GE
Water & Process Technologies

Sustainability Playbook

Reaching Significant Water Savings

www.gewater.com/water-footprint.jsp

Sustainability Playbook –

Reaching Significant Water Savings

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Preface

The term *water footprint* was coined in 2002 by UNESCO-IHE as an indicator of water use that looks at both direct and indirect water use of a consumer or producer. As water is becoming a more scarce resource globally, GE Water & Process Technologies developed a 4-step framework for reducing water footprint, gaining cost efficiencies and realizing brand value:

Step	**Action**	**Deliverable**
1	Baseline water footprint	Using a basic water balance, all water-consuming elements are captured with related direct and indirect costs.
2	Identify efficiency opportunities	Based on the water balance, sources for inefficiencies like leakages, waste and over usage are identified and ranked from highest water conservation potential to lowest.
3	Prepare an optimization plan	Prepare water savings project proposals based on product innovation. A portfolio of solutions is to be evaluated against the water reduction goal. Projects are prioritized based on cost, budget and complexity. Select a metric to measure efficiency.
4	Execute and celebrate	Deliver the water projects and capitalize on the results by reducing environmental risk and enhancing brand power. Report results in Corporate Social Responsibly report. At the end of the process you can revisit projects that were not selected in the first round and restart the process.

The Water Efficiency Process

Due to climate change, reducing the environmental footprint of industrial operations has become more important than ever. It is no longer sufficient to simply attain sufficient profitability while avoiding discharge of toxic wastes. Increasingly, industry must change strategies to become noticeably and substantially "greener," in both the use of raw materials like water, and in the discharge of by-products which in the past were considered benign (such as carbon, heat, odor, sludge, mildly saline water, etc.) Companies are now becoming more efficient in using resources, handling waste, optimizing supply chain operations and producing more environmentally friendly products. As water becomes more of a scarce resource, corporations are developing sustainability policies based on an effective water usage strategies. This document provides a framework for site managers, corporate officers, engineering firms and water saving advocates to develop a water efficiency objective and meet this objective by applying a variety of tools and metrics. What gets measured gets managed. The following four-step process will guide you through the necessary steps in delivering a reduction of water footprint and measuring the associated impact.

Figure 1: The Water Efficiency Process

Step 1 – Baseline Water Footprint

This first step will help you capture a baseline of your current water usage and related cost as a preparation for Step 2 which will assist in identifying sources of risk. Innovative companies perform water assessments on a regular basis to prepare for more stringent regulatory pressure in the future. In some cases customers are demanding suppliers become more environmentally progressive in an effort to reduce their own legal risk or simply to improve brand image. Wal-Mart is a good example of that. Performing water assessments is, in essence, a search for hidden dividends, leading to improvements that include water savings and improved wastewater quality standards.

Water Balance

Various levels of data points related to water operations can be collected. It is important that you don't spend time collecting minor details and focus only on the attributes that are necessary to reduce water footprint. A water balance is a tool that provides a full picture of every water-consuming component on site, and serves as the first step in uncovering hidden opportunities for savings. We propose the water balance format provided below, which is relatively simple to develop.

The water balance template includes six basic categories under which any water consuming entity on-site should be included.

- Inlet water pretreatment
- Cooling towers
- Boilers
- Processing (any water consuming facility which is a part of the production process)
- Wastewater plant (if it exists), or water effluent
- Other (ash ponds in a power plant)

For each unit operation, capture and diagram the water balance: that is, write down all flows of water into and out of the operation, and verify a mass balance of both the water flow and the key chemical constituents within or added to the water. This "mass balance" ensures an accurate understanding of the operation, and that no significant flows are forgotten (see Figures 2 and 3). In many cases, a particular component can be fed from an on-site source as a way to recycle water. If one of the six sources for measuring flow capacities does not exist, its water inflow and outflow will simply be noted as zero. Measured data can be retrieved from the following sources:

1. Flow meters
2. Utility bills
3. An engineering estimate based on previous measurements
4. System specs
5. Assistance from a water expert

Use GE's online water balance calculator to calculate your water efficiency www.gewater.com/water-footprint.jsp

A full list of sources can be found in **Appendix A – Sources for Measuring Flow Capacities**

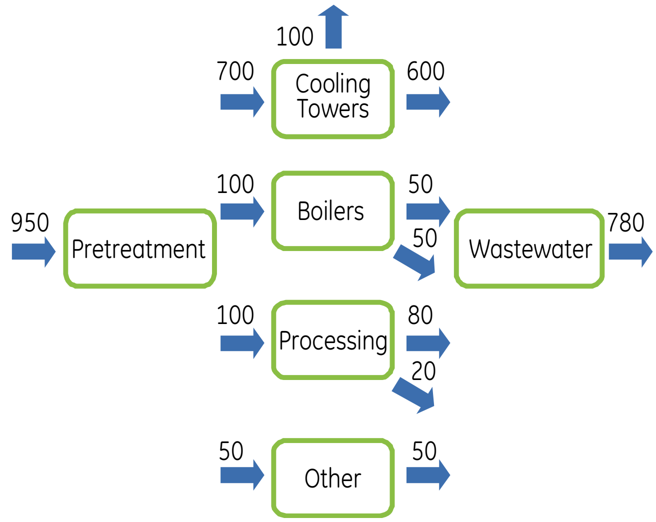


Figure 2: Water Balance Elements

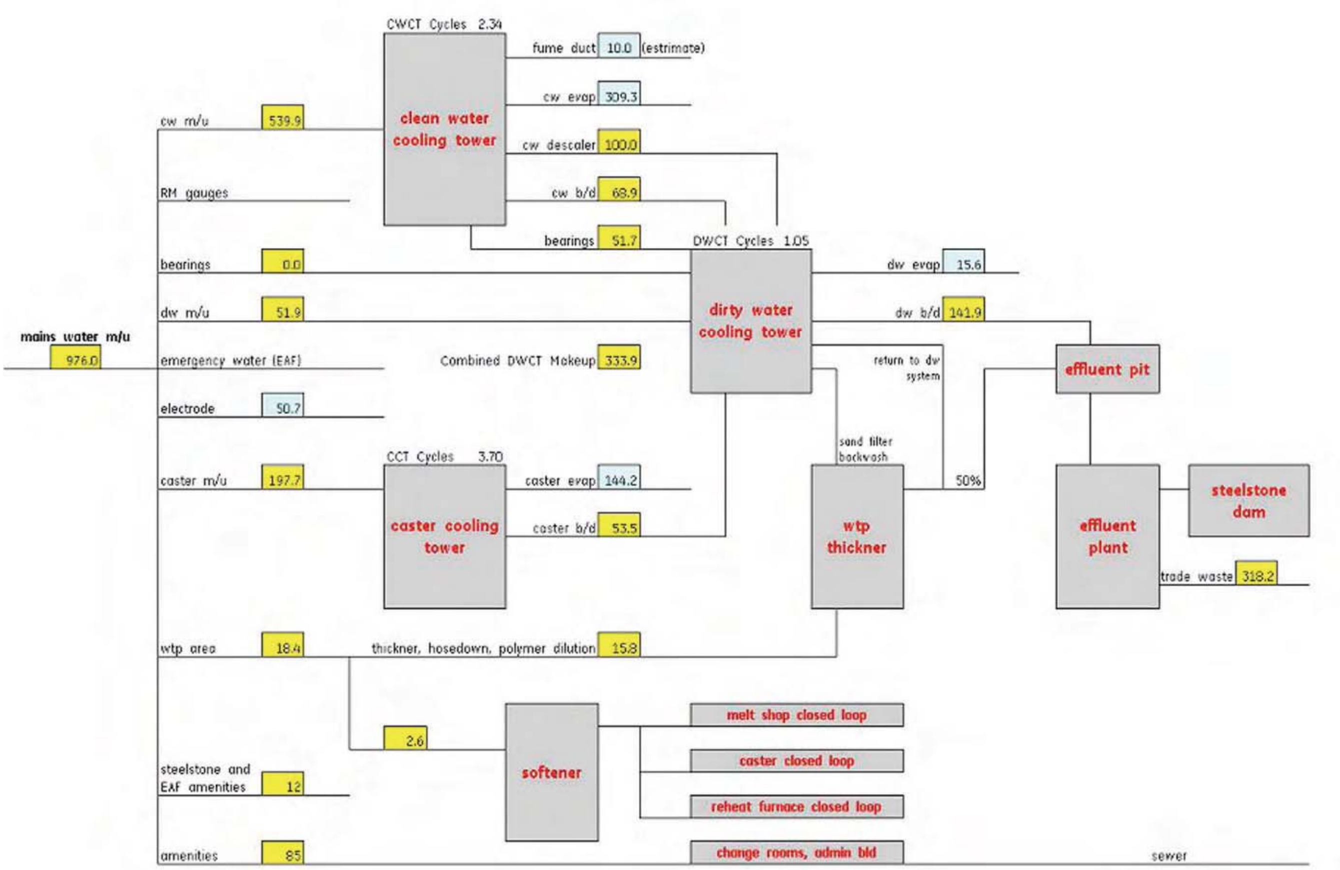


Figure 3: An Example of a Water Balance

Capturing Water Related Costs

In addition to capturing related flow capacities, collecting all related costs will provide an economic base to the opportunities identified in Step 2.

