it's not just about numbers, it's about how people see themselves, what they take pride in, what they hold to be important. Imposing new requirements on employees in an organization is not something that is always embraced with open arms; but at Toyota, the Race for the Greenest reveals a culture that is not only about performance by the numbers, but also about engaging people's pride and ingenuity for collective gain.

Energy as a formal performance indicator was first measured in Toyota North American operations in 1996, around the time that the Toyota Motor Engineering and Manufacturing North America (TEMA) corporate structure was formalized. In 2000, Toyota used over 9 Million BTUs per vehicle produced. The 6.3 million BTU target represents about a 30 percent improvement. Originally set in 2002 to be achieved in 2011, TEMA was close to realizing its goal in 2007, as shown in **Figure 1**. Since then, production slowdowns driven by the global recession have caused the per-vehicle number to creep up, as some energy uses cannot be throttled back in proportion to production. To illustrate the production slowdowns, in 2007, TMMK made over 500,000 vehicles; in 2009, it expects to make about 366,000.

Figure 1

North America **Energy Consumption** Per Unit



23% (12% 2009) Energy Reduction
20% CO_2 Reduction

Recreated based on image provided courtesy of Toyota (2009).

"Race for the Greenest" also shows a critical link in the Toyota EMO—between the facilities staff and the production teams. In a large manufacturing organization like Toyota, facilities is a service organization to the product units; it provides them the electricity, compressed air, steam, chilled water, natural gas

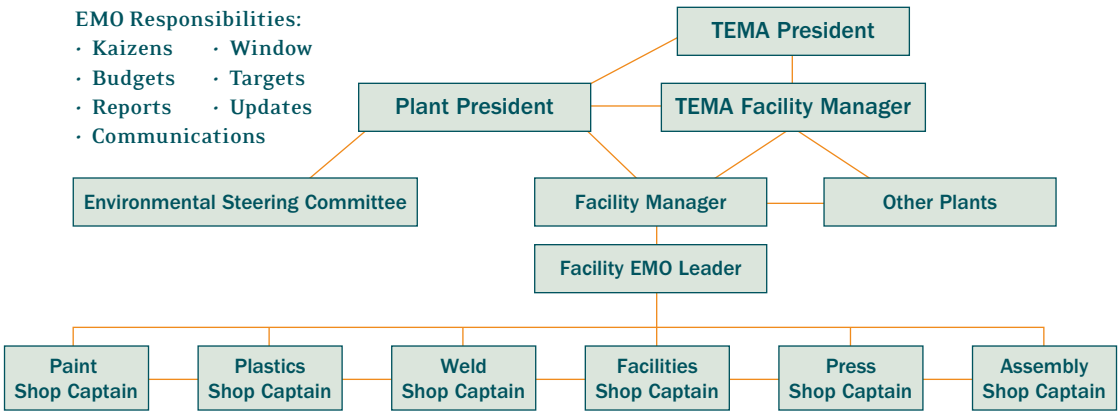
and other services they need to produce quality products. But the facilities team does not own, and is careful not to dictate, how the product units or "shops" run their operations. The production shops—assembly, paint, welding, stamping, etc.—have two primary mandates: (1) product quality and (2) production volume. Shop captains don't easily embrace ideas that might put either of these goals at risk. They need to be shown that meeting the energy and other Key Performance Indicators (KPIs) will help them, not hinder them, in meeting their quality and production goals.

The EMO has found that one way to overcome production shops' reluctance is through the use of pilot projects. EMO will commission one small project in one plant, document its success, and then engage the production staff in sharing their experience with others in the company. Peers from other shops and other plants inherently bring a greater comfort level to their counterparts than do facilities staff seeking to advance the EMO goals.

At TMMK, the magnetic board for "Race for the Greenest" covers only one wall of the meeting bay. The other two are covered with tables and charts showing the shops' KPI data. These walls, each perhaps 25 feet long, show how data-intensively Toyota's energy and other resources are managed. Charts like these seem to be posted everywhere at TMMK—in the production shops, facilities offices, and the power plant. They convey how visible these KPIs are to everyone who works there.

