U.S. CHAMBER OF COMMERCE FOUNDATION
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ENERGY-WATER NEXUS TOOLKIT

RESOURCES AND BEST PRACTICES FOR USING ENERGY AND WATER MORE EFFICIENTLY

ENERGY-WATER NEXUS TOOLKIT: RESOURCES AND BEST PRACTICES FOR USING ENERGY AND WATER MORE EFFICIENTLY

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INTRODUCTION

Companies everywhere work on environmental projects that are external to their footprints. Corporate Social Responsibility (CSR) and Sustainability teams at individual companies work on projects around the globe to improve the environment by increasing the efficiency of energy and water systems, collectively known as the Energy-Water Nexus. From installing new wells to improving power grids, these projects are important to improving the communities that companies have an interest in because of a local production center, growing market potential, or a need for these types of projects. Making water and electrical systems more efficient can be vital to improving water quality and energy availability around the world.

When it comes to instituting Energy-Water Nexus projects and efficiencies within a company's space, these considerations often fall under the purview of Operations teams. Finding a way to execute nexus projects, both internally and externally, is an essential aspect of multiple parts of a company's goals. It is necessary to both share best practices for these types of projects and figure out how different parts of a company can work together to execute them.

The International Association of Plumbing and Mechanical Officials (IAPMO Group) and the U.S. Chamber of Commerce Foundation (USCCF) have designed this toolkit to help CSR, Sustainability, and Operations staffs in three ways. First, it gives a brief overview of the Energy-Water Nexus, including the history, issues, and risks surrounding the nexus. Second, it illustrates how the CSR, Sustainability, and Operations staff of a business can work together to pursue more efficient resource management both in-house and in the broader community. Third, it offers practical solutions to different Energy-Water Nexus challenges that can translate into real cost savings, greater profits, and positive environmental impacts.

Energy-Water Nexus Overview

Energy and water are connected to the inputs and outputs of every business. In manufacturing, energy and water are used to power, cool, and clean machines; and to mix and produce materials. Data centers need power and water to operate and cool their technology. Accountants, consultants, and service industry personnel require power and water to perform their jobs.

Starting in the 1970s, environmental experts have identified the growing need for examining energy and water in a concerted fashion.[1] For example, if water is not available where it is required, companies must use energy to transport it. Hence, the cost of water is much higher than its nominal cost out of a faucet; it also includes the cost of power needed to move it from that water source to where it is demanded.

Since then, it has become increasingly apparent that energy and water are connected to whole systems of production.[2] The energy system is composed of everything that goes into power generation, which includes the electricity created by turbines powered by water or steam, biofuels created through foodstuffs, fossil fuels, and energy distribution to consumers. The water system is responsible for freshwater extraction, wastewater treatment, cooling energy systems, and crop irrigation.

A growing population is demanding more energy around the world. In 1949, the United States consumed about 9.4 billion MWh of energy. By 2007 that number had more than tripled to 29.7 billion MWh.[3] Of that total, roughly 835 million MWh of electricity per year is used solely in the moving, treatment, and heating of water.[4]

That increase of energy consumption in the United States stalled around 2000, through conservation efforts, better building design, and more efficient production methods. These gains are largely due to increasing efficiencies in the manufacturing sector. In the past 10 years, while production in the manufacturing sector decreased by only 3%, the sector's energy use decreased nearly 17%.[5] While these improvements are significant, they are not typical in much of the developing world.

Those same manufacturing processes are also a major part of water usage. While global demand for water is expected to increase 55% between 2000 and 2050, the increase in global manufacturing demand for water during the same period is expected to be 400%.[6] This number ignores the fact that much manufacturing growth during that period will come from those same locations where finding freshwater is already difficult.

According to the United Nations, 90% of global electricity generation requires water, either to turn turbines or cool systems, which makes water indispensable to the energy production process. In 2005 alone, the United States withdrew 143 billion gallons of water per day for thermoelectric power production. Four billion of these gallons were consumed (i.e., they did not return to a watershed).[7] So not only are energy and water efficiencies important on their own, but considering their interactions as a nexus can have significant impact.

Rationale for Connecting Business Units to Consider Nexus Risks

The connection between energy and water has a long history and companies around the world and in the United States realize the importance of treating them as a connected system. To make an impact and improve resiliency to nexus vulnerabilities, a business' external facing CSR team and its internal Operations and Management personnel need to work together to limit risks from inside and outside the business.

In a recent USCCF report, *The Energy-Water-Food Nexus: Insights for the Business Community*, the authors found six different risks outlined throughout the nexus literature:[8]

1. **Risk to Inputs of Operation**—One of the clearest ways that a company can face nexus risk is when energy, water, or food is a direct input to their operations and one or more of these resources becomes scarce. Fifty-one percent of CEOs expect their company's core business to be affected by natural resource shortages by 2018.[9]
2. **Regulatory Risk**—If some part of the government believes that nexus resources are inappropriately consumed by the private sector, a typical response is to generate new regulations to forcibly change consumption patterns.
3. **Risk of Unforeseen Trade-Offs**—The essence of the nexus concept is that these systems are all interrelated. These interconnections mean that actions that will positively reduce consumption of one resource may have overall negative effects on the consumption of other resources, like the power required for desalination of seawater.
4. **Reputational Risk**—To a certain extent, companies are risking their brand value if their consumption stresses nexus resources, especially locally. Thus, it benefits companies to consider how their role in the nexus may garner either negative or positive public sentiment in the community.
5. **Risks in the Value Chain**—CDP shows that 23% of Global 500 businesses surveyed were unable to identify whether they are exposed to risks across their supply chains.[10] If a key supplier experiences a shortage, this can mean a critical shortage in a company's inputs.
6. **Disaster Risks**—Nexus risks are heightened when a natural or manmade disaster affects a region. In normal times, energy and water systems can typically balance competing demands for resources. When disasters overrun or compromise these systems, the interplay of ripple effects can grow unabated into vicious cycles.

