GM's Robust Energy Management Meets "Challenge For Industry"

Alfred J. Hildreth, P.E., C.E.M
Seog-Chan Oh, PhD, Senior Researcher

ABSTRACT

Energy use is a large essential expense incurred by manufacturers or facility operators that contributes to greenhouse gas (GHG) emissions. At General Motors (GM), although our expenditure for energy is not a large percentage of our total cost, we do spend in excess of $1 billion annually. GHG emissions from energy use represent over 7 million metric tons per year of GM's carbon footprint. Hence, a robust energy management business process is needed to meet the challenge for industry. Management of energy and carbon to reduce environmental impact has become important enough to be included in our business plan, just as safety, people, quality, responsiveness, and cost are. Following a model similar to EPA Energy Star's seven step approach, energy as an environmental element has been integrated into GM's business policy and model. Based on top-level commitment and public goals to reduce energy and GHG by 20% from 2010-2020, GM uses its standardized global manufacturing system (GMS) to ensure that energy efficiency and conservation is properly managed through performance assessment, action plans, evaluating progress, and recognizing achievements. The methods used to integrate energy management into our business plan include dedicated resources at all levels in the organization. With people as one of our most important resources, having qualified energy leaders at the corporate, global, regional, and site levels is key to our success. A dedicated budget for systems and projects is required to implement initiatives, similar to other areas of the business. Forecasting energy, establishing targets, implementing projects and processes, regular monitoring, and corrective action when required ensures timely adherence to meeting our energy and carbon goals. GM recognizes achievements internally with various processes—plant energy performance recognition, employee suggestions, employee compensation tied

to business results, and others. Also, GM's recognition of our energy performance includes many external awards and recognitions: EPA Energy Star labels for two facilities; meeting Energy Star's challenge for industry for 54 plants globally over the past year, avoiding $90 million expenditure and 1.2 million metric tons of GHG emissions; winning a 2012 Energy Star partner of the year award in energy management; and many global, regional, and local awards for protecting the environment.

INTRODUCTION

About 83% of GM's GHG emissions and energy use result from our manufacturing operations compared with 17% for non-manufacturing operations. Therefore, the majority of our environmental efforts are focused on manufacturing. A manufacturing plant has processes that are typically complex and consume large and variable amounts of energy resources. Energy costs are steadily rising and are predicted to continue going up. Also, GM's commitment to our environmental principles requires monitoring facilities and controlling energy sources and carbon emissions to reduce our overall energy and carbon intensity. This requires adhering to goals and objectives throughout the vast number of our facilities globally. Everyone must work toward the same business plan to allow us to meet our public and internal goals—from top leadership commitment to centrally dedicated resources and within each facility. As energy management is integrated into our standard manufacturing process, GMS, the same "plan, do, check" rigor that drives the vehicle manufacturing process is incorporated into energy management. EPA's Energy Star energy management model outlined in seven steps fits well to describe GM's energy management system.

As with any business process, data management is an important tool for understanding the quantity of energy consumed, carbon emitted, and the effect of the process variables on the usage. GM gathers and analyzes energy, carbon, and water data along with climate, production, process, and equipment variables to set goals and monitor progress. To evaluate progress toward goals, we must understand the effects of climate, production, and process variables on consumption and track energy efficiency and conservation projects at each facility. Benchmarking of energy, carbon, and water intensity provides a method to assess performance targets for plants and allows identification of the facilities

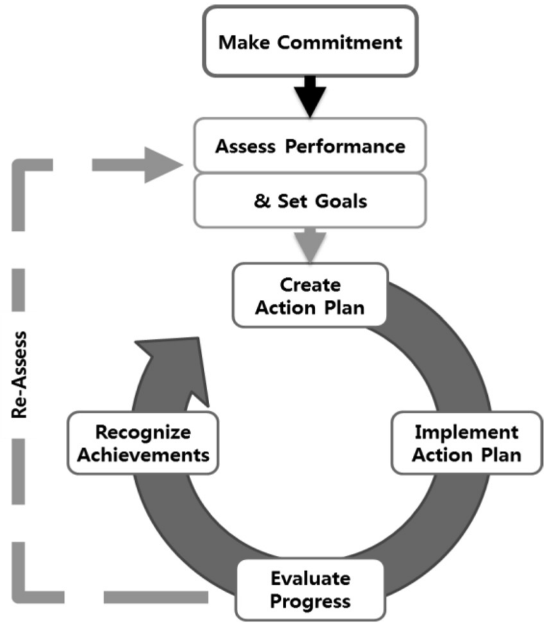

Figure 1. Energy Star- Energy Management Model [1]

that may have best practices for investigation or ones that need assistance to improve results.