Direct Costs

- Water use – $/volume × volume per period (minute/day/year). Volume units are typically gallons or m^3
- Wastewater discharge fees
- Pretreatment technology
- Energy costs associated with water use, If possible (heating, pumping, water treatment etc.)
- Regulatory costs (permits, compliance assessment, etc.)
- Costs for water management measures (staff time and resources, technology, equipment and materials)

Indirect Costs

- License to operate or grow (marginal cost for capacity expansion)
- Relationships with stakeholders (suppliers, financial institutions, employees, regulators, customers, shareholders, neighbors and local communities)
- Loss or damage of ecosystem/species

Multiplying the cost of water per gallon or cubic meter by the total use of water provides the total cost of water. Many companies measure total water use per unit of production. Toyota for example, tracks average cost of water per vehicle produced.

Activity	Unit Cost ($/1000)	Total Unit Cost ($/1000 gallons)
City water purchase		$1.55
Sewer rate		$1.78
Deionized using reverse osmosis		
Equipment	$0.37	
Energy	$0.97	
Labor	$1.12	
Total deionized water (flexible cost)		$2.46
Wastewater treatment		
Sludge disposal	$3.45	
Treatment chemicals	$2.30	
Energy	$0.22	
Labor	$5.46	
Total wastewater treatment		$11.43
Total cost of water		$17.22

Source: Water Efficiency Manual, North Carolina Department of Environmental and Natural Resources, edited.

Figure 4: An Example of Water Cost Analysis

By the end of this step you will have a detailed water balance, which includes flow capacities and related costs. You can start identifying projects to achieve the following:

- Cut leakages and waste – In the municipal space, in 2007, cities like Beijing, and London suffered from leakages
- Reuse water from internal sources like wastewater and cooling towers blow-down back into the system.

Step 1 Deliverable

A holistic inflow to outflow water balance, including all water consuming components and related costs.

Step 2 – Identify Efficiency Opportunities

The water balance developed in the previous step uncovers opportunities for water efficiencies and to develop a water sustainability policy, or expand an existing one into the water space.

A water savings policy is a crucial part of a company's sustainability policy in eliminating risk factors like leakage, inability to expand production, and compliance concerns. A water savings policy should be reported in the Corporate Social Report (CSR) since it is an effective way to communicate expectations with customers, employees, shareholders and other stakeholders.

Rank Your Water Usage

The following will help you find 10 to 20% inlet water savings. Based on your water balance, rank the various components by water usage and focus on the largest water users. Identify leakages and sources for waste like excess cleaning and washing.

Sources for Water Reuse and Recycling

Source: "At the Crest of a Wave: A Proactive Approach to Corporate Water Strategy" – The Pacific Institute and the Business for Social Responsibility

Cooling Towers – For many facilities, cooling towers represent the single largest opportunity for greater water efficiency. Cooling towers should be investigated to determine how many times water circulates before it is bled off and discharged. Increasing the recycle rate of the tower results in multiple savings, from water and sewer costs to savings on the purchase of chemicals used to treat both incoming and discharged water. Typically, cooling towers consume a significant portion of total water. As a rule of thumb, an increase from 5 to 8 cycles of concentration would reduce makeup volume by 9%. Since you will need to increase chemical treatment, this will likely be close to revenue neutral. Now you need to calculate the effect on total inlet water.

Example: In a 1000 GPM plant, 600 GPM go to cooling towers. An increase from 5.5 cycles of concentration to 8 cycles result in a 9% makeup water savings, which is a 5.4% of total influent volume.

9% x 600 = 54

54/1000 = 5.4%

Equipment Cooling – Replace single-pass cooling systems, where water is circulated once through a piece of equipment and then discharged to a sewer, with a process or cooling loop. This loop provides water at a pre-set temperature to cool equipment. When a process loop is not possible, reusing single loop discharge water for irrigation or other non-potable water requirements is another way to increase water efficiency.

Percent of Makeup Water Saved											
New concentration ratio (CR1)											
New concentration ratio (CR0)	**2**	**2.5**	**3**	**3.5**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1.5	33%	44%	50%	53%	56%	58%	60%	61%	62%	63%	64%
2		17%	25%	30%	33%	38%	40%	42%	43%	44%	45%
2.5			10%	16%	20%	25%	28%	30%	31%	33%	34%
3				7%	11%	17%	20%	22%	24%	25%	26%
3.5					5%	11%	14%	17%	18%	20%	21%
4						6%	10%	13%	14%	16%	17%
5							4%	7%	9%	10%	11%
6								3%	5%	6%	7%

Source: Water Efficiency manual, North Carolina Department of Environmental and Natural Resources

Figure 5: Water Savings Options for Cooling Towers

Equipment Rinsing and Cleaning – There are many efficient rinsing options for facilities. Counter-current rinsing is typically the most water efficient method for rinsing equipment. In this process, the cleanest water is used only for the final or last stages of a rinse operation; water for early rinsing tasks, when the quality of the water is not as important, can be collected from water that is used during later stages in the process. Other forms of efficiency rinsing include batch processing, when several pieces of equipment are cleaned at the same time, using rinses from one process in another. Cleaning process equipment can be a significant part of many food, beverage and pharmaceutical companies' manufacturing costs and in some cases can account for as much as 50 to 70% of a facility's total water use. As such, this presents a tremendous opportunity for water savings.

Alternative Water Sources – Large facilities are good candidates for alternative water sources due to the fact that they typically use large amounts of non-potable water. Companies may be able to update processes to allow for the use of saline and wastewater instead of fresh water. This approach reduces the impact on freshwater resources with subsequent benefits to the local community and the ecosystem. The two most useful "alternative" water sources for facilities are air-conditioning condensate recovery and rainwater harvesting.

- **Condensate recovery:** The condensate from air conditioners, dehumidifiers, and refrigeration units can provide facilities with a steady supply of relatively pure water for many processes. Because condensate water is relatively free of minerals and other solids, it could be used for cooling tower, boiler makeup and reverse osmosis feed water, or for drip-irrigation.
- **Rainwater harvesting:** Rainwater is another excellent source of non-potable water and can be used in many of the applications in which condensate recovery is used. Facilities in the U.S. considering the use of rainwater should check with local or state governments about possible restrictions. Some states allow facilities to detain water for irrigation and other uses that return water back to the system, but do not allow water to be retained permanently on a site.

Additional Savings Sources –

- Use domestic water efficiency techniques
- Ultra low flush toilets, urinal, faucet aerators, low flow showerheads, etc.
- Reduce landscaping irrigation time schedules, repair leaks, install spray nozzles, install and/or replace automatic shut-off nozzles

Engage Your Employees as a Source for Water Savings Ideas

- Survey your employee base by asking them to identify sources of waste. Employee awareness is a great way to uncover savings opportunities and to engage them in an execution program.
- Launch an employee awareness program. Provide them incentives and awards such as the most eco friendly employee award, for being proactive in helping your company save water.
- Communicate with them on weekly basis – progress, regulation and success stories.
- Hold managers accountable for adopting ideas and executing them.

The output of this step is a master list of water saving initiatives. Step 3 will build more rigor into this list with estimated water and pollutant savings as well as associated financial impact.

Metrics

Environmental impact goals can be managed only when they are measurable and quantifiable. Water footprint can be measured using a variety of metrics:

An Absolute Water Savings Volume

Example: Dupont has a water conservation goal of at least 30% by 2015 in sites where renewable freshwater supply is either scarce or stressed. This metric is the simple, intuitive and catchy but has limited consideration of production expansion, as future growth can result in an increased demand for water.

A Variable Metric of Water Used per Common Denominator

The most common denominators are unit production and revenue. Examples include†:

- **Power -** Gallons/KwHr. Certain power generation companies use gallons per British Thermal Unit (BTU) to measure the connection between water usage and energy production.
- **Hydrocarbon processing –** Gallons/barrel of crude oil
- **Beverage –** Gallons/liter of beverage
- **Automotive –** Gallons/vehicle
- **Steel mills** – Gallons/one ton of steel
- **Warehouse areas –** Gallons/ft^2
- Certain companies use water usage per revenue, e.g. Gallons/$1000 sales

†Calculations are normally done on average basis.

Bristol Myers Squib, for example, announced 10 percent reduction in water use, normalized by sales, from a 2001 baseline year and 20 percent reduction from a 2002 baseline year in countries where water resources are severely stressed. Another example is Coca-Cola, which in 2007 announced that it takes 2.54 liters of water to produce 1 liter of soft drink.

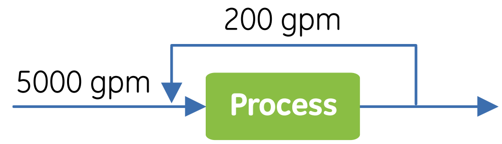
Reuse Efficiency

In his article "Reuse Efficiency – A New Way for Defining Water Reuse" James P Welch of GE coins the term "Reuse efficiency", which, signifies the quantity of water used when it is recycled in a system. Stated in mathematical terms, "Reuse Efficiency" is the amount of water reused or recycled divided by the system requirement. Reuse Efficiency is 0%, if a system reuses no water and 100%, if the system reuses all of its water and no makeup is required. The Reuse Efficiency calculation can be used to evaluate single systems like a cooling tower or applied more broadly to evaluate a manufacturing facility that includes cooling towers, steam generating systems and wastewater recycle. Reuse Efficiency can also be applied to municipal districts, cities and states to evaluate strategic alternatives.

