Leveraging Energy Management for Water Conservation

Sharon Nolen, P.E.
Eastman Chemical Co.

Growing concerns about the availability of clean water are driving companies to include water conservation in their sustainability initiatives. Instead of reinventing the wheel, adapt your energy-management program for water conservation.

Energy costs are significant in the chemical process industries (CPI), and CPI companies are intimately familiar with the topic of energy management; most have extensive programs to drive the efficient use of energy. Awareness of the long-term impacts of energy generation and use on the environment has grown, and with it concern for other practices and uses of natural resources. Such awareness is motivating companies to go beyond energy management and develop broader sustainability strategies, of which energy management is one piece.

More recently, discussions of sustainability have started to include water, sometimes together with energy. The two are not independent. The term water-energy nexus recognizes the inter-relationship between them. Energy is needed to supply water, either for treatment or transport, and water is needed to produce many forms of energy, to generate steam or for cooling in heat exchangers.

Although water and energy are closely related, the management of energy use is much more advanced than the management of water. Committees, managers, tools, and best practices for the efficient use of energy have been developed and are used by most CPI companies. That is not the case for water. But why reinvent the wheel? Why not start with learnings and practices related to energy, modify them, and apply them to water management?

This article does just that: It explains how your energy-management strategy can be applied to water conservation. It first discusses the importance of water conservation and why you should care. It then identifies the key components of a corporate energy strategy and the application of those components to water management. Throughout the article, Eastman's experiences serve as examples to illustrate the concepts.

Water conservation

You only need to scan the headlines to be aware of the growing concerns and issues surrounding the availability — quantity and quality — of water. Water is recirculated through the atmosphere, but very little new water is created *(1)*. Furthermore, only 2.5% of the earth's total water supply is fresh water, and the majority of that is inaccessible (Figure 1).

Companies are also motivated to address water concerns for other reasons, including public awareness (*e.g.*, customer inquiries about the use of water to manufacture products, and publicized sustainability scores). The public expects large chemical companies to manage water conservation just as these companies deal with energy management.

A multidisciplinary team charged with identifying emerging issues such as water conservation can be useful. Eastman has formed the Global Emerging Issues Working

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Team. Comprised of representatives from a wide variety of internal groups, the team identifies emerging issues and develops appropriate plans to address them. It develops multifunctional, global positions and strategies that mitigate threats and seize opportunities. It also captures insights, defines roles and responsibilities, maintains communications, and executes the strategies developed. Additionally, each issue is assigned a champion. Water conservation was one of the first issues the team identified, and the worldwide energy manager is the champion for water conservation.

Guiding principles

It is helpful to have a set of guiding principles, based on a company's specific concerns and issues, that can serve as touchstones for making decisions. As an example, Eastman has developed three guiding principles for energy management:

1. Ensure the accuracy of utility information.
2. Maximize operating efficiency.
3. Incorporate energy efficiency in capital investments.

These guiding principles apply as well to water as they do to energy.

Ensure the accuracy of utility information. Engineers and manufacturing managers who want to make the best decisions for the company may be hindered if they do not have the right information or if the information they need is not easily accessible. For both water and energy, it is important for manufacturing personnel to have access to the costs, usage, and any ancillary benefits.

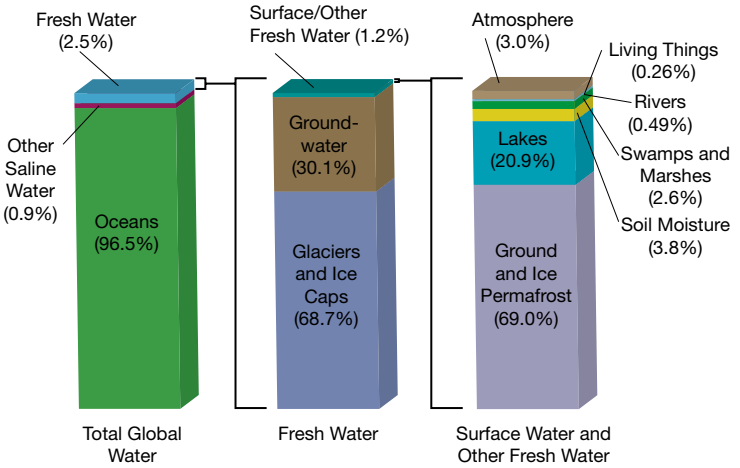
In many cases, this requires the installation of meters. In the absence of meters, spot measurements or calculations are better than no information, and at a minimum those should be made. Eastman has a standard energy survey process that includes a check of meters and allocated costs.