The methods and objectives to meet our energy, carbon, and water goals become part of our standard business plan deployment on global, regional, and local plant bases. Top leadership commitment to meet the public goals allows for allocation of the required resources of people, processes, and money to implement a robust action plan on a long-term basis. Some key elements of the action plan include: energy efficiency projects with dedicated budgets, sharing best practices globally and locally, requirements for countermeasures if monthly targets of intensity are not attained, dashboards to identify energy metrics and heating ventilation and air conditioning (HVAC) operating indices, and monitoring and reporting of energy shutdown effectiveness.

GM recognizes achievements in energy, carbon, and water performance internally for both individuals and teams or plants using standardized criteria. We regularly monitor energy shutdown effectiveness during extended holiday periods and recognize plants that meet the company goal. Our commitment and accountability partnership process regularly evaluates individual performances for those with responsibilities for managing energy, water, and carbon intensity. In some regions, GM's suggestion plan provides monetary compensation for individuals and teams that contribute to implemented cost-saving ideas. External recognition is also important, since it validates our commitment and progress compared to other industrial companies.

Finally, continuous improvement is a key part of GMS and is an integral part of our robust energy management system. Assessment of results and failures is completed on a regular basis so that improvements to the energy management system provide for year-after-year reductions in energy intensity.

This article will outline the business process utilized by GM that forms our robust energy management system and provides positive results, as evidenced by: global energy intensity reduction of 6% from 2010-2011; many awards and recognitions from prestigious organizations like EPA Energy Star; as well as from many local communities and organizations globally.

MAKE A COMMITMENT

Top leader support at General Motors was a first step in developing a robust energy management business system, as evidenced in our environmental principles, which go beyond simply complying with regulations. Our facility energy program is integrated into the overall business operations model. These principals are included in the GM code of conduct that applies to all GM personnel worldwide.

1. We are committed to actions to restore and preserve the environment.
2. We are committed to reducing waste and pollutants, conserving resources, and recycling materials at every stage of the product life cycle.
3. We will continue to actively participate in educating the public regarding environmental conservation.
4. We will continue to pursue vigorously the development and implementation of technology for minimizing pollutant emissions.
5. We will continue to work with all governmental entities for the development of technically sound and financially responsible en-

vironmental laws and regulations.

6. We will continually assess the impact of our plants and products on the environment and the communities in which we live and operate with a goal of continuous improvement.

GM employs a central team of energy experts who champion GM's energy business model. Led by a group manager and supported from a senior leadership team, the energy management program focuses on energy and carbon optimization through intensity reduction. In addition, each manufacturing and major non-manufacturing site has a local utility manager who is focused on site energy, carbon, and water issues, including efficiency and conservation. Larger sites have a dedicated energy conservation engineer who is focused on specific projects, operations, and keeping employees engaged in the conversation of energy, GHG emissions and water.

PERFORMANCE ASSESSMENT AND GOAL SETTING

General Motors has a contract with a third party to measure and report global energy, water, and production usage data for all our manufacturing and major non-manufacturing facilities. We currently track and report energy and water use intensity on a monthly basis at about 309 manufacturing and non-manufacturing facilities worldwide. The basis of our data validation is pulled from a utility invoice at a site and is allocated further to business units at sites using meter data: assembly, casting, engine, stamping and transmission. We also focus on non-manufacturing operations' energy use with normalization by area for metrics. Carbon dioxide is calculated by the system using standardized protocol emission factors to show energy's effect on carbon emissions.