Limiting the impact of these risks is a joint effort by everyone within a business. According to an EY/GreenBiz report, the C-suite is a crucial group for establishing sustainability and Energy-Water Nexus projects as a "strategic risk management issue as opposed to being seen simply as a means of 'doing the right thing.'"[11] The same sentiment was echoed in an IBM report:

> We believe it is paramount that leadership establish and communicate a sustainability vision supported by a well-defined strategy.…Regardless of how it fits into the overall business strategy, a successful sustainability program must have the right level of leadership attention and commitment.[12]

While buy-in of top leadership is generally accepted as an essential route to ensuring that a business takes a comprehensive look at its nexus risks, it takes the work of individuals in the CSR and Operations space to actualize that leadership. By working externally and internally for the company's goals to reduce its nexus risks, those two groups can work together to reduce a company's water and energy risks.

It is important that these two groups communicate and work together to manage resources more efficiently. Companies face challenging questions about when and where to make capital improvements. Successful projects that address nexus issues depend on support from multiple stakeholders in the company. Through presenting a number of different ways that businesses can address the Energy-Water Nexus, this report also shows some of the ways that CSR and Operations personnel can speak the same language, identify opportunities for savings, advance industry best practices, and effectively reach their energy and water sustainability goals.

PRACTICAL SOLUTIONS

Most of this toolkit concentrates on specific ways to increase the energy and water efficiency of a business. It is designed to serve as a primer so that CSR, Sustainability and Operations staff can work together to identify cost-effective changes that lead to the decreased consumption of these resources while saving money and avoiding some nexus risks.

These suggestions are presented in three distinct sections. First, the section on **Understanding How Your Company Currently Uses Energy and Water** establishes the importance of setting a baseline to recognize how many of these resources your company uses, specific tools on how to get those measurements, and ways that different types of companies and organizations conduct this work.

CASE STUDY: Microsoft's CityNext program, under the tagline "do NEW with less" is designed to help city and county governments around the globe to use smarter programs for development. Furthermore, CityNext has an entire section dedicated to how cities can improve their energy and water usage through better monitoring. Through Big Data, mobile, and social media technologies, Microsoft manages an integrated platform so that cities, counties, and utilities can use energy and water data more efficiently to monitor all aspects of the nexus systems.[13]

Second, there are two sections, both called **From Measurement to Action**. The first section concentrates on reducing water consumption, and the second on increasing energy efficiency. They offer the same type of analysis and tools for all types of water consumption that a company may experience in the office setting, in production processes, or throughout its physical footprint.

Understanding How Your Company Currently Uses Energy and Water

Every industry uses water and energy differently. Nevertheless, there are common resources that can be used to address the Energy-Water Nexus in your operations. Also, there are industry-specific case studies highlighting steps other companies have taken to address overall water and energy consumption.

Conduct an Energy-Water Audit and Baseline Assessment

Understanding how your company uses energy and water is key to address the Energy-Water Nexus. Conducting a water or energy audit early in the process helps gather the necessary facts and data. This information then enables you to identify and assess various options with a clear understanding of the costs and savings of each option. Companies can conduct their own internal audits using resources highlighted in this section or can hire outside firms to perform an audit for them. An audit helps to better understand your use of water and to identify steps you can take to improve the efficiency of your processes and systems with a focus on reducing overall costs.

To develop a plan of action, a company must understand its current total energy and water consumption. By establishing a baseline, the company is able to begin identifying areas where conservation and efficiency can be improved. It also establishes a benchmark whereby the business can demonstrate its cost and resources savings from the actions it undertakes. This process can be started by monitoring usage rates at meters or bills.

Resources:

- Once a company has completed these steps to find a water usage baseline, a comprehensive water management plan is helpful for commercial facilities to set water conservation goals and identify water conservation opportunities. This plan should include clear information about how a facility uses its water, from the time it is piped into the facility through disposal. Knowledge of current water consumption and its costs is essential for making appropriate water management decisions. EPA has put together helpful resources for companies to get started

CASE STUDY: Adobe Systems Inc. installed real-time main electric meters in three high-rise office buildings, totaling just less than 1 million square feet. These facilities included a cafeteria, fitness center, and 30,000-square-foot data center. The meters were purchased and installed for $19,969. These advanced meters were part of Adobe's total $1.1 million it spent on energy and energy-related projects. Adobe received $350,000 in rebates for these projects and saved *$1 million per year* in reduced costs. It earned a 122% return on investment, with a 10-month average payback. In addition, Adobe installed real-time digital water meters (known as pulse meters) on cooling towers to record water loss through evaporation and water leaks in order to reduce its sewage treatment bill. The installation cost was $43,000, and the savings attributed to reduced sewer treatment charges resulting from water leakage totaled $12,000 that year.[14]

developing their plan. It has also created a helpful tool on how to create an effective Water Management Plan.

- The Environmental Defense Fund-Global Environment Management Initiative (EDF-GEMI) Water Scorecard is an example of how companies can create visibility for water performance at facilities. The Water Scorecard Guide offers an overview of the scorecard concept, calculations used by AT&T in developing its first scorecard, and information about adapt the scorecard to your company's needs.