Reuse Efficiency = Reuse/(Makeup + Reuse) × 100

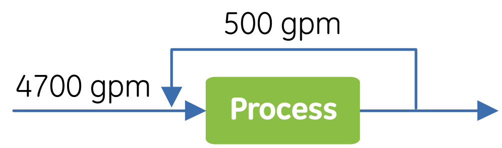
Example: We have a manufacturing facility that takes 5000-gpm makeup and reuses 200 gpm from the waste treatment plant.

The "Reuse Efficiency" = (200 gpm / (5000 gpm + 200 gpm)) ×100 = or 3.8%.



The same plant implements applications to increase cycles of concentration in the boiler and cooling systems. The makeup water is reduced by 300 gpm and the recycle is increased by 300 gpm.

The "Reuse Efficiency" = (500 gpm / (4700 gpm + 500 gpm))×100, or 9.6%.

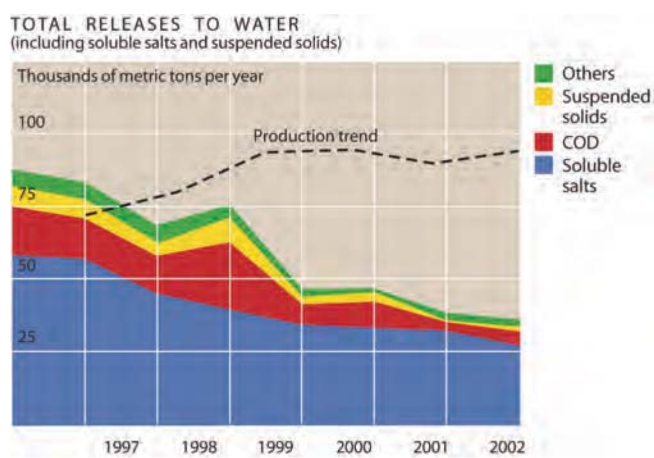


The concept of "Reuse Efficiency" defines the performance of a system for that point in time, offering to identify and prioritize reuse opportunities to optimize utilization of water resources.

Total Metric Tons of Wastewater Loadings

Regarding wastewater quality, most companies use their Corporate Sustainability Report to disclose volume of loadings in the following categories: COD, BOD, TSS and metals.

For example, Dupont Europe released a report that tracks its releases to water on an annual basis.



Source: DuPont Magazine 2/2003

Step 2 Deliverable

A list of opportunities for water conservation ranked by water usage with efficiency metric selected.

Step 3 – Prepare an Optimization Plan

This step outlines all key factors that need to be addressed in order to deliver a successful execution: solution technologies, budget approval, a timeline for implementation, a key stakeholders analysis and an employee communication plan.

A. **Identify process and product innovations** and estimate the total effect on water savings to establish a goal. Key factors to be included in this step are:

- Regulatory constrains and local water supply issues
- Corporate mandate
- Risk – Does the goal allow room for production expansion? Are there any environmental risks?

An extensive optimization plan includes a list of water savings and wastewater quality related projects. Each project should include the following factors:

- A generic description
- The internal process being fed
- Technology to be employed
- An estimate of the water volume savings
- Capital and operating costs
- A timeline for implementation
- An estimate for the level of difficulty in execution

The **"Water Footprint Reduction Technology Solutions"** described in Appendix B is a list of solutions that help create water savings. The solutions are sorted by level of implementation difficulty and timelines for implementation. They start with the most immediate and easy to implement, progress to projects that require additional infrastructure, and finally move on to longer term schedules. Any project selected for execution should start with a future state water balance, which will disclose an estimate of the new flow capacities and related cost efficiencies.

B. **Establish a budget** and procure funding. Outside funding and grants can be available.

C. **Develop a timeline** for implementation and schedule periodic reviews with the water efficiency team to monitor progress.

D. **Develop an internal communications plan** to continue engaging employees and creating awareness.

E. **Include all related stakeholders**, internal and external, to develop support in delivering water projects. A useful tool can be a stakeholder analysis (see Figure 7), which will develop a detailed sense of who the key stakeholders are, how they currently feel about the change initiative, and the level of support they need to exhibit for the change initiative to have a good chance of success. Based on your analysis, an action plan can be devised to align support and mitigate sources of resistance.

Stakeholder Analysis for Change

	Support Level					
Key Stakeholders	SA -2	MA -1	N 0	MS 1	SD 2	Supporting Observations

Figure 7: Stakeholder Analysis Framework

At the end of this step, everything should be ready to execute. The projects should be scoped and approved, employees informed and a water solutions supplier identified.

Support Levels

Support Levels are the team's assessment of each stakeholder's support of the proposed change, as demonstrated by his or her words and actions. They are "perceptions" and need to be validated through dialog with the stakeholders.

SA = Strongly Against – Clear actions and words that contradict the change.

MA = Moderately Against – Holding back resources and support

N = Neutral – Neither supportive nor opposed to the change, "Wait and See"

MS = Moderately Supportive – Sharing resources as required

SS = Strongly Supportive – Fully engaged and enlisting others

Prioritizing Projects

James P. Welch also offered the following graph to depict the costs/recycle relationships relative to competing projects. The diamonds represent individual projects with the associated costs and recycle potential. It may also be helpful to include "iso-cost" lines to relate projects in a given cost category versus the anticipated water savings. For instance, wastewater treatment costs may be $2/1000 gallons. All projects below this "iso-cost" line should be considered as potential "Greenwater" projects. The black line in the graph represents cycles of concentration. The curvilinear shape illustrates the relationships of diminishing returns with increased cycles-of-concentration. With each increase in cycles-of-concentration, the incremental amount of available water is reduced with a corresponding increase to treatment costs and system risk.

Once the graph is established, projects are prioritized radially by starting at the origin and the horizontal axis. Moving from the horizontal axis to the vertical axis identifies projects in a relative priority. In this way, clients can visually compare projects in relative terms and make decisions to address site objectives.

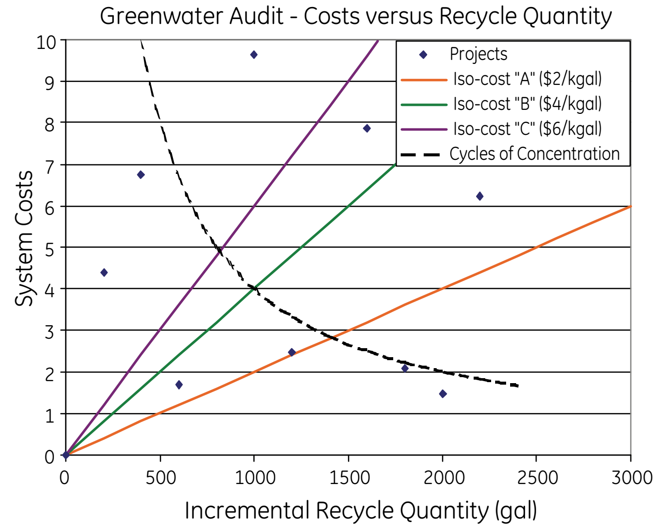


Figure 7: Stakeholder Analysis Framework

A second application of the graph might be to view water alternatives in a macro environment. Given the scenario of produced water that falls under Oil and Gas jurisdiction and viewed as a by-product from hydrocarbon production, produced water needs to be disposed of in a specific way and may not be discharge to the surface or public waterway. Framers and ranchers in need of water, pay escalated prices to secure water rights. Given the condition that produced water is less expensive to treat to an agricultural standard than the alternative, purchased water rights, farmers and ranchers are in affect paying a tariff for their water supply when treated produced water might offer a viable solution. Tools such as this can be used to visualize and optimize water alternatives.

Step 3 Deliverable

An operational plan for water conservation, which includes a list of funded projects, metrics and projects, teams with executive sponsors.

Step 4 – Execute and Celebrate

Reducing your water footprint not only improves your operating performance and compliance, but it also creates value for your customers and shareholders. This step focuses on measuring your return on environment and recognizing value.

Operating Performance		Environmental Performance
• Reduced consumption • Improved availability • Economical maintenance • Improved throughput	+	• Reduced waste • Make use of brackish water • Enhanced public image

Realizing Value

Reducing water footprint has several layers of value recognition. When monitoring a water project's progress, it is recommended to capture the achieved value in all categories:

Economic

Green is green. In order to execute a water related project, the economic value has to outweigh the cost of project. Using Steps 1-3 of the water efficiency process will allow you to compare the existing cost structure to a future state.

Risk Reduction

Experts at the institute of Risk Management in the UK define four broad categories for risk:

- **Financial –** Savings created from water projects and production expansion
- **Strategic –** Getting ahead of the competition by creating a more progressive sustainability policy and reporting it in the annual CSR report.
- **Operational –** Optimized supply chain with high efficiency
- **Hazard –** Prevention of safety and compliance issues

Environmental

Every gallon of water saved has a macro effect on the environment by being used for other purposes like residential water supply or agriculture irrigation. For example: Lake Lanier in Georgia was recorded on 11/29/2007 to have an inflow of 248.8MM GPD, outflow of 827.2 MM GPD with a deficit of (578.4MM) GPD. Every gallon saved translates into a reduction in the deficit and bringing the lake above its red line.