In 2012, GM's GHG emissions in North America were verified to ISO-14064 by an independent third party, and our global energy, water, and GHG data were audited for assurance to the AA-1000AS standard.

We use data from these sources for monitoring, managing and reporting:

- Established internal benchmarks and calculations of external benchmarks (EPI)
- Budgeting and forecast for energy and water

- Plant-level energy and water metrics goals/targets and performance (MWh/unit)
- CO_2e intensity performance (tons/unit or tons/square meter)
- Renewable energy use
- Internal and external reporting of energy, water, and CO_2e

Across all our U.S. facilities, we monitor about 2.5 million points of energy data per minute. We monitor energy use to ensure non-production shutdown levels and that heating, ventilating and air conditioning ("HVAC") equipment meets targets. To adequately manage this amount of data, we have a dashboard system called "Energy OnStar" that was developed for our HVAC systems. Assisted by a third party, plants can easily compare hourly performance of HVAC equipment and their energy use to various targets: heat/cool energy, fan energy, outside air index and rate, runtimes, temperature set points, supply air index, and hourly energy intensity.

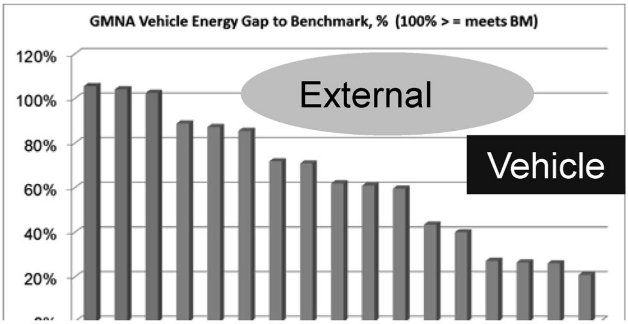

Figure 2.
GM's North American Assembly Plants Performance to Energy Star EPI

Annual external energy benchmarking for our global vehicle assembly plants is performed using the EPA ENERGY STAR energy performance indicator (EPI). We use this rating to determine the most efficient plants in our GM family and to set targets for future years. Similarly, for other manufacturing facilities, we use internal benchmarking tools that were developed using similar algorithms to the EPI to determine the most efficient facilities. Area-normalized metrics are utilized for non-manufacturing facilities.

Best practices are shared using a global web-based system where plants or central offices can input energy, water, or carbon-reduction best practices. Those are tracked at each stage of the evaluation and implementation process and shared accordingly. The ideas that do not rise as a best practice are labeled as a "good idea." These ideas are shared, but are not tracked for implementation.

Our budgets and targets are forecasted using multivariate regression analysis and a U.S. patent-pending, activity- based forecasting tool. Annual and monthly targets are normalized by production units for individual plants; vehicles, engines, transmissions, stamping tons, casting tons, and revenue for component plants. While we do not publicize individual plant goals, in our 2011 sustainability report that was published in January 2012, GM announced aggressive 10-year goals for energy and carbon intensity reduction of 20% from 2010-2020.

Individual plants are assigned a targeted intensity reduction of energy and water, which is rolled up and tracked regionally and globally as part of our business plan deployment objectives ("BPD"), while CO_2e is tracked regionally and globally.

To establish monthly energy and water cost budgets and intensity targets, GM uses two main methods for the majority of our facilities—standard multi-variable regression analysis similar to international performance measurement, and verification protocol (IPMVP). [2]

The IPMVP method is used for plants with fairly steady-state production and minimal process variations, and it correlates energy and water use to production and climate conditions and works well to forecast future years' monthly use to establish budget and intensity targets. However, if a facility has major changes in either production—one shift to three shift, significant variance year over year, major production process changes such as adding booths, processing a new part, or new equipment technology—then the IPMVP method is not adequate for forecasting purposes.