Maximize operating efficiency. Most companies have existing infrastructure that was purchased or developed before today's current level of concern about the stewardship of natural resources. However, no matter how inefficient the equipment or process is, attention to detail and maintenance can improve performance.

Rotating equipment such as turbines, pumps, and compressors should be routinely tested to ensure that each piece of equipment is operating at the best efficiency point on the operational curve. Also make sure that all unneeded equipment is turned off. The Treasure Hunt process (see the sidebar on p. 44) instructs teams to visit plants (those that do not operate 24/7) during nights and weekends to look for equipment that has been left running when it should not be.

Incorporate energy efficiency in capital investments. It is almost always more cost-effective to build energy efficiency into a new design than to retrofit equipment after it has been built. Engineering or procurement standards can ensure that equipment such as pumps, motors, and lighting favor more energy-efficient designs. A life cycle cost analysis is useful for determining whether it is more advantageous to spend money up front to reduce energy or water use over the life of the equipment.

These guiding principles form the basis for a strategy. Eastman's strategy consists of five components — employee awareness, measures, external resources, initiatives, and projects — that apply to both energy conservation and water conservation as well (Figure 2).



▲ **Figure 1.** Only 2.5% of the world's water supply is fresh water, and much of that is inaccessible. Source: *(2)*.

▲ **Figure 2.** A corporate strategy for energy management can be applied to water conservation. Eastman's energy strategy consists of five components.

Employee awareness

Companies have historically focused primarily on identifying and completing projects to improve energy efficiency. Projects are certainly an important piece of any energy-management program. However, in recent years, the value of employee engagement has become better understood. Effective energy efficiency programs incorporate employee awareness. The same is true for water conservation.

There is a general belief that, like safety, encouraging employees to think about energy efficiency both at home and at work pays off. The U.S. Environmental Protection Agency's (EPA) ENERGY STAR program provides a variety of educational materials for ENERGY STAR partners that are useful in this endeavor.

For example, ENERGY STAR provides posters, brochures, and even activity books for children to get the whole family involved in energy efficiency. And, several ENERGY STAR industrial partner companies hold energy fairs promoting home energy efficiency. Displays may include energy-efficient products from big-box retailers and local utilities promoting rebates. The company hosting the fair can build excitement by awarding energy-efficient products as door prizes.

Another useful tool to engage employees in energy efficiency is the ENERGY STAR Green Team checklist (www.energystar.gov/sites/default/files/buildings/tools/BYGTW_Green_team_checklist.pdf), which encourages companies to form teams to communicate ways to be more energy-efficient at home and at work. At Eastman, for example, a monthly newsletter is emailed to Green Team members that may include links to ENERGY STAR tips for saving energy at home or in the office, local recycling days, or other events of interest. Such newsletters can easily be expanded to educate employees about water issues as well, for instance by including a link to the ENERGY STAR tips for reducing water use at home.

▲ **Figure 3.** The reservoir stretching between Arizona and Nevada, Lake Meade, is no stranger to drought. Images taken by NASA in 2015 show that the lake's water level has dropped by about 120 ft in the last 15 years.

Employees who work in areas where water concerns are more prevalent, such as California or Texas, may need little education about water issues and conservation. However, large portions of the country do not face water concerns on a daily basis. In those areas, employee education may be a first step.

It is easy to share information about hot spots such as Lake Meade (Figure 3), whose water levels are rapidly declining, the Colorado River, whose water is being consumed before it can reach the Gulf of California, or the San Joaquin Valley, where the depletion of groundwater reservoirs is causing the land to sink. Although it may be more challenging to discuss local water issues, employees who do not live in those hot spots will probably find such discussions easier to relate to and more engaging.

Metrics

Energy intensity, *i.e.*, energy consumed per unit of production, is widely accepted as the most appropriate metric for energy efficiency.

The U.S. Dept. of Energy's (DOE) Better Buildings, Better Plants program provides guidance on calculating energy consumption and intensity — both baselines and variations over time *(3)*. The guidance identifies items to include (and exclude) from these calculations. For example, all purchased energy is included but heat recovered in the process is not. The DOE also provides guidance to help you convert site energy (energy consumed directly by the company, excluding the energy required to produce and deliver the energy) to source energy (energy consumed plus the energy required to produce and deliver the energy). A company can use linear regression to account for the effects of variables such as weather, annual production levels, and other factors on energy consumption and intensity.