Energy-Water Metering—Getting the Data You Need

Meters are sensors that measure and record water and energy consumption. Historically, water and energy metering and measurement occurred on an aggregate basis with measurements being provided for entire buildings or corporate campuses. These types of meters are critical to measuring overall usage and to assist utilities in recovering the costs of their services. In addition to standard meters, advanced metering and submetering can provide refined measurements of energy and water use. It provides the operations and maintenance transparency that is necessary to analyze a specific facility's or area's energy and water use, closely detect water losses or leaks, and identify ways to make the systems more energy or water efficient.

Advanced metering is a system that provides data on usage at regular intervals (every hour, minute, etc.). Submetering is a system where additional meters can be deployed to measure usage at a localized level – from a corporate campus to an individual building or from a building to a specific system or space.

Conducting a water and energy audit and receiving higher resolution data from sources such as advanced metering or submetering can play a pivotal role in shaping your corporate strategy for reducing water and creating an energy management plan.

Leak Detection and Repair Program

An aggressive leak detection and repair program can help facility managers better understand building water use and save money by avoiding water waste.

Data from advanced metering and submetering can also help detect anomalies with a facility's distribution system or from particular processes or equipment, ultimately leading to significant reductions in water and energy.

Reading meters, installing failure abatement technologies, and conducting visual and auditory inspections are important best practices to detect leaks. To reduce unnecessary water loss, all detected leaks should be repaired as quickly as possible.

Work With Your Utilities

Water and energy resources on the local level are increasingly under stress due to factors such as population growth, urbanization, and changes in climate. Part of addressing the Energy-Water Nexus in your company is to recognize the overall risks and stresses on those resources in your community. Work with the local water provider to understand the sources of water used for the water supply of your facilities and for energy production. Also work with the local energy provider to find the same information for electricity. Working with utilities can also provide a better understanding of how vulnerable the company is to shifts in the water supply or energy demand. This will help further assess the risks that severe drought or water shortages can have on a company's facilities or operations.

Resources:

- The World Wildlife Fund (WWF) has created a Water Risk Filter, an online application for corporate officers, facility managers, and investors to analyze the impact of their business activity on the water supply, understand potential risk exposures, and obtain ideas for mitigating risk.
- Ecolab and Trucost, environmental data and technological expertise firms, have developed a Water Risk Monetizer that uses a scientific model to quantify the impact of water scarcity on a facility in monetary terms. The tool builds upon existing approaches used by businesses to measure water risks and extends these insights by applying a monetary valuation.
- In January 2013, the World Resources Institute launched its Water Risk Atlas. The Atlas uses a robust, peer reviewed methodology and the best-available data to create high-resolution, customizable global maps of water risk. This tool helps companies, investors, governments, and other users understand where and how water risks and opportunities are emerging worldwide.

CASE STUDY: Approximately half of the 52-story Bank of America Building in San Francisco was submetered after energy managers learned that tenants exceeded by as much as threefold their energy allowance of 3 kilowatts per square foot (kW/sq ft). More than 120 submeters were installed, and the property owner saved $1 million in excess energy usage in the first year alone. The cost of the submetering hardware and software in this application resulted in a payback period of *days*, complemented by energy usage and cost savings of 30% per year.[15]

CASE STUDY: Dow Chemical Terneuzen in the Netherlands is part of Dow's global commitment to have its sites be independent from local sources of drinking water by 2020. This commitment is particularly important at Dow's Terneuzen site, since pressures on the local water supply requires some water to be transported over 75 miles to make up the deficit. Dow has worked to build increased water capacity for its site by collaborating with local water utilities and providers. They have installed new systems to recycle municipal and its own waste water for use in agriculture, manufacturing processes, and cooling systems. These efforts have resulted in a reduction in CO2 emissions of 60,000 tons per year and a 95% reduction in the cost and energy required to secure its water supply.[16]

From Measurement to Action: Impacting the Nexus by Reducing Water Consumption

The commercial and institutional sector is the second largest consumer of water in the United States, accounting for 17% of withdrawals from public water supplies.

In a typical office building, the three largest uses of water are restrooms (37%), heating and cooling (28%), and landscaping (22%), making these areas an easy starting point for reducing water and related energy consumption.[17]

WaterSense Labeled Products

Installing highly efficient plumbing fittings and fixtures can help save billions of gallons of water in the United States every year. WaterSense, a partnership program created by the Environmental Protection Agency, offers a simple way to identify water-efficient products and services. Plumbing products that have earned the WaterSense label, including toilets, bathroom faucets, urinals, showerheads, and spray valves, have been certified to be at least 20% more efficient without sacrificing performance and have been verified by an independent, third-party certification laboratory.

WaterSense has helped consumers save a cumulative 757 billion gallons of water and more than $14.2 billion in water and energy bills.[18] By the end of 2013, reductions of 101 billion kWh of electricity and 37 million metric tons of CO2 were achieved through the use of WaterSense labeled products.

Resources

- The EPA's WaterSense at Work is a compilation of best practices to help commercial and institutional owners and managers establish an effective facility water management program and identify areas where they can reduce facility water use and save energy.

Outdoor Water Use

For many facilities, a significant portion of water is used for outdoor purposes.

Water Usage by Type and Institution[19]

CASE STUDY: The University of California and California State University System provides a good example of the insight submetering can provide. In one facility, electric and gas meters had been manually read each month. After the existing electric and gas meters in the building were tied into the campus energy management system and their energy use was analyzed, it was immediately apparent that there was high night time electricity use. Much of the lighting was found to operate after hours and the air handlers operated continuously, even though the building was unoccupied at night. The chiller and boiler also operated during this time, performing simultaneous heating and cooling. Equipped with this information, university officials were able to take steps to immediately rectify the situation.[20]

Depending on the size of the property, facility type and local climate outdoor water use can account for 5% to 30% of total water use.[21] On commercial and industrial campuses, water is used outdoors for a variety of purposes including: landscape irrigation, swimming pools, and water features. By focusing on these areas, it is possible to achieve significant savings in both water and energy.