GM developed a patent-pending activity based energy accounting (ABEA) method to improve the accuracy of forecasting for plants with extraordinary circumstances, which are becoming more prevalent. ABEA is based on the fact that the operation of a production facility requires distinct levels of energy, depending on different activities such as full-capacity production, reduced-capacity production, and non-production. [3] The method first obtains highly accurate hourly energy use rates for different energy use activities and the rates are used to estimate the amount of energy that will be consumed during a subsequent time period as shown in Figure 3. This proposed method is easily tailored to the flexible production schedule so that it can minimize the problems caused by over- or underestimation of energy use with IPMVP. There are five distinct states, which the manufacturing system can be in at any given time, and each state has a different energy load characteristic. These states are shown in a universal modeling language (UML) state diagram in Figure 4 along with the transition options from each state. The varying loads for each state must be considered when creating a predictive model to ensure accurate results.

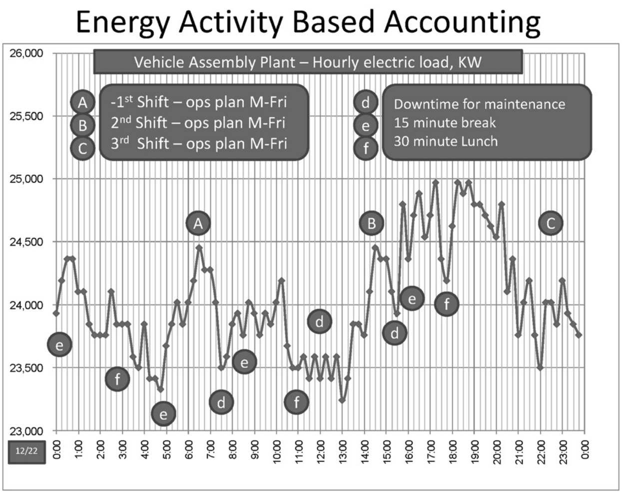

Figure 3. Energy Profile For Manufacturing Operation States

The production state of the system is that in which products are being produced at a production workstation or assembly line. This state is a high consumer of resources because most equipment in the facility is being run at high levels. During a normal workday, there will be times (such as lunch or between shifts) when the system can be put in a set-back state to save energy. In this state, the system equipment is turned off or down to a lower level until production resumes again.

If there is an extended period in which the system does not need to run, such as weekends or holidays, the system can be put in the shutdown state, in which only a few limited systems are running that are required for a minimum airflow, critical operations, and emergency lighting. In this state, the system uses minimal energy. To

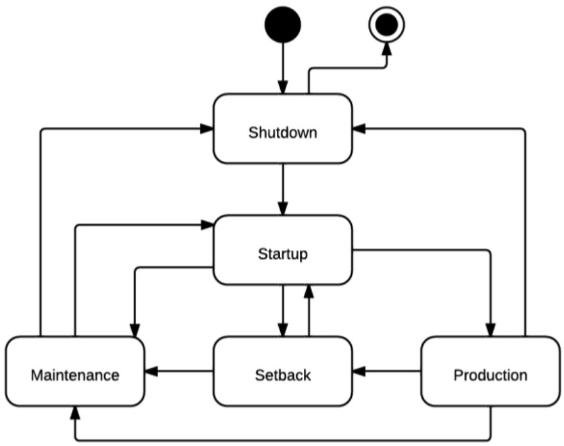

Figure 4. UML State Diagram of Plant Manufacturing Operation States

transfer from shutdown to a higher-level state that uses more energy, the system is put into a startup state. This state is a high consumer of energy because the system is operated at high levels to quickly increase system conditions to operating conditions. This is similar to the time when a vehicle accelerates, which requires more gas than when cruising or parked. The final state is the maintenance state, in which the system has minimal system requirements for necessary repairs to be performed. All these states use energy at different loads, so it is important to consider these states and the production schedule for plant energy use prediction purposes. To forecast a future period, modifications to the load may be required based on changes in future months or the hours of production versus non-production. The forecast is determined by the sum of products of the load and hours for each state as shown in Figure 5. Details about activity-based energy management can be found in Figures 4 and 5.

Energy performance reviews are done regularly at GM facilities. These on-site evaluations of a plant's energy performance and practices are conducted by qualified energy managers, using a standard toolbox to review each plant's energy practices compared to the best under GM and include recommendations for improvements. Also, each site has random audits during non-production periods to find and eliminate waste in the energy business system.