Creating a Competitive Advantage

Social responsibility enhances a company's image. Going beyond compliance and getting ahead of regulation can reduce time and money. Recognition comes in various forms. GE rewards its customers with an ecomagination Award given to its customers for delivering positive economic and ecologic impacts.

Step 4 Deliverable

A marketing communications plan that promotes achievements and realizes brand value from operational savings.

Summary

In conclusion, the four-step process is a structured framework to setting water footprint goals, executing initiatives, monitoring progress and celebrating success. The theme that connects all four steps is the ability to measure the water footprint using metrics. In their book "Green to Gold: How Smart Companies Use Environmental Strategy to Innovate, Create Value, and Build Competitive Advantage", Dan Esty and Andrew Winston state the following:

"Environmental metrics show a company where it stands. Data and indicators are critical to fact-based decision-making and sound environmental management. They drive continuous improvement and allow managers to mark progress against pollution control and resource productivity goals."

Appendix A: Sources for Measuring Flow Capacities

Category	Source
Total water inflow	• Municipal water meter and utility bill • Internal water sources flow meters
Pretreatment	• Filters backwash flow x frequency • Water used for floor washing
Cooling towers	• Makeup flow meter • Other waste streams that go into tower (boiler blowdown, RO reject, filter backwash, sample sink drains, once-through coolers • Blowdown flow meter. If a meter is not installed, calculate by using the following formula: Makeup flow/(cycles of concentration – 1)
Boilers	• Feed water flow meter • Makeup flow meter = dematerialized output, unless demineralizer water used elsewhere, feed water flow = makeup + condensate • Blowdown – Steam flow meters or calculate using the following formula: Steam rate /(cycles – 1)
Processing	• Since processes usually pay utilities bills for water, an inlet flow meter should be installed
Wastewater	• Sum up all waste streams from all applications above • Initial flow into first holding tank

Appendix B: Solutions for Reducing Water Footprint

Cooling Tower Cycles of Concentration

Description – Increase cooling tower optimization by increasing the cycles of concentration and reducing blowdown stream flow capacities by applying chemicals programs.

Process Being Fed – Cooling towers makeup water

Technologies Employed –

- Chemistry
  - Fifth generation polymer
  - On-line polymer monitor
  - Silica deposit control product
  - Third generation biofilm removal agent
- Feed and Control – On-line polymer monitor for fifth generation polymer
- Monitoring

Estimated Volume Saving – 0 to 40% of total inlet water

Timelines for Implementation – Immediate (<2 months). A wastewater discharge permit change may be required as a result of an increase in material concentration, which may influence implementation scheduling. Additionally, Total Dissolved Solids limits may also influence timelines.

Level of Difficulty in Execution – Very easy, quick fix

Mobile Water Demineralizer

Description – Replace the onsite demineralizer with mobile trailer demineralizer water, improving quality of boiler feedwater, increasing cycles of concentration and reducing blowdown flow.

Process Being Fed – Boiler feedwater

Technologies Employed – Mobile trailer to improve maintenance costs and reduce washing water usage

Estimated Volume Saving – 0 to 8% of boiler makeup

Timelines for Implementation – Immediate (<2 months). A wastewater discharge permit change may be required as a result of an increase in material concentration, which may influence implementation scheduling. Additionally, Total Dissolved Solids limits may also influence timelines.

Level of Difficulty in Execution – Very easy, the quickest fix

Industrial Water Reuse

Description – Use any water-consuming component on site as a potential source of water for another component.

The most common internal water sources are:

- Cooling tower blowdown water
- Boiler blowdown water
- RO reject streams
- Wastewater plant
- Process unit wastewater

Power Industry

- Ash pond discharge
- Scrubber blowdown
- Coal pile runoff

Food Industry

- Lost condensate recovery – reuse (dairy and food plants)
- Meat/poultry wash water reuse

Process Being Fed – Mostly cooling towers but the source can be routed to any water consuming component. Cooling tower blowdown can be diverted to scrubbers.

Technologies Employed –

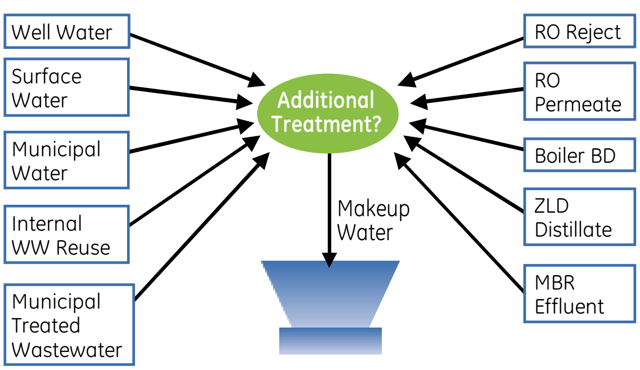
- Biological treatment to reduce TSS, BOD, COD, organic content and other loads of contamination
- Membranes - Reverse osmosis, membrane bio reactors, ZeeWeed* UF membranes for industrial water reuse
- Brine concentrator and evaporator for a zero liquid discharge
- For food processors, Entrapped Air Floatation and reverse osmosis/UF membrane for wastewater reuse, as well boiler cycles optimization using pretreatment before going into reverse osmosis

Estimated Volume Saving – 0 to 10% of total inlet water

Timelines for Implementation – Immediate (<2 months) if infrastructure exists, 2 to 6 months otherwise. A wastewater discharge permit change may be required as a result of an increase in material concentration, which may influence implementation scheduling. Additionally, Total Dissolved Solids limits may also influence timelines.

The food processing specific solutions above are longer term projects, one year on average.

Level of Difficulty in Execution – Easy – moderate



Cooling towers can use many sources of lower quality water with proper pretreatment design and chemical treatment

Figure 8: Cooling Tower Makeup Water Reuse Sources

Municipal Wastewater Reuse

Description – The concept behind this solution is using an alternative external source of water, municipal wastewater, to be reused, solving wastewater BOD issues. The cost of water will usually be lower using this solution. This kind of project will usually require high capital costs and long term time lines which will generate high water savings.

Process Being Fed - Facility inlet water

Technology Employed – Wastewater treatment solutions, pumping and infrastructure

Estimated Volume Saving – 0 to 100% of total inlet water

Timelines for Implementation – 2 years

Level of Difficulty in Execution – Difficult. This project will require government interaction, permits and infrastructure laying work.

External Industrial Wastewater Reuse

Description – The alternative external source used in this case is industrial wastewater from another plant. The benefit of choosing this option is the low cost of water and diminished dependency on municipal sources. However, this solution does creates a dependency on production and wastewater quality of the source plant.

Process Being Fed - Facility inlet water

Technology Employed – Wastewater treatment solutions, pumping and infrastructure.

Estimated Volume Saving – 0 to 100% of total inlet water

Timelines for Implementation – 2 years

Level of Difficulty in Execution – Difficult. This project will require government interaction, permits and infrastructure laying work.

Additional Solutions that Can Be Utilized

- Many facilities use once-through water to cool small heat-generating equipment. Once-through cooling is a very wasteful practice because water is used only a single time before being sewered. Typical equipment that uses once-through cooling includes: vacuum pumps, air compressors, condensers, hydraulic equipment, rectifiers, degreasers, X-ray processors, welders, and sometimes even air conditioners. Options for eliminating once-through cooling are typically very cost effective and are normally focused on reuse.
- Any water used for landscape design and irrigation is always a good source for savings.
- Installing cartridge filters on waste lines, contaminated only with TSS and reusing the stream.
- Identify a low TDS stream going to waste, then install a poly tank and pump with level control to direct flow to the cooling tower.
- Take a portion of plant effluent and add standard UF and RO membranes to reduce TDS, put treated effluent into a poly tank and pump ahead of ion exchange system. You can recover 65 to 70% of plant effluent as product water.
- Reduce wasted condensate. Remember, each gallon of condensate saved represents a reduction in water intake of 1.25 gpm and a reduction in waste plant loading, as well as heat savings.
- Look for application of multi media filter Electro Dialysis Reversal (EDR) technology. Remember, EDR can get 90% recovery of inlet flow, 95+% removal of ions, but does not remove any silica.
- Is there a plan to collect rainwater, filter it, and use it as tower makeup?
- Is desalination of brackish water an option?
- A mobile exchange trailer can be a good option for putting an RO ahead of a 2-bed demineralizer, which will reduce demineralizer waste from 20 to 24% to 2% and the RO reject can be added to the cooling tower.

Appendix C: Products of ecomagination℠

ABMet*

The ABMet system has been proven effective for the removal of metals, metalloids, nonmetals and inorganic compounds such as nitrate. ABMet systems can treat both arsenate and arsenite without pre-treatment. Selenate and selenite complexes can be successfully removed. ABMet systems are configured for site specific waste streams and contaminant groups and have been used to successfully treat water for mining, refining, chemical, power generation (for FGD selenium removal), agriculture and other industries. ABMet systems can stand alone or work in tandem with existing water treatment systems already removing organics or treating acidic streams. 99+% Removal of: Selenium, Arsenic, Mercury, Chromium, Cadmium, Copper, Zinc, Cobalt, Nickel, Antimony and Nitrate.