Outdoor Water Use—Landscaping

Most building and facilities that own or maintain the surrounding landscape use water to maintain the health and quality of that landscape. In many situations, though, the use of that water can be controlled and minimized.

- Drip irrigation on planting areas, instead of using traditional sprinkler heads can reduce landscape water consumption by 20% to 50%.[22]
- Smart Irrigation Controllers can reduce water use by 15% compared with clock timer or manual irrigations systems. Smart Controllers take into account weather data and on-site conditions.[23]
- Efficient sprinkler heads can reduce water use by 30% when compared with traditional sprinkler heads.[24]
- Effective landscape design incorporating native or drought tolerant plants, appropriate grading to avoid water runoff, and maintaining healthy soils to enable plants to develop strong root systems can all contribute to water reductions outside.

As many areas around the world face increasing demands on potable (drinking-quality) water, there are other reliable and economical sources of water that can be used for outdoor and industrial processes. Using alternate sources of water for non-drinking purposes extends current water supplies and can help replace groundwater aquifers. In 2009, use of reclaimed water substituted for more than 127 billion gallons of drinking water while serving to add more than 79 billion gallons back to available groundwater supplies.[25] Alternate sources include:

- Rainwater Catchment Systems: Captured rainwater can easily replace a substantial amount of water used for non-potable purposes. It can be used for flushing toilets, laundry, grounds maintenance, irrigation, vehicle washes, cooling, and industrial processes. Rainwater Catchment comes in a range of system sizes and complexities, from small, passive systems (e.g., rain barrels) to larger systems with fitted pumps, controls, and treatment systems (e.g., active systems or cisterns).
- Grey water: slightly used water (Grey water) from other parts of a facility can provide an alternate source for landscape irrigation. Grey water is derived from

discharges from sinks, showers, laundry and from certain industrial processes.

Outdoor Water Use - Pools, Spas and Water Features

There are more than 50,000 commercial indoor year-round swimming pools in the United States, including at college campuses, hotels, resorts, gyms, therapy centers and apartment complexes. Commercial facilities with pools can be heavy energy consumers due to the need to maintain water temperatures between 80 and 86 degrees. This can result in buildings with swimming pools consuming more than five times more energy than the average commercial building.[26]

Variable frequency drive (VFD) technology is a proven method for reducing the electricity consumption and extending the operational life of a wide range of electric motors. This is achieved by its ability to control the rotational speed of an alternating current motor, enabling it to conserve energy when the device is not in high demand.

From Measurement to Action: Reducing Energy Use Through Heating and Cooling Systems

Heating and cooling our facilities consumes energy—a lot of it. Of the roughly 59 billion square feet of total commercial floor space, about 82% is heated and 61% is cooled. In spite of dramatic improvements in efficiency over the past two decades, energy use for heating and cooling remains a very large portion of the total national energy use and still provides a significant opportunity for energy use reduction.[27] According to the Department of Energy's *Buildings Energy Data Book*, in 2015 buildings are expected to consume more than 40% of the total energy used in the United States.[28] Of this amount, nearly 36% will be used for space heating, 12.6% for water heating, and 2.8% for space cooling. All of these processes involve water usage, making building climate control one of the biggest in-house nexus issues.[29]

Cooling Towers

Cooling towers are an important component of many refrigeration and climate systems. They help regulate temperature by dissipating heat from recirculating water

CASE STUDY: Since 2009, Hilton Worldwide has reduced its water consumption by 13.1% across its more than 4,000 properties. The Hilton Palacio del Rio Hotel in San Antonio reduced its water consumption by 49%, saving 26 million gallons or 80 acre-feet of water per year. This also resulted in a combined $160,000 in water, sewer, and energy cost savings per year.

CASE STUDY: In Silicon Valley, the Campbell Union School District's sprinklers are used to water the grounds and playing fields on 12 campuses. The district found that temporarily shutting off each of the 45 irrigation control boxes by hand when it was raining was not worth the maintenance team's time. But in 2009, the district installed new "smart" controllers that automatically adjust daily watering to weather conditions. In one year, the use of smart controllers slashed the school district's water use by 39% and cut its utility bills by $108,000.[30]

CASE STUDY: Many companies are taking advantage of turf replacement rebate programs being offered by utilities. At a brewery in Southern California, MillerCoors is replacing two acres of green turf and will feature a new landscape design that incorporates a pathway of decomposed granite and a bed of river rocks. For its water-saving efforts, the beer company will receive a check for $187,000 from the Metropolitan Water District of Southern California (MWD) through the agency's turf replacement rebate program. Of the $85.6 million MWD has allocated for turf replacement rebates under the program, about 60% is slated for commercial customers.[31]

CASE STUDY: The Walt Disney Company recognized that the challenges related to water are highly localized. As such, the company evaluates water-related challenges on a site-specific basis and designs conservation programs catered to the location. As part of the development of the New Fantasyland at the Magic Kingdom at the Walt Disney World Resort in Florida, the reclaimed water infrastructure was expanded and is now being used for landscaping and flushing fixtures in the new Guest restrooms. This avoids the need for potable water used in the region by about 27.1 million gallons per year.[32]