Figure 2

TEMA Energy Management **Organization**



Company Wide Energy Program

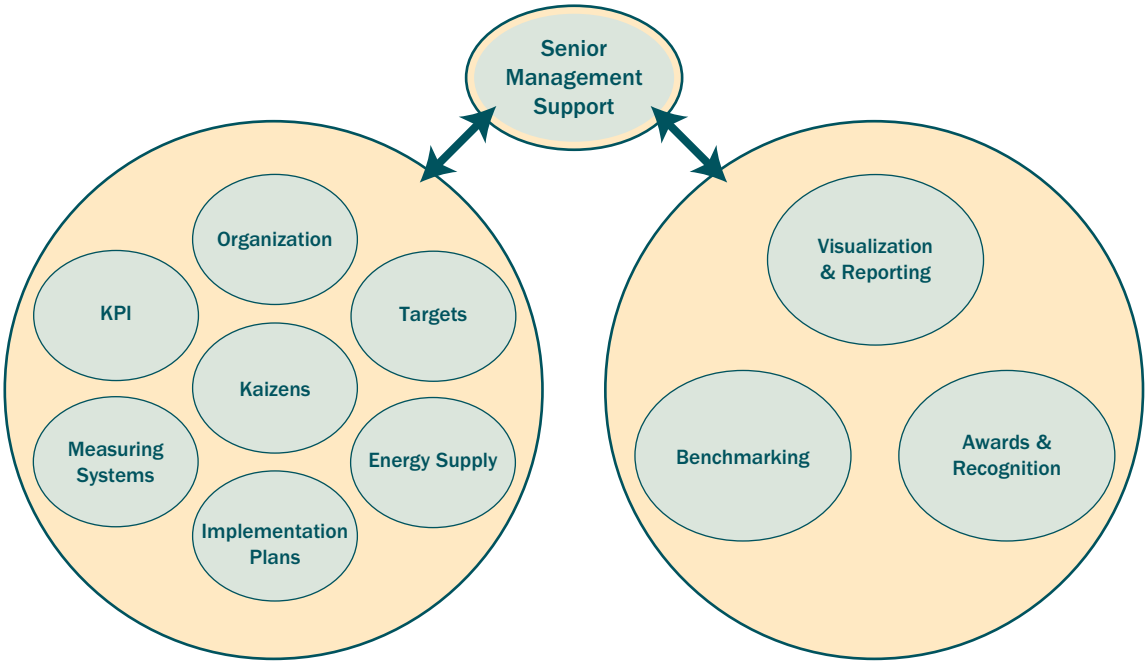
Recreated based on image provided courtesy of Toyota (2009).

Figure 2 charts the EMO's relationships in North America, from the President of TEMA to the individual production shops at each TEMA facility. The term "Kaizens" in this figure refers both to Toyota's overall Kaizen philosophy and to the practical application of the term as a database of efficiency technology information.[1]

Figure 3 elaborates on the EMO's several roles in supporting the various elements of the energy program. Reporting to and receiving support from senior management, the EMO focuses on the six internal activities on the left side of the figure, from KPIs to target-setting. It also maintains the three more outward-facing activities on the right side—creating visually-interesting reports for senior management, benchmarking performance against competitors and third party programs, and pursuing awards and recognition, both inside the organization and with third-party programs like ENERGY STAR.

Figure 3

TEMA Energy Program **Key Elements**



Recreated based on image provided courtesy of Toyota (2009).

1 The Japanese term *kaizen* means "improvement." Within Toyota, it describes a philosophy as well as specific practices aimed at continuous improvement in manufacturing, business in general, and even life overall. In the workplace, kaizen typically refers to activities that continually improve any or all functions of a business, from manufacturing to management and from senior management to shop-floor workers. By improving and standardizing various practices, technologies, and processes, kaizen aims above all to eliminate waste.

Like other successful energy management programs, Toyota's EMO maintains a monthly/quarterly/annual data collection and reporting system, and an accountability system that operates at all levels, from individual shops to senior executives. **Figure 4** illustrates a typical graphic from such a report, though the full reports contain a multitude of tables and graphs.