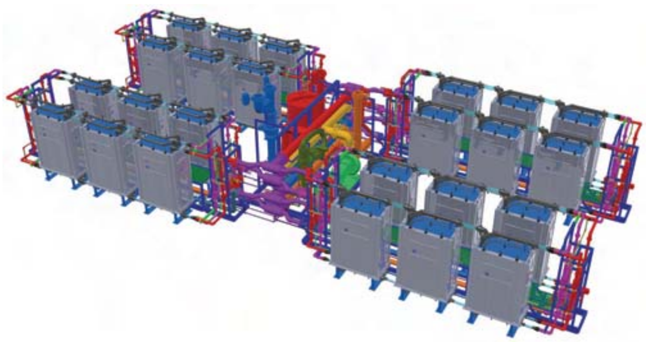
Improve Operational Performance

ABMet systems reduce the concentration of selenium in coal-fired power plant flue gas desulfurization blow-down by up to 1000-fold versus untreated water. ABMet systems are simpler and more cost-effective than other technologies: compared to nanofiltration systems, a typical ABMet system requires 79% less energy to operate, saving more than $24,000 in electricity costs per year or enough energy to power 21 U.S. homes; compared to ferrous-iron systems, a typical ABMet system requires far less chemical addition, saving more than 77% or approximately more than $225,000 in chemical costs per year; and finally, compared to wetlands treatment systems, an ABMet system uses 90% less land area and reduces the amount of water-borne selenium discharged into the environment.

Improve Environmental Performance

Water treated by ABMet systems contain even less selenium than allowed under some of the worlds toughest drinking water standards, being the first commercially viable stand-alone technology that can consistently reduce selenium concentrations in water to below 10 parts per billion.

Electro Dialysis Reversal (EDR)



Electrodialysis Reversal (EDR) is an electrochemical separation process that removes ions and other charged species from water and other fluids. EDR uses small quantities of electricity to transport these species through membranes composed of ion exchange material to create a separate purified and concentrated stream. Ions are transferred through the membranes by means of direct current (DC) voltage and are removed from the feed water as the current drives the ions through the membranes to desalinate the process stream.

GE EDR technology is very water efficient, with designs up to 94% water recovery, reducing the burden on water sources, and minimizing the volume of waste that requires disposal. GE EDR systems have an automatic Polarity Reversal self-cleaning feature that reduces the fouling tendencies of the water by reversing the polarity of the electrodes every 15 to 20 minutes. This change in polarity causes scale and organics to disassociate from the membranes.

The GE EDR product line has a wide flow capacity with the ability to treat anywhere from 4,000 GPD up to 1.6 million GPD per unit (15 m^3/day to 6,060 m^3/day per unit). Electrodialysis reversal systems are able to reduce dissolved ions in process streams of up to 12,000 ppm total dissolved solids (TDS) from 50% to up 94% removal. By using multiple stages (stacks in series), systems are optimized to handle a wide range of treatment needs.

Improve Operational Performance

EDR employs an electrolytic process that removes ionic species from water. It produces potable water from brackish sources, thus providing fresh water in areas where it is scarce. In a typical water treatment facility producing 3.8 million gallons per day at 83% efficiency, using EDR instead of competing technologies eliminates the need for over 28,000 pounds of chemicals and saves over $100,000 dollars per year.

Improve Environmental Performance

EDR is an ideal desalination technology to treat municipal drinking and wastewaters as it can treat water with free chlorine residual. Its high recovery rates maximize fresh water creation while minimizing wastewater disposal. EDR can operate from 85 to 94% efficiency depending on feed water quality.

PRO* & Titan* Reverse Osmosis Systems

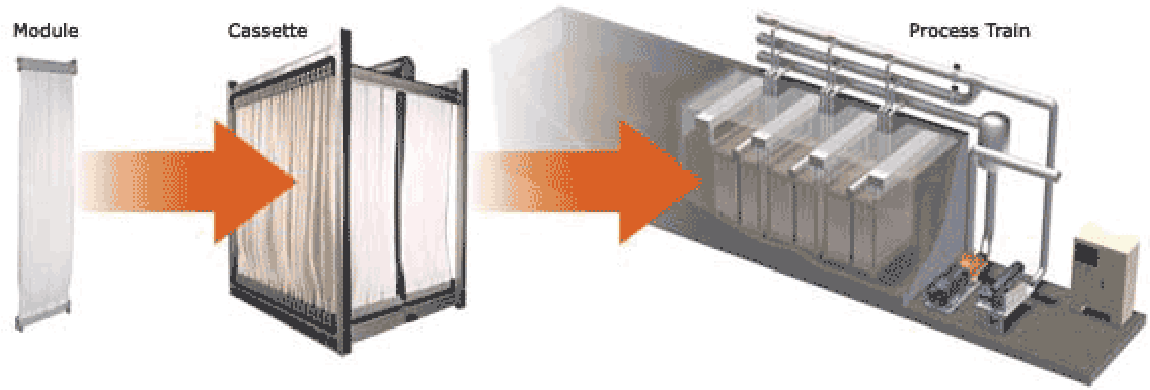
Improve Operational Performance

PRO and Titan Reverse Osmosis Systems for boiler feed water are designed to improve boiler efficiency when installed ahead of water softeners on low-pressure coal fired or natural gas fired boilers without heat recovery, or when installed ahead of a demineralizer on high-pressure boilers. When installed on a typical low-pressure coal fired boiler with a steam production rate of 675,000 lbs per hour, these systems are designed to save over 10,000 tons of coal per year or over $557,000 annually, as well as reduce over 21,000 metric tons of CO_2 per year.

Improve Environmental Performance

When installed on a typical low-pressure natural gas fired boiler the systems are designed to save 210 million cubic feet of natural gas per year, or a saving of over $1.5 million. In addition, PRO and Titan's designs allow savings of over 62% of water treatment chemicals and softener salt when installed ahead of softeners, a savings of over $402,000 annually. When installed ahead of a demin, it achieves savings of over 90% of acid and caustic chemicals, saving the customer more than half a million dollars.

ZeeWeed* 500 & ZeeWeed 1000



A full-scale ZeeWeed treatment facility is comprised of a given number of modular components: modules, cassettes, and trains. A module is the basic building block and the heart of a ZeeWeed system. Each module contains thousands of horizontally strung membrane fibers that have millions of microscopic pores in each strand. Water is filtered by applying a slight vacuum to the end of each fiber which draws the water through the tiny pores and into the fibers themselves. The pores form a physical barrier that allows clean water to pass through while blocking unwanted material such as suspended solids, bacteria, pathogens and certain viruses. Multiple cassettes are joined to form what is known as a process train. The train is a production unit containing a number of cassettes immersed in a membrane tank. Multiple process trains form a ZeeWeed treatment plant. ZeeWeed membrane systems can remove particles that are larger than the pores on the membrane fiber. Contaminants that exist in dissolved form, or are smaller than the pore size, can also be removed by the membranes if they are first transformed into insoluble species or larger particles. Treatment processes commonly coupled to ZeeWeed to accomplish such conversions include enhanced coagulation and oxidation.

Improve Operational Performance

ZeeWeed Membrane Bioreactors (MBR) incorporate the most advanced process aeration controls, which reduce energy consumption by over 50% compared to competing products. ZeeWeed offers up to an 11% reduction in capital & operating costs when used as a pretreatment to reverse osmosis for seawater desalination, brackish water treatment or industrial process water.

Improve Environmental Performance

ZeeWeed produces a drinking water quality that meets stringent EPA standards while using up to 60% less chemicals, 30% less land, and producing 35% less residual waste than conventional potable water treatment systems; and its membrane bioreactors produce a high quality effluent that meets or exceeds the world's toughest discharge and reuse standards. ZeeWeed MBR can earn up to 6 points for LEED certified green buildings by recycling up to 100% of the gray and black water within the development. ZeeWeed systems have the capacity to reuse over 200 million gallons per day of wastewater.

Desalination

Customers in water-scarce regions find that the Seawater Reverse Osmosis (SWRO) Series & EDR from GE Water & Process Technologies solves their need for desalination while optimizing operating costs. EDR and RO systems are available in fixed land-based and mobile designs. GE designs and builds the systems and in many cases also operates them under full-service build-own operate contracts.

Improve Operational Performance

GE is one of the largest suppliers of desalination plants in a world in which over 1 billion people now lack access to clean water and about two-thirds of the world's population will live in water-stressed areas by 2025. GE's installed seawater desalination platforms produces more than 500 million gallons a day of water; that's equal to the daily water required for a variety of uses by more than 10 million people. GE is a leader in membrane-based desalination technology, which is among the most energy-efficient technologies for transforming salty water.

Improve Environmental Performance

GE built and will operate El Hamma in Algeria, which is one of the world's largest seawater RO water desalination facilities and which will produce over 52 million gallons per day of potable water. Seawater RO desalination plants require substantially less energy than do thermal seawater desalination processes such as multi-stage flash (MSF), making them substantially more cost-effective. If all existing MSF desalination plants were switched to energy-efficient reverse osmosis, the reduced greenhouse gas emissions annually would be equal to taking almost half of all autos on US roads (> 66 million cars) off the road for a year. GE's ultrafiltration pretreatment to SWRO desalination plants can require up to 50 percent less land area than competing seawater desalination pretreatment technologies, making them easier to site.