CASE STUDY: At Shell's bitumen producing Carmon Creek Project, water is a major resource for nearly every production process, from steam needed to help push the bitumen through the well, to treatment once it is pumped out of the well, to cleaning materials. Conserving water by using nonpotable sources a significant part of Shell's new plans for the project in the 2010s. Most of its steam for the production process will come from recycled "produced water," water that comes up with the bitumen. Additional steam will come from an underground formation that holds older produced water. This process significantly reduces Shell's need to use water from an aquifer or the nearby Peace River.[33]

CASE STUDY: In reviewing its water usage data, AT&T discovered that less than 1.5% of its approximately 9,000 buildings (125) were responsible for about 50% of total water use. Moreover, 36 out of those 125 buildings were in regions categorized as having water-stress levels of either high or very high. In one facility, AT&T upgraded a cooling tower filtration system, which cost less than $100,000 to install but returned $60,000.00 in annual water and sewer savings. It also resulted in a 29% reduction in overall water use and a 70% reduction in discharges. In other facilities, AT&T discovered that smaller investments resulted in significant savings. At one of those facilities, AT&T made a free air cooling upgrade costing $4,000 to expand free air cooling in the building but that delivered nearly $40,000 in annual savings.[34]

that is used to cool chillers, air-conditioning equipment, or other process equipment. Heat is released into the air through an evaporative process. By design, cooling towers can use significant amounts of water and can be an important source for energy and water savings.

Additionally, water-cooled cooling towers can be replaced with ground source heat pump loop fields of vertical or horizontal configurations. This makes sense because rejecting heat energy into outside air during the hot summer months can be done, but it requires a lot of energy to do so. It also results in significant water losses associated with evaporation from conventional cooling towers. In many cases, the heat that is sent into, or "rejected," to the loop field during the cooling season, can be recovered from the loop field and charged back into the building during the heating season. During the shoulder seasons when heating and cooling are more variable, heat being rejected by one part of the building can be recovered and sent into parts of the building that still require heating. These systems can also incorporate the fire protection system as a part of the heating and cooling distribution system (Tri water systems) and reduce the installed cost of the HVAC system and the fire protection system.

Resources:

- EDF, AT&T, and GEMI have developed a set of tools and resources to help organizations build their own program to reduce water and energy use in buildings—and save money in the process. These toolkits address components such as cooling towers, mechanical chillers, and heat exchangers.
- The US Department of Energy has compiled a number of best practices regarding cooler tower management that facility managers should take. These practices relate to operations and maintenance as well as retrofit and replacement options.

Advanced Control Systems

Advanced controls systems can be easily retrofitted into an existing system that can also result in a significant reduction in energy consumption by coordinating optimum start-stop times, enabling newer systems to modulate to the real-time energy demands and allowing the building owners and operators to take advantage of daily free cooling potentials at night. Most of these controls are computer-based systems with remote alarming and monitoring capabilities. Any existing building with a physical plant that is 20 years or older would probably see significant reductions in energy consumed, as well as increases in occupant comfort associated with the installation of an intelligent hydronic (water-based) comfort system.

Resources:

- The Hydronics Industry Alliance has curated a number of articles, white papers, and training programs to illustrate the technical and mechanical benefits of different HVAC systems at the Education section of their website.
- In "Hydronic systems offer better efficiency," there is a direct side by side comparison of how hydronic systems

CASE STUDY: Recognizing the conservation benefits of VFDs, MGM Resorts International initiated plans in 2011 to retrofit the company's pool, spa, and water feature pumps with VFDs. The pumps were operating at a consistent speed in most applications 24 hours a day, 7 days a week. With more than 300 pool pumps at MGM Resorts, the Corporate Sustainability Division and Property Operations recognized that the installation of VFDs could dramatically reduce the company's energy use. MGM Resorts has saved more than 13.7 million annual kilowatt hours and $1.2 million in annual costs from the retrofit of 294 pumps.[35]

CASE STUDY: Smart water management at Lockheed Martin facilities supports smart energy management, since a significant portion of its energy use stems from heating, cooling and circulating water in operations.

During 2014 Lockheed Martin conducted an analysis of water use reduction associated with its energy reduction activities to further understand the Energy-Water Nexus in relation to achieving its voluntary reduction targets for carbon emissions and facility energy and water use. The water savings realized by all affected stakeholders associated with its energy reduction activities (5.8 billion gallons from 2010 to 2013) was substantially greater than the water savings from their on-site facility water reduction projects (0.4 billion gallons from 2010-2013). During the year the company's facilities implemented more than 30 energy-efficiency projects such as HVAC improvements, retro-commissioning activities, lighting upgrades and peak load reduction programs. These initiatives will result in approximately $3 million of cost avoidance and 15,000 metric tons of CO2 equivalent of greenhouse gas (GHG) emission reductions annually.

The company has also used the World Business Council for Sustainable Development (WBCSD) Global Water Tool to determine water risks at its facilities, Lockheed was able to minimize water usage throughout many of its locations. Two of these examples focus on heating and cooling efforts. The first is a Reverse Osmosis system at a facility in Marietta, GA. There, 27.5 million gallons from the waste water treatment system are treated and reused in their cooling towers. The second of these examples is an electrostatic precipitation system to treat circulating cooling tower water. This reduces the amount of new water required in the cooling towers and reduces water usage by nearly 3 million gallons a year.

offer better energy efficiency than standard HVAC systems that rely on moving air through a building.

Heat Recovery Systems

Heat recovery systems represent the greatest possible reduction in base energy consumption of any building. Many of these systems have been on the market for years and have a good track record of savings and reliability. In some cases, by utilizing state-of-the-art hydronic delivery systems, it is entirely possible to capture the heat accumulating on the south, east, and west sides of a building, and transfer it to the north side of the building without having to consume much additional energy. These systems are commonly called water source heat pump systems.