What sets large manufacturers like TMMK apart from the average company, however, is the added levels of data monitoring they apply to their operations. TMMK staffer Bill Pulliam manages the plant's Enterprise Building Integrator (EBI) software, through which he can monitor up to 30,000 data points in the 1,300-acre complex. EBI enables him to look deeply into HVAC units, individual shop equipment, and other operations. EBI can generate very detailed reports, with data measured down to one-minute intervals or less, for individual units or shops, so shop captains can diagnose issues as needed. Shop captains pay attention to this information because they must meet specific KPI targets, and if their weekly or monthly reports deviate from those targets, they will often follow up with facilities staff for data and assistance. For example, Roger Wallin highlighted an email from a shop captain, asking for a weekly report on six HVAC units in that captain's shop. Pulliam can access this system from home, and can even manage some units remotely. On the Friday morning of a July 4th weekend, he logged in to be sure the main HVAC units were shut down as planned. Sure enough, the data curves for that long weekend stayed flat.

The NASCAR racetrack imagery in "Race for the Greenest" also shows how TMMK has adapted the Toyota kaizen philosophy in its own uniquely American way. As a practical tool, kaizens are specific proposals, entered into standard forms and loaded into an enterprise-wide database. Individuals are encouraged to develop and submit kaizen ideas into this system, and the database is available to Toyota worldwide to share these innovations throughout the company.

Figure 4

Recreated based on image provided courtesy of Toyota (2009).

Ultimately, it is the sum of Kaizen ideas developed in each facility that drives future goal setting. Both operations changes, and capital investment recommendations, are summed and translated into energy use and cost per vehicle, and the summed potential savings are applied to future years' energy savings targets (see the Pew project web site[2] for examples of Toyota's Kaizen reports).

Facilities staff work as hard as production shops to drive down energy usage and costs. Historically, they focused on running utility plants, in separate buildings from production units, and piping steam, compressed air, and chilled water to the various shops through miles of pipes. Facilities staff and equipment systems were physically and organizationally somewhat distant from production. But as the company's energy goals per vehicle pushed both facilities and production staff to rethink their ways, this pattern changed. Facilities staff began finding ways to bring energy supplies closer to production units. Rather than generating steam in a bank of huge boilers, and piping high-pressure steam for long distances, with all the attendant losses at each step of this process, facilities staff began placing smaller, hot water boilers at production unit locations. This saves energy first by allowing lower temperature and pressure in the system, second by eliminating the step-down losses from running high-pressure steam through pressure reducing valves to serve process loads, and third by eliminating the thermal losses from long pipe runs across the plant. At TMMK, facilities staff have reduced central boiler needs from six units to two, and plan to shut down these remaining units soon.

The other way that TMMK reduces steam demand is through reducing heating loads, and through heat recovery, in the paint shop operations. The easiest step was to experiment with elimination of the first water rinse tank through which the auto bodies pass to remove surface dirt. After being satisfied that unheated water worked just as well for this step, the next target was heat recovery. The paint shops are the biggest energy users in the plant partly because they must incinerate exhaust air to burn off the hydrocarbons and other residues of the painting process. This produces 640-degree air; by applying heat exchangers, TMMK staff was able to recover a large fraction of this heat and pump it back into the steam loop. This first reduced loads on the boiler system and made localized hot water units more efficient.

But the most overlooked energy use at Toyota, as is the case in many manufacturing operations, was compressed air. Steam boilers, cooling systems, electric motors, and sometimes lighting have typically received the greatest focus in most efficiency programs. This has changed as efficiency programs look harder into all aspects

2 http://www.pewclimate.org/energy-efficiency.

of plant operations. Such examinations quickly show that compressed air runs many of the assembly and other production tools, keeping electricity and fuels away from critical production steps, where a spark or a gas leak could be a health and safety risk, not to mention the risk of stopping the production line. TMMK generates compressed air at the central utilities plant through a bank of huge compressors. Facilities staff save energy by replacing compressors as funds and opportunities permit. Their most recent Atlas-Copco compressor saves 25 percent or more energy than its predecessor, paying for itself well within the company's three-year payback guideline. But it is also quieter and maintains pressure more reliably than earlier generations.

The view from the utilities plant compressor control booth shows another way that TMMK saves compressed air energy. As the first shift goes to lunch at 11:30 a.m., the compressor load drops like a rock, falling 40 percent in a matter of minutes. In the past, this would not have happened; but facilities worked with production staff on a shutdown routine that takes air tools offline during lunches, breaks, nights, and weekends. The practice in the past had been to leave tools on, partly because shop-level staff were not aware of the energy needed to keep the system pressurized even when tools were not in active use, and partly because there was a perception of performance risk in shutting off and restarting tools. Facilities staff worked with shop captains to show them the energy impacts of leaving tools on, and to reassure workers that the reliability of the tools would not be compromised and that restart times would not be a problem. In addition, production crews and facilities staff alike watch religiously for air leaks, the Achilles heel of compressed air systems. Leaks are inspected and repaired regularly, and it is the KPI reporting system that allows staff to see when compressor energy use is drifting up, triggering a deeper look.