Advanced Membranes

It's like finding a new source of affordable water for your processes: reclaiming water from condensate, rinsing operations, and low-solid effluents. The innovative combination of membrane, chemical and physical purification methods from GE Water & Process Technologies can extract the hidden value from your process and waste streams - generating savings while helping the environment.

Our unique technologies can help you economically recycle water and even achieve zero liquid discharge. Offerings include: Advanced membrane systems, Chemical treatments, Fixed-media devices, Evaporators and crystallizers and Enhanced Air Flotation (EAF).

Improve Operational Performance

GE is one of the world's largest manufacturers of integrated membrane-based water treatment systems for industry and is a global leader in the use of membrane filtration for waste prevention. GE's membranes are used in a wide range of applications, including purifying water for soft drinks, water reuse, and removing heavy metals from wastewater.

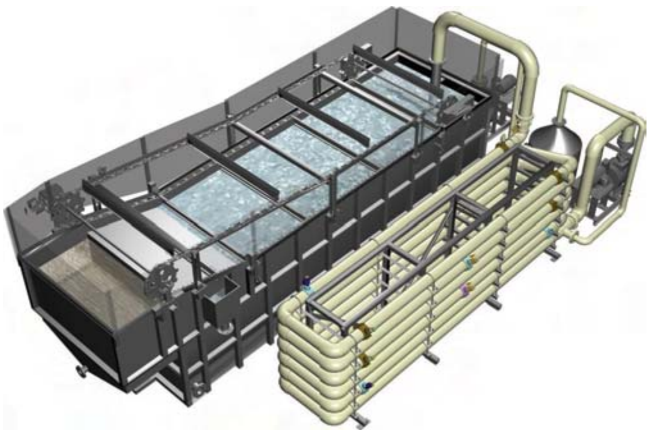
GE is a world leader in Reverse Osmosis, Nanofiltration and Ultrafiltration technologies, with membranes that can operate at high temperatures and throughout wide pH ranges.

Improve Environmental Performance

GE membrane systems enable mining companies to recover as much as 80 percent of the valuable minerals and metals in their waste streams, while treating nearly 250 million gallons of mining wastewater annually and reducing the impact on rivers, streams, and groundwater. GE membranes enable textile manufacturers to recover much of the water used to dye their fabrics, allowing them to reuse as much as 1.2 billion gallons a year.

The use of GE process membranes by GE's major customers has eliminated the disposal of industrial wastewater by more than 21 billion gallons per year, reducing the burden on treatment plants and conserving clean water for domestic and agricultural needs.

Entrapped Air Flotation (EAF)



Improve Operational Performance

GE's Entrapped Air Flotation (EAF) system treats industrial wastewater streams by removing biological oxygen demand (BOD), chemical oxygen demand (COD), and total suspended solids (TSS) using significantly less ferric sulfate than dissolved air flotation technology using similar treatment chemistries. EAF requires less powerful compressors and pumps than dissolved air flotation technology, reducing the energy required to treat wastewater. A typical EAF system treating a wastewater stream of 52 million gallons of water per year uses 60% less electricity than an equivalent dissolved air flotation system, saving $4600 in electricity costs per year at 2007 average U.S. prices.

Improve Environmental Performance

Compared to dissolved air flotation technology, GE's EAF system generates sludge that is higher in solids content, reducing the amount of sludge requiring disposal. At one food processing plant, replacing the dissolved air flotation system with GE's EAF increased sludge solids content up to 15% compared to a dissolved air flotation system. This reduced the amount of sludge production by 20 million pounds per year. Improving the quality of the sludge allowed it to be rendered for beneficial reuse instead of land applied and reduced the need to haul sludge by 180,000 truck-miles per year. This helped eliminate over 368 metric tons of CO_2 emissions, or as much CO_2 as is absorbed by 100 acres of Southeastern U.S. forest land.

DusTreat* Road Dust Control

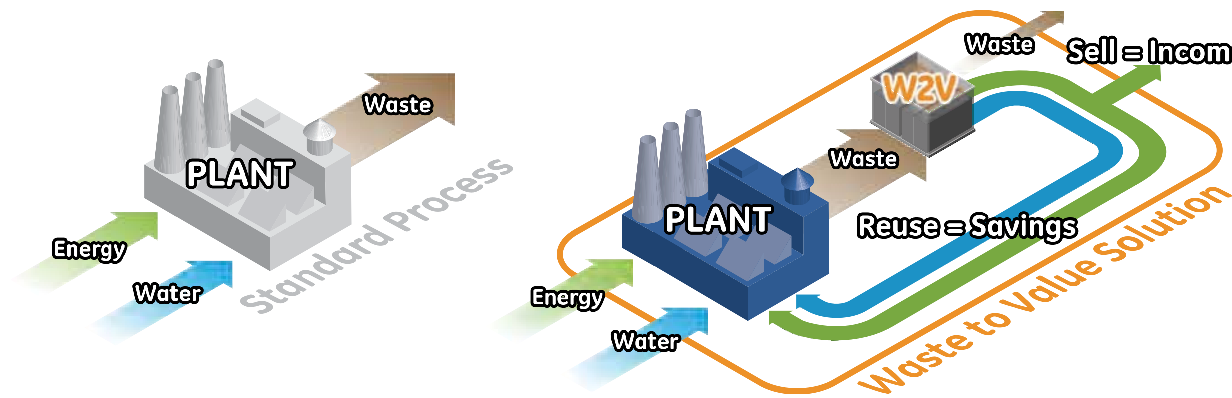
Improve Operational Performance

GE's DusTreat Road Dust Control Treatment programs can reduce the operational cost of watering for dust suppression at mines. At one large gold mine in Nevada, switching to DusTreat programs from a magnesium chloride treatment on 7 miles of haul roads reduced water use for dust suppression by 99% and reduced water truck operating costs by $378,000 per year.

Improve Environmental Performance

GE's DusTreat Road Dust Control Programs can reduce the need to operate water trucks for dust suppression at mines, saving fuel and avoiding greenhouse gas emissions. At the same Nevada gold mine, switching to DusTreat Program saved 48,000 gallons of diesel fuel per year by reducing the need to operate water trucks, avoiding the emission of 491 metric tons of CO_2 per year, or the equivalent of taking 89 passenger vehicles off U.S. roads for a year.

Waste to Value



Improve Operational Performance

GE's Waste-to-Value solution allows customers to produce their own electricity and thermal energy from wastewater, as well as save on disposal costs by eliminating wastewater stream. At a brewery in the UK that produces 630,000 gallons of wastewater per day, GE's Waste-to-Value solution is designed to generate over 3.6 million kWh of electricity and over 19,000 MMBTU of heat from wastewater per year, projected to save over $586,000 in electric and natural gas costs annually, and save over $1.1 million in waste disposal fees per year, based on 2007 prices.

Improve Environmental Performance

GE's Waste-to-Value solution reuses water and reduces greenhouse gas emissions through the destruction of methane and the production of renewable energy. This allows the same UK brewery to reduce GHG emissions by 5,768 tons of CO_2 per year, or the equivalent of taking more than 2,500 cars off U.K. roads for a year. In addition, 99% of the wastewater is reused, saving over 220 million gallons of water per year, or enough to fill 333 Olympic-size swimming pools.

Appendix D: Case Studies

- Cambra Foods, Ltd.
- CIA Nitro Química Brasileira
- Dupont
- Gypsum Plant
- Repsol YPF
- ST CMS Electric Company
- Unilever

Canola Processor Uses RO System to Save 965,000 Gallons (3,900 m^3) of Water

Challenge

Canbra Foods Ltd. is one of the largest and oldest Canadian-based canola oil producers. As Canbra's manufacturing process demands the use of a large amount of steam, the plant requires a large amount of city makeup water.

In order to maintain the purity of the incoming water, the company used a basic softening system with the use of sodium zeolite softeners. The softening system, however, was not nearly as efficient as Canbra would have liked. There were other problems as well. The amount of water required by the system was excessive. What's more, it also used a tremendous volume of salt; which not only created a huge expense but also had a significant impact on the environment. And finally, fuel consumption in the boiler house was a concern to Canbra, since the burning fuel is a contributor of greenhouse gases to the atmosphere. Consequently, while the softener system was somewhat useful, Canbra was convinced that a different system would be more effective and decided to look for alternatives.

The question was, which alternative would be best? Canbra could have obtained a fairly high quality of water using weak acid cation system but in the end those systems would have cost twice as much as the original softening method. In addition, it would have required the company to bring sulfuric acid on site. It would have also required the construction of degasifying towers, a significant expense and an engineering challenge.

Canbra needed to have ultrapure water because without it, they would experience corrosion problems in their return systems. In the end, this would not only harm the system but would negatively impact the overall manufacturing process.

Solution

Canbra had initially formulated a plan to proceed with a weak acid cation system. However, after conducting some in-depth research, Canbra personnel determined that reverse osmosis (RO) might be a potential solution.

Subsequently, GE Water & Process Technologies provided Canbra with a Reverse Osmosis system. The system is used to supply high purity makeup water to the boilers.