Using these data evaluation tools, GM announced their public intensity reduction goals for 2010-2020:

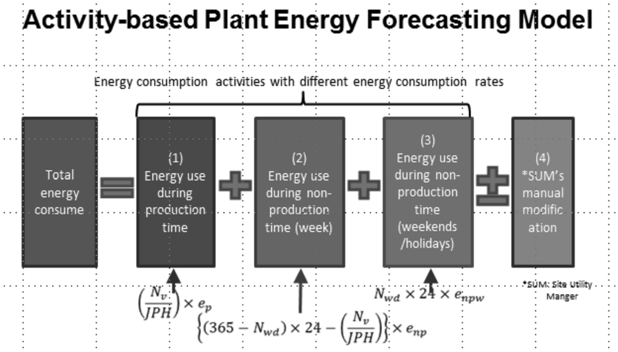

Figure 5.
Calculation of Energy from Various Activity Based States

- Energy 20%
- GHG 20%
- Water 15%

Our public reporting to the carbon disclosure project states that we are on a glide path to meet these goals with our progress in 2011.

GM recognizes that reducing carbon from business activities can also be accomplished externally to our own operations. Chevrolet marketing has committed to investing up to 40 million dollars over the next few years in projects that will help reduce up to 8 million metric tons of carbon dioxide from the atmosphere. That's equal to the annual impact of a forest the size of Yellowstone. To date, the program has reduced 860,496 metric tons of GHG with committed projects of 4.6 million metric tons.

ACTION PLAN

GM has integrated energy and water efficiency and conservation planning into our standard BPD process at various levels in the manufacturing process—the team, the department, the plant, regional and global personnel. Environmental and energy methods are established at each level to meet the objectives and tracked along with other manufacturing aspects—safety, people, quality, responsiveness, cost—to ensure that we meet our required performance. These plans are posted in plants for visual management of our plan, do, act, and check activities.

Each plant and major non-manufacturing facility develops an "energy sufficiency plan" that identifies initiatives and projects that will be implemented to meet the objectives. These are tracked and shared between plants for collaboration on methods that will move us closer to meeting our objectives.

Energy, water, and carbon reduction projects are part of our efficiency plans and, in the U.S., they represent about half of the reduction plans. GM allocates budgets to spend for high-return projects for U.S. facilities. A central office team collects proposed projects from facilities and prioritizes them based on return-on-investment and the probability of successful implementation then develops a project implementation plan. In 2011, GM's U.S. plants were allocated $12 million to implement energy cost savings projects for energy, water, and carbon reductions. Utility rebates were added to this amount in areas where available, and those amounted to about $1.5 million.

The types of implemented energy projects fall into two categories: retrofit efficiency and design in energy efficiency. Retrofit projects are described above with a either a central dedicated budget or in some regions on a plant-specific basis using a standard business case model for approval. Design in efficiency is implemented by working closely with manufacturing and product engineers to design new or major modifications of processes for paint shops, welding equipment, and casting plants using the latest high energy efficient equipment and systems. An example in 2011 was the multi-million dollar replacement paint shop targeted and engineered for a 50% energy intensity reduction. The types of these projects that were implemented in 2011 have been reported in GM's carbon disclosure project report in 2012:

Energy Efficiency in Process:

- Three wet paint process eliminates an oven
- Downsize paint booth for small vehicle
- Use 90% recirculation in paint booths
- Optimize booth set-points for energy
- Dehumidify cupola hot blast air
- Redesign furnace heating elements

Energy Efficiency in Buildings:

- Lighting from HID/T12 to T8/T5/LED
- HVAC control upgrades
- Variable frequency drives on motors
- Steam elimination
- Heat recovery
- Use of free cooling during winter months
- Install construction walls
- Compressor controls

Energy Conservation:

- Reduced light levels based on updated IESNA
- Right-sized HVAC for occupancy and process
- Lighting controls, weld and paint systems that are mostly automated and can operate "in the dark"
- Demolish unused building—consolidation
- Repair steam and air leaks

Implementation of energy management is integrated into our standard business plan with responsibilities assigned at the appropriate levels and regular checks are performed to determine status of activities designed to meet the plan. Typically, implementation responsibilities reside at the local level with support from central office. Project implementation is either managed at the plant or regional level, using central office resources to supplement the plant as required. The North America energy team uses "energy optimization leaders" to assist plants with implementing reduction initiatives. This provides not only additional resources for the plants, but provides coordination of best practice sharing between plants. Other global regions use similar organizational structures to support plant level implementation of energy conservation.