Water source heat pump systems have been around for the better part of 50 years. For industrial applications, the potential for waste heat recovery can significantly reduce the size of the physical plant required to generate hot water for the processes used in the building. Simply recovering the heat from the hot drain water leaving one machine and using that energy to preheat the incoming cold water for another process can reduce energy consumption by as much as 50%. In certain applications, the overall efficiency of the connected physical plant can also realize a significant increase in efficiency due to heat recovery. For ventilation systems typically used for commercial office buildings, there are energy recovery ventilators (ERV) that can recover the sensible energy associated with conditioning a building, and the latent energy associated with the same processes. This system can result in a more comfortable environment and happier, healthier building occupants.

ERVs are typically recommended for use in warmer climates where it is desired to remove humidity from incoming fresh air. While not a dehumidifier, ERV systems transfer moisture from incoming, humid air to the stale indoor air that is being vented to the outside. A related technology, Heat Recovery Ventilators (HRV) reclaim energy from exhausted stale indoor air to temper incoming fresh air - heat is retained during cooler seasons, and removed during warmer seasons. These systems capture about 70% of the energy already expended to temper incoming air.[36]

Drain waste heat recovery (DWHR) systems hold great potential in recovering the residual energy leaving a process in the drainage stream and use that energy for preheating the replacement cold water.

Refrigerant waste heat recovery (RWHR) can reclaim the heated thermal energy that is normally just discharged into the atmosphere and use it anywhere that thermal heating energy is needed.

Resources:

- The US Department of Energy has produced a report on waste heat recovery highlighting the technologies and opportunities that exist.

Insulation of Hot Water Supply and Circulation Return Lines

Largely due to the inexpensive price of energy over the past century, little thought has been given to insulating domestic hot water lines. It was seen as a poor investment because any energy or heat lost from the piping was actually useful to heat the building. However, as the cost per unit of energy increased, this negligible energy wasted started adding up, and suddenly the economics associated with this energy conservation effort became quite obvious. Not only do these pipes lose energy into the building during the heating season, but they also lose heat into the space during the cooling season, which is an expensive and long-term waste of energy. Many of these older buildings had a circulation return system on them to ensure that points of use farthest away from the hot water source would always have “instantly hot” water coming from the tap. Although this was initially done as a convenience to the end users, it is a great way to conserve our most precious resource, water, from not having to run the water down the drain for a significant amount of time before getting hot water to the point of use.

Whenever accessible and possible, all hot water conveying pipes, and chilled water pipes as well, should be insulated to lower the standby losses of these pipes into the surrounding conditioned space. If it is impossible to reach the domestic hot water (DHW) piping due to structural preclusions, another possibility to consider is setting small, electric tankless hot water generators at points of use (restrooms) throughout the building, and eliminating the circulation return pumps and piping from the system. This will provide end users with the necessary instant hot water for washing hands in restrooms, and eliminate the continuous standby losses associated with uninsulated or poorly insulated DHW piping systems.

In situations where the lines are all insulated, but the circulation return pump runs continuously, there are many manufacturers of controls and highly efficient pumps

CASE STUDY: At the General Mills plant in Vineland, New Jersey, water used to cool soup cans in the final stage of the canning process is now being captured and recycled. This saves 56 million gallons of water per year. Furthermore, the plant is able to offset energy use by extracting and transferring the heat coming from the used water into other processes. This has lowered energy usage by 16%.[37]

available that can be programmed to only allow the pump to run during certain time frames and will shut the pump off once hot water is coming back to the pump.

Solar Heating Systems

Solar heating systems reduce the consumption of electricity, natural gas, or oil by furnishing clean, renewable solar energy for each of these purposes, thereby saving the owner significant money over the near to midterm. Solar domestic water heating systems typically supply 70% of the required energy, while space heating systems can be designed to provide even higher percentages. Solar swimming pool heating systems are typically designed to provide from 70% to 100% of the heating energy.

Solar heating systems convert sunlight into heat for a variety of end-use applications.

Solar heat collectors are manufactured in a number of configurations based on the end-use application and convert sunlight into heat that is subsequently transferred from the collector to a "load." End-use loads include heating domestic water (e.g., tap water, showers), heating buildings (i.e., space heating), and heating swimming pools. Although these are the most common applications in the United States, solar heating systems are also available for "process heating" (heat required for a variety of manufacturing processes), and air-conditioning (cooling of air in buildings).

Resources:

- The Solar Energy Industries Association has collected examples of how utilizing innovative solar and heating cooling (SHC) systems on U.S. businesses and commercial buildings helps save energy and money.

Radiant Heating and Cooling Systems

Radiant heating and cooling systems are hydronic systems that transfer energy into or out of a given building by using a series of closed piping systems, which are imbedded in common building materials to provide heating and cooling. Hydronic HVAC systems for commercial buildings have proven to be one of the most efficient and sustainable systems available. Unlike conventional systems, a positive side effect of a radiant system is the elimination of duct leakage, which wastes up to 30% of the system's energy for certain types of buildings.[38] Newer radiantly heated and cooled buildings, when coupled with state of the art heating and cooling equipment, will result in significant reductions in energy consumption. These hydronic systems are completely compatible with all alternative energy systems known to mankind. They will result in the highest degree of comfort possible, which will result in marked increases in employee efficiency, and reductions in sick days lost due to airborne illnesses.[39] These hydronic radiant heating and cooling systems are completely compatible with all known methods of introducing alternative energy measures, like solar photovoltaics, solar thermal, ground source heat pumps and more. They can be designed to recover their own internally generated energy, again resulting in significant reductions of base energy consumption, resulting in much smaller carbon footprint for a given application.