Reference 4 provides another approach for determining the water consumption baseline at a manufacturing site.

Benchmarking is available for some industries. For example, the Solomon Energy Intensity Index allows refiners to assess their energy intensity against their peers. ENERGY STAR has developed similar information for other industries (*e.g.*, automotive) and identifies the top-quartile performers with the ENERGY STAR certification.

However, the chemical industry produces such a wide variety of products that no similar standardized benchmark exists. Even within a single company, the energy intensity of products can vary by more than an order of magnitude.

Water metrics are much more challenging to determine than energy metrics. CPI companies typically track energy

intensity at the corporate level, *i.e.*, total energy consumed for each product that the company manufactures. While this works for energy, it is not always the best way to calculate and track water use.

It is sometimes better to determine the water use of individual manufacturing sites. Water is more pertinent at the local level because its consumption is a local issue. Water is a local resource and its availability may vary significantly from one plant site to the next.

Industry uses a variety of metrics for water use. Water quantity may refer to the amount of water purchased from a local utility, withdrawn from a local reservoir or river, or consumed. Some companies track only this quantity, while others track water intensity by dividing the quantity of water used by units produced (or other divisor such as area of land). And, different manufacturing sites might use different measurements to track water use.

Tracking water consumption is just one piece of a water-management program. Another is setting goals based on those metrics. Water conservation goals can be quantitative. For example: Reduce water consumption by at least 30% at global sites that are located where the renewable fresh water supplies are either scarce or stressed, as determined by the United Nations analysis of river basins globally. For all other sites, maintain the level of water consumption on an absolute basis through the year 2016, offsetting any increased demand from production volume growth through conservation, reuse, and recycle practices.

Water conservation goals can also be qualitative. A major reason to set a qualitative goal is that it is difficult to accurately measure water use. The amount of water that enters a plant (*e.g.*, purchased water and water taken from rivers or other reservoirs) and the amount that is discharged by the plant can be measured. However, the total amount of water used is not always a straightforward mass balance of these measurements. For example, stormwater runoff may be routed to the wastewater treatment stream to ensure that outfalls are not contaminated, cooling tower water lost due to evaporation is difficult to measure, and, depending on the chemical process, water may be generated as a byproduct. All of these uses and losses can be quantified by adding

Treasure Hunt

The Treasure Hunt is typically a three-day event during which multidisciplinary teams identify and evaluate opportunities for reducing energy consumption at a particular plant site. Unlike energy audits that focus on equipment modifications that require capital expenditures, treasure hunts focus on operational opportunities, which are typically low-cost to no-cost efficiency improvements (*e.g.*, eliminating the use of unnecessary equipment, lighting upgrades, negotiations with utility providers). Teams typically include someone from the company's energy team, onsite personnel (a process engineer, maintenance worker, and someone working in plant operations), and external consultants or vendors with expertise in a particular area. Employees from other sites also participate in treasure hunt teams to encourage broad application of findings. Treasure hunts involve several elements:

Preparation. The process starts months before the event. The person initiating the treasure hunt should first discuss the opportunity with senior management and get their support. The facilitator then assembles teams (typically three), identifies the scope of the treasure hunt, develops an agenda for the event, and gathers and records information on the current energy consumption and the costs of that energy, equipment specifications, and operating parameters. The teams prepare opportunity detail sheets — forms that are used on the day of the event to capture and summarize the specifics of potential energy-saving opportunities.

Training. The facilitator meets with the teams to confirm roles and responsibilities, schedule training for those involved in the treasure hunt, and review the agenda.

The hunt. The treasure hunt begins with an introduction by the facilitator followed by a brainstorming session to generate potential ideas for energy reductions at the plant. The teams then tour the facility looking for potential energy saving opportunities, which they record on the opportunity detail sheets along with the potential energy savings and greenhouse gas emissions reductions.

Flesh out ideas. The teams reconvene to flesh out the most promising ideas and further develop them. The company's energy team members lead this discussion.

Define projects. The energy team and manufacturing personnel collaborate to better define project ideas and discuss their potential energy savings, impact on production, chance of success, and resources required for implementation.

Track project progress. All of the projects identified in the previous step, even those not being implemented at this time, are recorded in a database and regularly reviewed. The progress of projects selected for implementation is also recorded in this database.