PROGRESS EVALUATION

Our BPD process regularly measures control points for each objective and method for all manufacturing operations, including energy, water, and carbon intensity. Using our global utility web-based system information, monthly energy, water, and CO_2e intensity performance-to-targets are communicated to plants on scorecards to determine their status of meeting monthly and annual goals. Any performance with less than a "green" status requires a countermeasure to be developed for corrective action, which is also tracked with additional emphasis to ensure achievement to goals.

Status of implementation of projects and energy sufficiency plans are tracked at the central office to identify areas that need additional resources for implementation. Weekly performance toward non-production energy shutdown targets is communicated to plants at the department level to show progress and determine if corrective actions are required. A dedicated third-party team evaluates opportunities identified in operating HVAC systems using a dashboard system, Energy OnStar, and develops corrective action plans for weekly review with the central office and plants. In 2011, this process has identified and implemented more than $2 million of energy savings. Monthly meetings are held with the environmental site leadership team ("EMSLT"), plant, and regional and global energy teams to evaluate the progress toward meeting goals, the status of projects, and to share best practices.

GM reaches out to various organizations to network on energy, water, and GHG activities. The Department of Energy (DOE) energy assessments, participation in trade associations like automotive industry action group (AIAG) and supplier partnership for environment (SP), as well as being a partner with Energy Star, all contribute to GM's success in finding methods to reduce energy, water, and GHG in our processes through available resources and networking with competitors, technical groups, and suppliers. As an example, without Energy Star's participation, the industry would likely not have an external benchmark system for automotive assembly plants.

RECOGNITION

Employee performance toward goals is measured and rewarded using GM's commitment and accountability program ("CAP"). Employees from central staff to the plant level have objectives to reduce energy and water intensity, and their performance to these goals is evaluated at mid-year and year-end. Recognition of achievement can be monetary if GM's meeting various other goals activates enhanced variable pay. The allocation of rewards is also dependent on attainment of individual goals, e.g. meeting energy and water intensity goals.

Team recognition is available as either monetary in U.S. and Canada or non-monetary in other countries. The awards are presented to employees from their supervisors for demonstration of various values: commitment, teamwork, trust, growth, recognition, fairness, and health and wellbeing. Non-monetary awards can be initiated peer-to-peer for similar achievements.

In the U.S., GM's quality network program includes a formal employee suggestion system. Employees who suggest an improvement to an existing process can receive a portion of the implemented savings up to $20,000. Many valuable energy and water reduction ideas have been implemented in the last year, yielding hundreds of thousands of dollars in energy, water, and carbon reduction savings.

In 2011, General Motors received a 2011 Energy Star certification from the EPA for superior energy performance at our Lansing Delta Township automobile assembly plant which met the energy performance indicator at greater than the 75^{th} percentile. Lansing Delta Township is the first GM plant to receive this recognition—one of only three automotive manufacturing plants in the country recognized in 2011. Additionally, as part of the Energy Star buildings program, GM's warehouse in Lansing, MI received an Energy Star label.

For our manufacturing facilities without an EPI, GM has gained recognition from Energy Star's challenge for industry for 54 manufacturing facilities globally in 2011 and 2012, which contributed to avoiding $90 million and 1.2 million metric tons of GHG emissions. GM also made *Newsweek's* green rankings, ranking #148 out of 500. In 2012, GM was also the proud winner of an Energy Star partner of the year award for energy management, which is EPA's most prestigious honor.