CASE STUDY: In 1993, the South East London Combined Heat and Power Plant (SELCHP) was built to burn waste to provide power. But it was not until 2008 that Veolia signed a deal to develop SELCHP's capacity to take the previously unused generated heat and use it to provide heat for 2,500 homes in five council estates in Southeast London. This circular economy model was made more efficient by finding a way to transfer the heat to homes, and it plans to reduce carbon emissions by 8,000 tons a year and provide energy at low fixed rates for residents for the next 20 years.[40]

Hydronic radiant heating and cooling systems reduce the energy consumption of a typical commercial building by reducing the amount of air movement necessary to maintain occupant comfort. This reduction in air movement has been shown to reduce energy consumption of a typical commercial office building by as much as 50%. Hydronic radiant heating and cooling systems can be retrofitted into existing buildings with some modifications.

Resources

- The Radiant Professionals Alliance has a section of FAQs that helps answer some of the technical questions of these types of heating and cooling systems, including definitions, what "counts" as radiant technology, and how to convince stakeholders of its long term profitability and effectiveness.
- An article by Greg Cunniff originally in PM Engineer, "Hydronics offers a cool, comfort advantage," describes some of the technical reasons that using water instead of air movement or refrigerant to cool spaces is an energy efficient and more comfortable way to cool spaces.

CASE STUDY: Stapleton-Spence Fruit Packing Company, a leading packer of prune concentrates, purees, juices, nuts, and other dried fruits, uses steam heat to rehydrate dried fruit for sale. Before installing a solar heating system to preheat well water before it goes to the boiler, Stapleton-Spence used roughly 650,000 therms of natural gas per year to heat water to steam. Now the system saves 1 therm for every 75 gallons consumed, which saves them $15,000 a year on a $60,000 system expected to last 20 years.[41]

CASE STUDY: NOMAD Aquatics and Fitness Center in Huntersville, North Carolina heats two large indoor pools. Per competition policy, the pools have to be maintained at 79 degrees, but that was difficult and costly to maintain. NOMAD's energy bills were nearly $12,000 a month. After installing 269 solar collectors at a final cost of $130,000, the system saves the Center $96,000 a year in energy costs. The expected lifespan of the system is 15 years, making NOMAD much more resilient to future energy costs.[42]

CASE STUDY: In fall 2010, George Washington University in Washington, D.C. installed solar water heating systems in three residence halls. In total, the three heaters produce about 10,000 therms of energy per year, the equivalent of almost 300 MWh. The sustainability team at the University also considered the carbon cost of installing the equipment and found that those costs would be offset within four months of operation.[43]

CASE STUDY: The FedEx Rocky Mountain Tech Center in Colorado Springs, Colorado is one of the most energy efficient data centers in the country. Part of the reason for that comes from how the data centers are cooled. Rooms of servers can get quite hot, but they need to be kept relatively cool to maximize their performance and limit the amount of power required to operate. In data centers, energy efficiency is measured by its power usage effectiveness (PUE) ratio; the ratio of how much energy is needed to run auxiliary needs (e.g., cooling, lights) versus the energy needed to run the actual computing environment. Where the typical data center has an average PUE of 2.5, Rocky Mountain Tech center has a PUE of 1.28, so it uses about half the amount of cooling and lighting and other non-computer power as a data center of similar size. FedEx accomplished this by using variable drives to monitor power usage, using the cool and dry environment of Colorado Springs, and other methods to more effectively remove heat.[44]

CASE STUDY: Infosys, one of India's top three software companies, implemented a program in 2011 that resulted in the world's largest HVAC side-by-side comparison. In Hyderabad, India, it constructed a new facility that was actually two separate buildings right next to each other built to have exactly the same cooling needs, including the same physical orientation, same footprint, and same structure. In one of the buildings, Infosys used a highly efficient Variable Air Volume (VAV) system, with the standard cooling tower and pump mechanism pushing air through ducts. In the other, it used a radiant system that ran cooled water through the structure and fans to push that cooled air around the structure through rooms. After a year, the radiant system was found to be 34% more efficient, and about 1% less expensive.[45]

CSR, SUSTAINABILITY, AND OPERATIONS TEAMS WORKING TOGETHER

One of the biggest challenges that CSR teams face is communicating opportunities and goals to all company staff. It can be difficult, especially in companies with large staffs or with employees spread across a number of locations, to build a groundswell of support for programming if employees are not informed.

Cross-company communication about internal water and energy use is particularly paramount for staff across all business units. Companies by and large do not charge separate business units for the energy and water they consume, so they do not have reminders or penalties based on consumption of those resources. Instead, there can be internal incentives for hitting efficiency targets, which can be easier to track with submeters for both water and energy.

For these nexus issues, the most important line of communication in a company is between CSR, Sustainability, and Operations personnel. Establishing and maintaining that line of communication is the basic building block to strong working relationships, where the internal expertise and focus of Operations personnel can be matched with the environmental focus of the CSR and Sustainability teams. At the same time, a company's major developments in nexus efficiencies can lead to significant communications gains in a community.

Training of Maintenance and Operations Personnel

Addressing the Energy-Water Nexus in facilities is usually not a one-time event. A cadre of Maintenance and Operations personnel is required to implement and

maintain the efficiencies that have been achieved. It is important that the personnel involved with building operations and maintenance, energy management, safety, and design functions are properly trained and certified to carry out required tasks. In all cases, a knowledgeable, skilled, and well-trained management and technical staff and a well-planned maintenance program can provide a number of benefits:

- Reducing the number and cost of capital repairs
- Reducing the amount of unscheduled shutdowns and repairs
- Extending equipment life and facility life
- Realizing life cycle cost savings
- Providing safe, functional systems and facilities that meet the design intent

Personnel should be trained in core competencies related to building operations and maintenance, energy management, sustainability, water efficiency, safety, and building performance measures. This will help ensure that the changes a company makes to address Energy-Water Nexus issues are lasting.