Results

From June 2004, when the system was first installed, until June 2005, Canbra will have saved 965,000 gallons (3,900 m^3) of water. Part of this water savings is due to the decreased demand for softener regeneration, a process that uses 3,500 gallons (13 m^3) of water each time. In addition, through using only a ton of salt every day and half, about 230 tons of salt were saved. Finally, the RO system has helped the company reduce fuel consumption in the boiler house by 15%, which avoids the emission of over 3,000 tons of greenhouse gases in the atmosphere every year.

Canbra has achieved significant cost savings by reducing the amount of water treatment chemicals added to the boiler for water treatment by 80%.

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RO technology from GE helps Cia Nitro Química reduce natural gas consumption, greenhouse gas emissions, in addition to water consumption and the generation wastewater

Challenge

With 19 million inhabitants, the metropolitan region of São Paulo, in Brazil, is one of the five most populous cities in the world. Since 1980, its population has more than doubled, also turning it into the largest industrial center in Brazil. Although this rapid growth has increased economic development, it has also considerably increased air and water pollution, especially in the city's two main rivers, the Tietê and the Pinheiros.

To conserve water and reduce waste, and other environmental pollutants, many local factories are installing systems with less environmental impact.

Cia Nitro Química Brasileira is one such example, having reduced natural gas consumption by 45% and consequently, reducing gas emissions and the discharge of effluents from the boilers by 90%. As one of the leading chemical industries, the plant produces 328,000 tons/year of nitrocellulose, fluorhydric acid, aluminum fluoride and sulphuric acid utilized in a wide variety of sectors, including manufacture of varnishes and lacquers, aluminum, herbicides, fertilizers, as well as chemical, steel, petroleum, alcohol fuel, paper and cellulose industries.

The plant's production process demands a significant volume of high purity demineralized water, to generate steam. In order to reduce water consumption and reduce emission of effluents, the plant opted for the installation of a system of demineralization through the reverse osmosis technology of GE Water & Process Technologies.

The factory workers noticed that the water softening process that was being utilized did not produce water of sufficient quality to refill the boilers. The formation of scale and incrustations considerably reduced the thermal exchange and consequently, the efficiency of the boilers, significantly elevating the consumption of energy. The cost of maintenance was very significant and compromised the availability and reliability of our systems. In order to minimize these problems, regular emptying and bleeding off of discharge water in the boilers was necessary, which caused an increase in the consumption of water and effluents, greater consumption of fuel, chemical products, etc. The problem was aggravated with the installation of the compact boiler, with a greater vaporization charge.

Solution

These operational difficulties, together with the company's desire to reduce natural gas and water consumption, led the plant to opt for improvement of its steam generation system with the installation of a system of reverse osmosis (RO) from GE.

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"We chose the RO system from GE because of the company's excellent reputation, competitive financial proposal, and a guarantee that it would meet our strict performance standards", affirmed Rosan Coutinho, energy department manager, who is responsible for the distribution of utilities and plant production of sulphuric acid.

RO is a mechanical process involving the reversal of flow through a semi-permeable membrane from a solution with a high concentration of mineral to the high purity or "permeated" stream, on the opposite side of the membrane. The driving force for the separation is pressure.

Results

With regard to the high purity water produced by the reverse osmosis system in GE, the effluents from boiler discharge were reduced by 90%, reducing as well, the loss/waste of energy. The reduction of effluents was 106,200 m^3/year (2.5% of the total plant), and the consumption of water in an equivalent amount. These reductions, in turn, reduced the relative costs relative to industrial wastewater by US$75,500/year and the consumption of water in US$29,500/year based on 2006 prices.

Now, the boilers operate almost continually, without the frequent interruptions required by the previous water treatment system. In addition, the boilers now operate in compliance with the ASME/ABMA directives.

The incrustations which formed within the boilers were minimized substantially, and now, they operate in a more efficient manner. The plant has therefore reduced natural gas consumption by 7,461,000 m^3/year, reducing proportionally the greenhouse gas emissions, resulting in US$2,070,000 savings per year based on 2006 prices. In addition, the more efficient operation has enabled Cia Nitro Química to reduce its electrical energy consumption by 6,672 MWh/year, resulting in an annual savings of US$320,000.

"The project has met our expectations for financial gains, operational efficiency, and environmental benefits", said Coutinho. "In financial terms, the RO system was easily justified, showing an excellent return on our investment. And, as a business with 70 years of history with a deep commitment to this region, the environmental benefits are also extremely important to us."

GE
Water & Process Technologies

Case Study

Dupont and GE Join Forces to Conserve Water at Dutch Fluoroproducts Plant

New Water Treatment Solution Yields 44% ROI and Saves 265,000 m^3 of Water

Challenge: Conserving Scarce Municipal Water

With its low-lying coastal geography, the Netherlands has long needed to carefully manage its water resources. For centuries, it has been a world leader in the conservation and protection of scarce drinking water supplies.

This commitment to water conservation has been particularly evident at the DuPont de Nemours manufacturing complex at Dordrecht. "We have a strong corporate commitment to minimizing the environmental impact of our manufacturing processes," says Rob Rasenberg, Technology Manager, Du Pont de Nemours (Nederland) B.V. "The heat exchangers of our cooling towers require large volumes of water, and we are continually seeking ways to conserve this natural resource."

The cooling tower of the Dordrecht Fluoroproducts plant, for example, utilizes 265,000 m^3 (70 million US gallons) of high-quality, purified water each year for the production of Teflon™ and other fluoride-based materials. Until last year, this cooling tower makeup water — equivalent to the amount of water consumed by five thousand Dutch residents — was purchased from the local municipal water company.

"The challenge was finding an alternative source of water of sufficiently high-quality," explains Rasenberg. "We need to avoid biological contaminants, corrosion, and scale deposits that could harm our equipment, reduce cooling efficiency, and require cumbersome cleaning efforts involving significant labor, downtime and chemical usage."

Solution: Tapping Unused Wastewater

In 2002, as part of the ISO 14001 environmental management certification process, GE Water & Process Technologies engineers recommended that DuPont utilize the outflow from a groundwater purification plant as an alternative to the use of potable municipal water for the cooling tower makeup water at the Dordrecht Fluoroproducts plant.

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The purification system was built in the mid-1990s to remediate decades-old fluoride pollution at the Dordrecht plant. The purified water was previously discharged into the Merwede River in the Rhine-Maas Delta.

“The outflow of the groundwater purification plant was a wasted resource. We simply needed a treatment and monitoring system to ensure that the water could be safely used in our cooling towers,” says Rasenberg.

Laboratory tests performed at GE verified the feasibility of utilizing the purification plant’s outflow without any adverse effects on the existing heat exchange equipment and the cooling tower. GE engineers specified a chemical treatment regime for biological control with continuous dosing of Spectrus* OX1272, as well as treatment for corrosion control and scale inhibition. The new treatment regime utilizes almost identical chemical doses as the treatment required for the municipal water source, but the Spectrus OX1272 is introduced further upstream in the feed water coming from the purification plant.

“The engineering team at GE was able to prove to our satisfaction that we could safely use the water from the purification plant without any detrimental effect on our equipment,” said Rasenberg. “We worked closely together to design a system to link the purification plant to our Fluoroproducts cooling tower, with an automated monitoring system to ensure that we meet the quality standards we set for the cooling tower makeup water.”

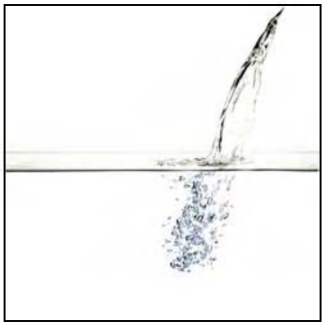
DuPont has installed a PaceSetter* Platinum system from GE to automatically measure the turbidity and conductivity of the groundwater purification system outflow and perform chemical dosing. If the turbidity or conductivity levels exceed a safe threshold, the PaceSetter Platinum system will automatically divert the groundwater purification system outflow to a buffer tank and turn on the municipal water feed. In addition to providing automated control, the system also provides off-site monitoring capability.

Results: Conserving Water and Reducing Costs

The project was completed in January 2005, saving €170,000 (US$215,900) in municipal water charges during 2005, with intermittent usage of the new water source, while the system was being optimized. On a going-forward basis, the reuse of the purified water will result in annual savings of €230,000 (US$292,100). Not only will the plant avoid purchasing 265,000 m^3 (70 million US gallons) of municipal water each year, but the groundwater purification plant will also avoid discharging 265,000 m^3 (70 million US gallons) of water from the purification plant into the Merwede River.

The total cost of the project, including the PaceSetter Platinum system and all piping and pumps was €445,000 ($565,150). This investment will produce an internal rate of return of 44%. “We have achieved an excellent financial return on this investment, in addition to the environmental benefit of reusing a water supply that would otherwise be wasted,” said Rasenberg.

Customer Uses GE Chemicals to Reduce Solid Waste at Gypsum Plant by 645 Tons per Day



Challenge

A large diversified energy company located in the in the Midwest, USA, has a commercial business at one of their power plants that produces about 2,400 tons per day of high-quality gypsum – a soft, white mineral, which is sells for use in manufacturing wallboard.

Producing high-quality gypsum requires the removal of several unwanted byproducts; chief among these are silica, iron, and aluminum oxide. The importance of removing the byproducts is crucial because the gypsum must maintain a purity of 95% in order to be sold to produce wallboard.