Energy savings opportunities identified during treasure hunts typically fall into one of four categories:

- operational (*e.g.*, eliminating unnecessary use of existing equipment)
- small capital projects (*e.g.*, lighting upgrades)
- large capital projects (*e.g.*, building renovations)
- procurement (*e.g.*, renegotiating utility supply contracts).

Reference 9 provides more detail on conducting treasure hunts and includes worksheets and checklists that can be modified for your facilities.

more meters. But the cost of additional meters may be prohibitively expensive for a natural resource that is, more than likely, fairly cheap.

External resources

Realizing the synergies between energy and water, government agencies are expanding their programs established to assist industry with energy management to include water conservation. The EPA has done this with its ENERGY STAR Industrial Program and the DOE with its Better Plants Challenge program. Both offer valuable resources and the opportunity to collaborate with other industrial energy managers who are also dealing with water conservation.

The EPA's ENERGY STAR Portfolio Manager is an online tool that companies can use to measure and track energy consumption and benchmark the performance of one building or a group of buildings to that of other similar buildings across the country. Portfolio Manager can now be used for water as well. While percentile rankings are not currently available for water use (as energy comparisons are), they should become available as more companies use the database and the information becomes more prevalent.

The DOE is expanding its Better Buildings, Better Plants program to include water — to help partners save water and reduce their utility bills *(5)*. Some Better Plants Challenge partners have completed a pilot program in which they expanded their resource management strategies to include water, set water savings goals, tracked progress, and shared solutions. The results of that pilot effort are now being offered to other participants in the Challenge program. The DOE plans to publish its findings from the pilot program soon.

Additional external resources are conferences, including those held by the Water Environment Federation (WEF), the American Water Works Association (AWWA), and WateReuse.

Tools are available to assist companies in determining which of their manufacturing sites are in water-stressed areas now and are likely to be in the future. Two of the most commonly used are the World Resources Institute's (WRI) Aqueduct Water Risk Atlas *(6)* and the World Business Council for Sustainable Development's (WBCSD) Global Water Tool *(7)*. Both tools provide a good starting point for companies that want to start a water conservation program. However, users must independently confirm the results (*i.e.*, whether water scarcity is actually an issue) because the tools are not accurate for all very localized issues. No single tool covers all of the critical issues of a particular site when it comes to managing water availability. This is primarily due to the many complexities and factors associated with water stress at the local level across watersheds and industries.

Another useful tool is the Water Risk Monetizer developed by Ecolab and Trucost *(8)*. The Water Risk Monetizer is a publicly available financial modeling tool that helps businesses anywhere in the world assess water-related risks in financial terms and incorporate water-related risks into business decisions. It provides risk-adjusted water prices based on the cost of water if supply and demand were accurately reflected, the potential revenue that could be lost due to water scarcity at a facility, and other information to help companies weigh water-related issues when making business decisions.

Tracking water consumption is just one part of a water-management program.

Water-treatment providers can be great resources as well. Eastman has turned to its water management service provider for help in water conservation. Water-treatment suppliers typically work in partnership with their clients to identify water savings opportunities, some of which also result in energy savings.

Site-wide initiatives

A valuable energy-management strategy employed by chemical companies is implementing best practices for dealing with common issues (*e.g.*, steam and air leaks) or equipment (*e.g.*, steam traps, insulation, lighting). Eastman identified seven such areas and has developed a questionnaire to assess the progress of each site in each area. The results serve to identify common areas of concern, needs for improvements, and best practices at individual sites that can be shared throughout the company. Having a centralized group and system to manage energy in these common areas is a cost-effective and efficient use of resources.

This same concept can be applied to water conservation. A good example of this is condensate return. If condensate can be returned from the process, energy *and* water can be saved.

Water reuse should also be evaluated. Like heat, water exiting one process or area can be compared against requirements for another process or area for possible reuse through process integration.

Projects

Ideally the energy manager has a budget specifically for energy-efficiency projects. This will enable more projects to be completed, and the energy team members will be perceived as welcome partners rather than uninvited guests. Eastman currently dedicates $8 million per year to energy projects. Water conservation projects may be included in that budget if they have a good payback, because energy is typically being saved in addition to water.

Many approaches can be used to identify project oppor-

tunities for energy and water conservation. One is to hire a consultant to work with manufacturing, utility, and energy personnel to review chemical processes in some detail and brainstorm ideas for more-effective energy (and water) utilization. An advantage of this approach is that it gives participants a sense of urgency, as the consultant is working for a fixed period of time. An outside perspective may trigger insights on new issues or challenge old paradigms. A consultant can also be helpful in providing a structured framework to bring the exercise to completion.