TMMK's management of compressed air energy use is emblematic of the way Toyota implements its energy efficiency strategy company-wide. One of the most effective methods the EMO uses to drive operational improvements in plants is to conduct unannounced "Treasure Hunts" that seek low-cost efficiency opportunities. A departure from the "energy audit" terminology of traditional energy management, "Treasure Hunts" connotes opportunity, with a hint of fun, as distinct from the compliance-based implications of the word "audit." In a typical Toyota Treasure Hunt, a team of energy experts from other facilities visits a plant, with their presence known in advance only to senior managers. The Hunt typically starts on a Sunday, and focuses primarily on finding equipment that is left on and other operational improvements. The team then observes the first shift on Monday, compares its practices with the second Monday shift, prepares a report, and presents it to plant leadership and shop captains on Tuesday. Because the Treasure Hunt team is composed of Toyota peers, its findings tend to bear weight, and with

senior management hearing the recommendations, they tend to get implemented. The final report is reviewed by the plant, action items are prioritized, and then the kaizens are scheduled for implementation based on resources. These activities are then followed up, confirmed and best practices are shared with other plants.

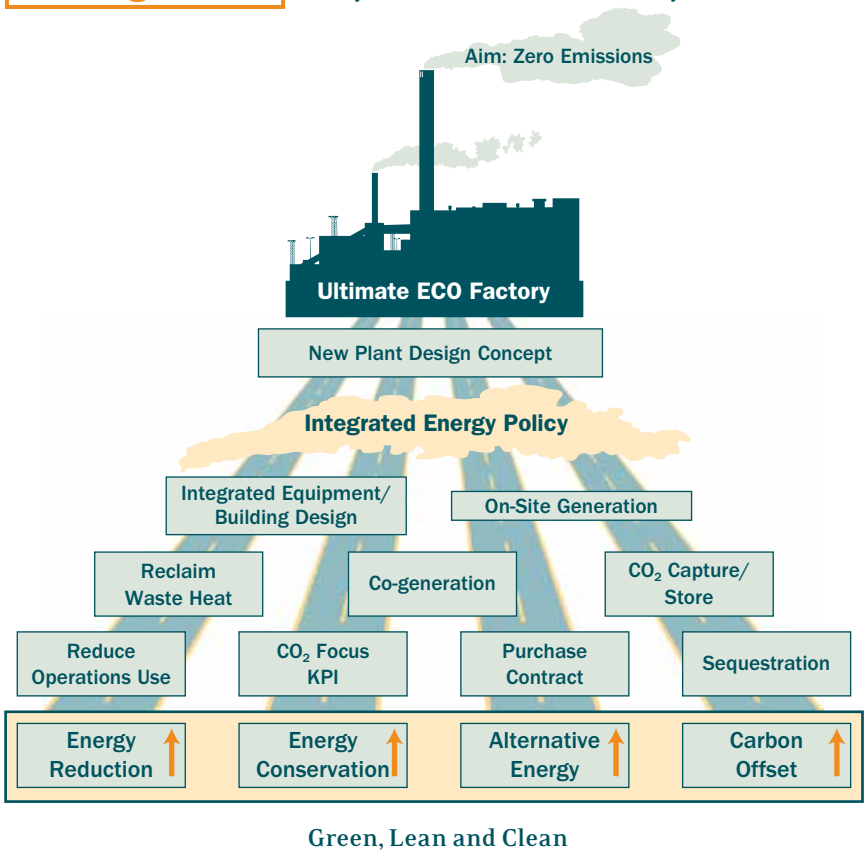
The summary effect of TMMK's management systems, investments and practices won it membership in the U.S. EPA National Environmental Performance Track program (recently phased out), which was designed to recognize and drive environmental excellence by encouraging facilities with strong environmental records to go above and beyond their legal requirements. TMMK qualified because of the company's past achievements, continuous commitment to environmental compliance, and implementation of a strong Environmental Management System. Admission into the Performance Track program was selective, based on a company's history of environmental excellence. TMMK was one of only seven facilities in Kentucky to achieve Performance Track acceptance, and was one of four Toyota plants in North America to be accepted into program. Toyota has also won EPA ENERGY STAR Partner of the Year award and individual plant awards several years running, qualifying it for a Sustained Excellence Award for 4 consecutive years.