Resources:

- IAPMO Group is an industry leader in providing training to personnel working on plumbing and mechanical systems. One of its training programs, Green Plumbers, offers plumbing professionals with in-depth training on issues such as high-efficiency plumbing fixtures; conducting water audits; harvesting rainwater; reviewing reuse systems, onsite waste water treatment, and solar hot water heating; and calculating water, sewer and energy savings. Maintenance personnel are prepared with the skills they need to apply these systems as well as to determine the impact they are having.
- The Qualified Water Efficient Landscaper (QWEL) professional certification provides landscape professionals with 20 hours of education on principles of proper plant selection for the local climate, irrigation system design and maintenance, and irrigation system programming and operation. QWEL is recognized as an EPA WaterSense labeled Professional Certification Program for Irrigation System Audits.

Building Commissioning

Building commissioning is the process of verifying in new construction that the building's subsystems for mechanical (HVAC), plumbing, electrical, fire and life safety, building envelopes, interior systems, lighting, wastewater, controls, and building security achieve the level of efficiency and performance that was intended by the building owner and designed by the building architects and engineers.

Retrocommissioning is the application of the commissioning process to existing buildings. It is another type of commissioning that occurs when a building that has already been commissioned undergoes another commissioning process.

Commissioning of new and existing buildings is a prime tool for improving building energy and water performance. Building owners can realize higher occupant satisfaction, lease rates and property values while reducing utility bills. Energy savings are often in the 10% to 20% range.[46]

The results are compelling. The Department of Energy conducted a study on commissioning projects that revealed more than 10,000 energy and water-related problems, resulting in 16% median whole-building energy savings in existing buildings and 13% in new construction, with payback time of 1.1 years and 4.2 years, respectively. In 2004, Lawrence Berkeley National Laboratory estimated $18 billion per year of potential savings from commissioning throughout the United States from addressing the most common faults in commercial buildings.[47]

CONCLUSION

By not undertaking projects that address Energy-Water Nexus vulnerabilities, a company is left with a number of risks, ranging from impacting long-term resiliency to local reputation.

It is likely that energy, and certainly water, are not getting any less expensive in the long term. Increased efficiencies and better management of those resources and how they intersect are going to be crucial for all end users, especially companies, to predict and manage costs. Taking steps now to improve energy and water efficiency can be key to future profitability.

One of the major concerns regarding profitability for many companies is the initial investments required to execute the projects outlined in this report. Many can be expensive at the outset, but the return on that investment is realized quickly. Moreover, the life cycle analysis of newer technologies almost always shows them to be more profitable than current energy-water technologies. Often, economies of scale can be achieved by undertaking these improvements collectively rather than piecemeal.

Many of these improvements are complementary to future gains in energy-

water efficiencies. By making facilities more energy and water efficient, companies can be better placed to benefit from broader future technologies, such as less costly and centralized ways to produce energy or process clean water.

Between combating risks and making a strong business case, there are plenty of reasons to engage in Energy-Water Nexus programs. Effective programs achieve cost savings, reduce risk, and demonstrate leadership.

Step 1: Begin With Clear Priorities and Objectives

The success of any program hinges on a company's long-term commitment to address Energy-Water Nexus issues in its facilities and operations. CSR and Operations stakeholders first need to communicate with each other to establish plans that have clearly defined priorities and objectives. Often, the best place to start to define these priorities is by closely assessing your company's current energy and water consumption and by establishing a baseline from which future efficiencies can be measured. Stakeholders throughout the company should be involved in developing these priorities.

These priorities, once set should be communicated to the entire organization, and well-established priorities and action plans are more successful when securing necessary support from top-level managers.

Step 2: Develop Comprehensive Projects

The cumulative savings and benefits from comprehensive Energy-Water Nexus projects are often significantly higher than those for single measure approaches. Projects should be prioritized using criteria such as cost-effectiveness, payback periods, the amount of energy and water to be saved, environmental impact, visibility and scalability. Beginning with projects that are readily scaled to other facilities can create early positive results and help to encourage acceptance of your plan. Scalable projects result in significant savings in time and money rather than on approaches that are unique to just one facility.

Step 3: Focus on Life Cycle Costs

In looking at Energy-Water Nexus projects, life-cycle costs should be considered when weighing various approaches, including no-action alternatives, for investments in order to understand the full implications of the choices available. Life cycle costs include all costs and savings of acquiring, installing, owning, operating, and disposing of a building, facility, or piece of equipment. This data can be essential when addressing the initial hurdles and sticker shock that can arise when undertaking more significant projects.

Moreover, It is important to quantify the performance of the efficiency measures being considered and collect the resulting savings through sound evaluation, measurement and verification (EM&V) methods. Special attention should be made to calculate baseline measurements and savings correctly to understand the full impact of the project.

In conclusion, businesses in the United States recognize that the use of energy and water in their facilities is interconnected. This awareness is heightened by fact that changes in climate and technology contribute to an evolving landscape that decision makers need in order to reduce risk and increase competitiveness.

By taking an integrated approach, however, CSR and Operations personnel have an opportunity to tackle the challenges of reducing water and energy consumption in their facilities. Businesses can learn from the experiences of others and forge new paths in realizing savings in money, energy and water.

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