Eastman hired a consultant to help jumpstart the idea-generation process. The consultant helped Eastman create a list of good project ideas for energy efficiency, which we catalogued in a database. Employees have since added new ideas to the database and mined the list for opportunities. Projects that at first were not of high priority or did not have a high payback may become more appealing for several reasons, including: funds become available, energy prices increase and improve a project's economics, or growth may require infrastructure expansion unless conservation projects are completed.

Energy-related projects typically involve upgrading to more energy-efficient equipment or heat recovery opportunities. Specific examples include:

• a compressor used on a low-pressure natural gas line was eliminated by running a line from a source of high-pressure natural gas

• control valves were eliminated by installing variable-frequency drives.

Some projects save water and energy. In fact, two Eastman projects that saved both received American Chemistry Council Energy Efficiency Awards in 2015:

• cooling water is now being recycled as feed to a washing process

• a new heat-recovery system designed to reuse waste condensate reduced a dryer's steam consumption.

Both of those cases are recovering for reuse water that was previously sent to the sewer.

Not all projects require expenditures. For example, fine-tuning temperatures on heat exchangers using refrigeration and steam to just meet but not exceed requirements can yield savings as well.

Another strategy for identifying project opportunities is the Treasure Hunt (sidebar, p. 44), a method developed and shared by Toyota. This is an example of ENERGY STAR industrial partners sharing nonproprietary information to improve the efficient use of available natural resources.

Many of the same concepts used for energy-efficiency projects can be applied to water conservation projects as well. Perhaps the most challenging aspect of implementing water conservation projects is their lack of economic payback. While energy projects often enable significant cost reductions, water projects almost never do.

Whether a company is ready to implement water conservation projects or not, little effort is required to begin identifying potential projects and creating a system for archiving the ideas. Should water availability become a concern in the future, that backlog of ideas can be valuable.

Developing a water conservation strategy

Many aspects of an energy-management program can be carried over into the realm of water conservation. However, it is important to develop a specific objective statement for water conservation. Eastman's objective, for example, is: Develop an understanding of water issues and properly identify and manage water risks and opportunities so that Eastman is positioned to respond to manufacturing and customer needs and escalating issues.

Once a company has developed its objective for water conservation, a good next step is to identify sites that are in water-stressed areas. The two tools mentioned previously — the World Resources Institute's Aqueduct Water Risk Atlas and the World Business Council for Sustainable Development's Global Water Tool — can be used for this purpose. These tools provide an indication of the level of water stress for a particular geographic region, but they do not account for the amount of water used by the facility or any highly localized issues.

Also inquire of each site to gain a better understanding of any local constraints or concerns. Site management in water-stressed areas is probably aware of the issues and may have adequate plans in place to address them. However, a corporate-level evaluation can identify best practices and gaps in various sites' plans, as well as promote sharing among facilities.

As the corporate water program develops and sites are asked to provide more information, consider taking the following actions:

• First, identify the appropriate external contact who can provide information on water use and costs. Members of the company's energy team may be a good starting point. In many cases, they may have information on both energy and water. At a minimum, they can probably provide the name of the right contact if water is not their responsibility.

• Seek to learn how much water is used, whether there are any local constraints, and whether the facility has taken or has planned actions to address any constraints.

• Determine current water costs and expected escalations.

Establish goals for the frequency of assessment for water issues, such as:

1. Begin with sites in water-stressed areas.
2. Conduct water assessments of new sites within two years of acquisition.
3. Develop a schedule for evaluation (or re-evaluation)

of all sites every five years, with roughly 20% of the sites evaluated in each calendar year.

4. Accelerate the evaluation schedule if there is a triggering event, such as a drought or planned expansion at the site.

Roles and responsibilities

Many groups within the corporation are (or should be) involved with water conservation.

Environmental affairs. In many companies, the environmental affairs staff has established contacts for regulatory issues. In addition to regulatory issues, this group may become aware of nonregulatory issues, such as those related to the availability of water. This group can serve to inform the energy manager of these issues and also provide information on available resources.

The environmental affairs group can also advise on water discharge limits. Discharge limits are typically based on a concentration level, and the ability to meet them could be affected by water conservation projects that reduce the quantity of water discharged but increase solute concentrations. Discharge limits may also include maximum water temperatures, which could be similarly affected by water conservation projects.