CONCLUSION

Meeting the challenge for industry to reduce manufacturing energy intensity requires diligent adherence to business practices that focus on performance. There is no one single factor; a blitz of sustainable projects requires all of the elements of Energy Star's documented planning process.

Without top-level commitment, the human and financial resources needed for energy reduction will not be available on a consistent basis. There isn't any business activity that can survive without these resources. A robust data management system with comprehensive and valid data is needed to establish targets for performance evaluations and public reporting. Dashboard systems that can put the information into perspective are needed when the volume of data becomes so large that it becomes difficult to interpret otherwise.

Thriving businesses need to plan for the future, and intelligent energy budgeting and metric forecasting provides a normalized method for future planning of targets, budgets, and can be used to explain anomalies in performance, such as extreme climate conditions, changes in process or production, and energy efficiency. Without a method to understand these relationships, the data could be misinterpreted. Having data and understanding how they relate to the business provides a logical method to develop public goals for energy reduction.

Every business has action plans with regular monitoring and corrective actions. Significant successes in reaching our 6% energy intensity reduction in 2011 were: consistent implementation of energy efficiency design and retrofit, conservation, and behavioral projects and processes. Regular communication is a key part of any business, and energy reduction is no different. Sharing best practices, performance to targets, lessons learned, and new technology on a regular basis promotes results when local sites implement them with available resources. Participation with organizations like DOE, AIAG, SP, and EPA Energy Star provides valuable and expert energy and environmental resources as well as networking opportunities.

After all this hard work, recognizing achievement becomes a necessity. People enjoy seeing accomplishments publicized, and recognition provides an incentive to accomplish even more. Finally, the proof of a robust energy management system lies in the results, and GM has shown that adherence to the business system described herein provides energy intensity reductions, as shown in Figure 6.

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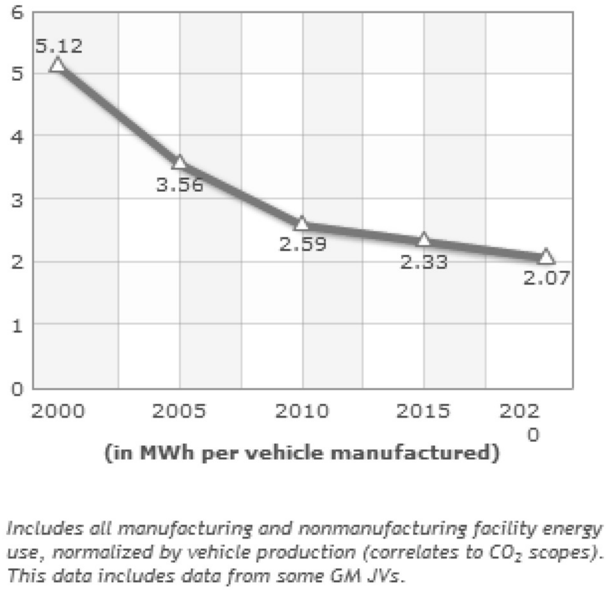

Figure 6.
GM's Global Energy Per Vehicle Performance.
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ABOUT THE AUTHORS

Al Hildreth, PE, CEM, is the company energy manager for General Motors, focusing on energy and utility budgets, metrics, benchmarking, efficiency projects, water and carbon reporting. He has worked for GM for over 30 years, including five years in Europe and Asia and 10 years with Saturn Corporation in Spring Hill, TN. He previously worked for a manufacturer of air pollution control equipment in R&D. He is a registered professional engineer, certified energy manager, and a certified hazardous materials manager. He received his B.S. degree in engineering from Oakland University and a M.S. degree in engineering from Rensselaer Polytechnic Institute.

Seog-Chan Oh, Ph.D., is a senior researcher at the General Motors Research and Development Center, Warren, MI where he has worked on research and development activities in advanced manufacturing area including wireless manufacturing, network-centric manufacturing, and sustainable manufacturing since 2007. He received the B.S. and M.S. degrees from Dongguk University in 1993 and 1996, respectively, and the Ph.D. degree from Pennsylvania State University in 2006. Before he began his Ph.D. studies, he was an IT consultant for seven years at Daewoo Information Systems.