While the EMO's day to day work is intensely focused on running existing equipment at peak efficiency, eliminating waste, and looking for individual Kaizen opportunities, the company also has a larger vision. The Toyota plant of the future will be a zero-emission facility. Although none yet exist, elements do, as illustrated in **Figure 5**. The intent is to minimize emissions at all plants. Current energy efficiency activities are shown in the green boxes, along with broader carbon emissions strategies like buying carbon offsets or sequestering carbon. Moving "down the road" toward the Ultimate Eco Factory, Toyota envisions designing advanced energy efficiency with supply strategies like onsite renewable energy and combined heat and power (or cogeneration) systems. If the company can drive down its energy needs to a minimum, purchase or generate non-emitting energy supplies, and use other strategies to offset any remaining carbon emissions, it can reach the goal of a zero-emission factory.

For example, Toyota is committed to buying or making renewable energy. However, the business case must still be made. TEMA's EMO has looked at innovative solar photovoltaic financing structures, which can bring the effective cost of solar power down to 14 cents per kilowatt hour. However, at TMMK, electricity can be purchased from the grid at a much lower cost, so the solar Kaizen will have to wait until those two cost curves are more realistic. TEMA's new Mississippi plant, temporarily mothballed until the auto market recovers, is planned to incorporate several of these elements.

Figure 5

Building Blocks to Toyota's Ultimate ECO Factory



Recreated based on image provided courtesy of Toyota (2009).

Increasing use of renewables is just one of Toyota's challenges. Any large investment is hard to justify in the current economy, making some of the more capital-intensive kaizen ideas harder to bring on line. Major production technology changes also fall in this category: reducing carbon emissions in energy markets that do not reflect carbon prices is another ongoing challenge. If future climate policies drive up electricity prices in U.S. power markets as many expect, for example, this would help justify solar and other higher-cost items. But until those prices become real, it is hard to justify the capital cost in an extremely competitive consumer market and a soft economy.

Conclusions

Toyota has developed one of the world's most thorough and integrated energy efficiency strategies, building on its cultural as well as technical assets. Culturally, the Kaizen philosophy helped engage individuals across many levels of management and many functional units in the common cause of driving down energy waste. This application

of individual responsibility in service of collective goals has helped the program establish itself within the organization quickly, and increased the likelihood of sustained success. As people take ownership of the goals and the practices needed to reach them, the efficiency strategy becomes part of the company culture. Technically, Toyota's strong engineering talent was able to tap its physical assets to support the strategy. Toyota plants have very fine-grained data monitoring and reporting systems that enable staff to pinpoint performance issues down to individual shop and equipment levels. Years of engineering experience have produced Kaizen project information in the company database, making its technical knowledge available across the organization. And the company's "Treasure Hunt" practice of bringing in experts from peer facilities to examine improvement options at other plants keeps plant staff on their toes, and increases the credibility of the findings, coming as they do from Toyota peers. The success that flows from these efforts is recognized and reinforced regularly at the highest levels, as evidenced by the plant president coming to monthly Race for the Greenest festivities.

Key lessons learned from Toyota's energy efficiency successes include:

- Work hard to make your Kaizens permanent. Temporary improvements are of limited value. Remove old methods, equipments, and processes after improved versions are developed.
- Look at new technologies and try to build them into the design and production process. Pilot projects can be helpful in demonstrating success and overcoming resistance from production staff and others more focused on product quality and volume.
- You can never report too much information. At the same time, it is important to recognize that different company officials will require different types of information. A deluge of data can be costly and cumbersome to sift through, especially for senior managers with limited amounts of time on their hands. Toyota goes to great lengths to gather and report vast amounts of data, but equally important is the effort the company puts into rolling this data up into more streamlined reports that senior management can easily digest and act upon.
- Awards and recognition—both internal and external—are important. These have the effect of motivating facility staff to go beyond strict compliance with environmental laws and regulations and instead reach for a higher level of energy efficiency and sustainability.