The energy team. The energy manager and members of the energy team can positively influence water conservation as they work toward more energy-efficient operations. They can promote awareness, involve other organizations, and maintain a project list. In addition, they may be needed to evaluate infrastructure issues such as the adequacy of sewers.

Sustainability council. Coordination with the group overseeing the corporation's sustainability initiatives is essential. The energy manager needs to work closely with this group to ensure appropriate alignment of goals and consistent internal and external messaging.

Global public affairs and policy group. The energy manager can work with this group to support consistent legislative and regulatory advocacy efforts for both energy and water issues.

Life cycle assessment team. Customers have begun to ask questions about water use and the water intensity of products. As more information becomes available, the life cycle analysis team can begin to incorporate water consumption into its assessments.

The path forward

Eastman has a successful energy-management program that has been recognized for five consecutive years as an ENERGY STAR Partner of the Year. It is the only chemical company to have achieved the highest ENERGY STAR Partner of the Year Sustained Excellence Award. As water conservation became an issue of increasing importance, it was only natural for us to consider whether the energy-management program could be expanded to include water conservation. We found that many elements of the program can be leveraged for a water conservation program.

While Eastman is early in this journey, we are clearly focused on understanding water risks, identifying water conservation projects, and increasing employee awareness. We envision that the water conservation effort will be included in a more encompassing water strategy for the company. CEP

SHARON NOLEN, P.E., is Manager, Worldwide Energy Program at Eastman Chemical Co. (Email: snolen@eastman.com). She previously worked at the U.S. Environmental Protection Agency's (EPA) research facility in Research Triangle Park, NC. After moving to Eastman in 1989, she held a variety of leadership positions in process engineering, plant engineering, corporate quality, information technology, and utilities before assuming leadership of the Worldwide Energy Program in 2010. Under her leadership, Eastman has been recognized by EPA for five consecutive years as an ENERGY STAR Partner of the Year. Eastman is the only chemical company to have ever received Sustained Excellence, ENERGY STAR's highest award. Nolen is also Eastman's representative for the Dept. of Energy's (DOE) Better Buildings, Better Plants Challenge program. She holds a BS in chemical engineering from Tennessee Tech Univ. and has completed the Univ. of Tennessee's Executive Development Program. She is a Professional Engineer and a Certified Energy Manager.

Literature Cited

1. **World Health Organization,** "Water Sanitation Health," www.who.int/water_sanitation_health/hygiene/en/ (accessed Feb. 2016).
2. **Shiklomartov, A. I.,** "World Fresh Water Resources," Ch. 2, Gleick, P. H., "Water in Crisis: A Guide to the World's Fresh Water Resources," Oxford University Press, New York, NY (Aug. 26, 1993).
3. **U.S. Dept. of Energy,** "Energy Intensity Baselining and Tracking Guidance," http://energy.gov/sites/prod/files/2016/02/f29/Energy%20Intensity%20Baselining%20and%20Tracking%20Guidance.pdf, DOE, Washington, DC (Feb. 2015).
4. **Nystuen, D. L.,** "The Sustainability Challenge: Reduce Your Plant's Water Footprint," *Chemical Engineering Progress*, **107** (4), pp. 28–33 (April 2011).
5. **U.S. Dept. of Energy,** "Better Plants Water Pilot — Overview," http://energy.gov/sites/prod/files/2015/01/f19/Better%20Plants%20Water%20Pilot%20Overview.pdf, DOE, Washington, DC (accessed Feb. 2016).
6. **World Resources Institute,** "Aqueduct Water Risk Atlas," www.wri.org/resources/maps/aqueduct-water-risk-atlas, WRI, Washington, DC (Oct. 2013).
7. **World Business Council for Sustainable Development,** "The WBCSD Global Water Tool," www.wbcsd.org/work-program/sector-projects/water/global-water-tool.aspx, WBCSD, Geneva, Switzerland (Mar. 2015).
8. **Ecolab USA and Trucost,** "Water Risk Monetizer," https://tool.waterriskmonetizer.com (accessed Feb. 2016).
9. **U.S. Environmental Protection Agency,** "Energy Treasure Hunt Guide: Simple Steps to Finding Energy Savings," www.energystar.gov/sites/default/files/buildings/tools/Energy_Treasure_Hunt_Guide_Jan2014.pdf, EPA, Washington, DC (Jan. 2014).