The customer's existing gypsum removal process, called Flue Gas Desulfurization (FGD), involved the depositing of the unwanted byproducts into a waste water pond. When the pond reached capacity, which was every four months, the customer had to remove the solids and ship the refuse to a landfill. The existing FGD process was both environmentally and financially draining, producing a large amount of sulfur and costing the customer millions of dollars.

Additionally, a fair amount of gypsum was being lost in the existing process, further increasing overall production costs. The customer needed a chemical control system that would enhance the performance of the existing FGD process by reducing the amount of sulfur, and thus the massive amount of water produced.

Solution

Following a comprehensive analysis of various treatment options, the customer turned to GE, who supplied a polymer and biocide chemical that treated the water produced during the FGD process. The chemical polymer, when mixed with the thickeners in the FGD process, caused the solids in the gypsum mixture to settle more efficiently while the biocide prevents the solid mixture from turning septic.

Results

As a result of adding the polymer and the biocide to its FGD process, solids are being removed and the remaining purified water is returning to the FGD process without being wasted. Through this process, the customer is also producing a higher quality product and losing less gypsum during its FGD process.

GE's chemical solution has reduced the solid discharge at the plant from 2,400 to 645 tons per day, and the customer has reduced yearly impurity costs be 50%, while doubling it removal of solids.

The new solution has ensured that the customer is meeting all applicable environmental regulations. Because remaining waster is now returned to the FGD process. The customer is no longer depositing unwanted byproducts into the wastewater pond.

GE's solution has allowed the customer to maintain its commitment to conduct business with respect for the environment, while providing its customers with low cost, reliable, and efficient energy services.

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GE
Water & Process Technologies

Case Study

Repsol YPF awarded GE ecomagination Leadership Award for environmental improvement

GE's Dianodic* Plus contribution to Repsol YPF´s environmental impact reduction through effluent reuse in cooling circuits during contingency situations resulted in significant additional operational savings.

Challenge

Repsol YPF is an integrated international oil and gas company, operating in 30 countries. It is involved in oil and gas downstream and upstream operations, as well as chemical processing and gas and power distribution. It is also one of the ten major private oil companies in the world, the largest private energy company in Latin America in terms of assets, and the leading company in Spain and Argentina.

La Plata Refinery, a processing plant extending along 340 hectares in the interlock among La Plata, Berisso and Ensenada districts in the province of Buenos Aires, is the greatest crude oil processing plant in the country – amounting to 30,000 m^3/day, i.e. 30% of Argentina's total refining market.

Given its capacity for crude diversity processing throughout Argentina, Refinería La Plata is devoted to refining processes aimed at producing a wide array of products – gasoline, gasoil and aviation fuel for transportation purposes, lube oil, paraffins, petroleum coal, petrochemical gasoline, petrochemical polypropylene, liquefied petroleum gas (LPG) and, asphalts.

By mid 2005, Repsol YPF's La Plata Refinery faced a critical situation. Several challenges regarding its liquid effluents and the absence of a control action plan were increasing costs and, were inconsistent with current regulations.

Therefore, the management of La Plata Refinery decided to invite GE Water & Process Technologies to design a short-term action plan which would prevent liquid effluent discharge from exceeding discharge parameters to the river. Longer term, the plan would need to solve any other problems arising from effluents with these characteristics.

Solution

GE Water & Process Technologies implemented a three tiered plan which included:

1. Creation of a joint team composed of energy, processes, laboratory and environmental experts from Repsol YPF, local experts and GE international experts.
2. Evaluation – Survey of facilities and operational conditions, recovery of analytical historical information and special analysis of water samples performed by GE Water & Process Technologies' Global Centre for Investigation and Development Excellence at The Woodlands, Texas, USA.

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3. Statistical data analysis applyling Six Sigma methodology for the selection of technologies, process simulation and operative implementation of feasible solutions.

The work carried out along these three guidelines allowed GE to identify the most efficient solution to this problem – effluent reuse as makeup water in the Mayor Conversion cooling circuit, thus avoiding its discharge into the Río de la Plata.

To complete the reuse process, it would also be necessary to replace traditional chemical treatment technology in cooling circuits with GE Water & Process Technologies' Dianodic Plus technology. The system would then be able to tolerate higher contamination levels – C.O.D, ammonia, etc.- while being protected from corrosion, bioloical fouling and scaling.

This made it possible to create total effluent reuse conditions in contingency situations.

Results

Thanks to the implementation of the GE Dianodic Plus technology, Repsol YPF attained a 16,000 m^3 decrease of its effluent discharge and makeup water consumption, as well as significant pollutant reduction in liquid effluents and, an overall savings of US$ 530.000 in operational costs.

In addition, Repsol YPF´s implementation of a Comprehensive Management Program comprising effluent chemical treatment processing through PolyFloc and KlarAid technology and, GE Water & Process Technologies' technical maintenance at its La Plata Refinery allowed for water management centralization. This, in turn, stabilized the whole system and eliminated all possible contingencies.

The efficiency and significance of this solution led Repsol YPF to be granted the 2006 ecomagination Leadership Award, a GE Water & Process Technologies reward program which globally recognizes customers with an outstanding performance in environmental conservation.

Within the framework of GE's global ecomagination initiative, this award is granted to those clients who, through their teamwork and innovative solutions, reach environmental objectives such as the reduction of water, energy and emissions, while decreasing the overall cost of its operations. Considering the existence of environmental concerns such as water scarcity, this award emphasizes the positive balance between industrial and environmental challenges.

GE
Water & Process Technologies

Case Study

GE's Helps ST CMS Electric Company's Effluent Water Treatment Program Dramatically Reduce Water Use, Protect the Environment and Save Money

Challenge

Driven by a desire to protect India's precious water supply and the environment, ST CMS Electric Company took a serious look at the millions of gallons of cooling water blowdown it was conventionally discharging each year. The 250 Megawatt lignite-fired plant uses a lot of water for cooling purposes, and the blowdown water after reuse in ash disposal was sent to Nalla as clarified ash water. As India has focused on maximizing its scarce water resources and protecting the environment and public health, plants such as ST CMS' in Tamilnadu could contribute to the conservation.

As part of environmental improvement in accordance with CMS' corporate policy, utilization of the ash pond water for cooling water makeup was initiated in the year 2004. "We were using 15,000 m^3/d of water," said Mr Muthukumar, the Chief Chemist, which compared favorably with the best of industry norms. "However, we decided to explore possibilities of further improvement."

Representative K, Vijaykrishnan of GE Water & Process Technologies, who was involved in the project, said that ST CMS was conducting a study for reuse of ash pond water for cooling system makeup and GE joined the efforts with very positive and innovative ideas in the combined study of the project.

Solution

Based on the study, it was decided to recycle the ash pond water back to the cooling tower makeup and the cooling water blowdown for ash handling. The water was recycled to the cooling towers, leading to huge savings in water and in the electricity needed to run the plant. After 11 months of recycle operation, the condensers remain clean and well protected, thanks to GE's superior cooling water treatment program.

The cooling water system is an open recirculation type with a capacity of 26,400 m^3/hr. The makeup water consumption for the cooling tower was at an average of 15,000 m^3/d.

ST CMS taps bore well water to meet its entire cooling and service water needs.

Results

The results have been very impressive. Water savings are an amazing 482,166,460 US gallons, with daily water savings of 5,000 m^3. Total financial savings exceed US$26K annually and the plant now uses six bore well pumps, instead of eight, with a daily savings of 10,800 Rupees or US$251.

The plant has become a model for others in India to follow, attracting attention from people interested in replicating the recycle program.

"The recycling program perfectly met our needs and expectations," said Mr. N. Sundararajan, GM of the ST CMS plant. "It has saved us money, protected our scarce resources and proven to be very reliable."

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GE's RO System Helps Unilever Reduce Water, Natural Gas Consumption and Chemical Usage

Challenge

In the face of rising and unpredictable energy prices, the ongoing campaign to improve energy efficiency is necessary for the Unilever plant in Rexdale, Ontario to remain competitive. The Rexdale plant consumes huge quantities of energy for the annual production of 185 million pounds of margarine and other vegetable-oil products, and energy expenditures represent 15% of all production costs.

To meet an aggressive goal of reducing energy consumption by at least 6% per year, the Rexdale plant's Energy Team has implemented, and carefully documented, 120 projects since 1999, saving more than $4.2 million in energy costs, based on 2006 prices, and avoiding about 23,000 tons of greenhouse gas emissions.

The initiatives of the plant's Energy Team are also part of the Unilever corporate commitment to environmentally responsible practices at its 365 manufacturing sites across six continents. In 2005 for the seventh year running, Unilever led the food industry category of the Dow Jones Sustainability World Indexes (DJSI World), based on assessment of corporate economic, environmental and social performance.

"By 2003, our Energy Team at the Rexdale plant had already attacked many of the more obvious ways of reducing energy consumption, but we needed to take additional initiatives to keep pace with our company goal of achieving further reductions of 6% per year," explains Doug Dittburner, chief engineer and head of the Energy Team at the Unilever plant in Rexdale, Ontario.

"We turned to GE Water & Process Technologies to investigate whether we could achieve significant, measurable improvements in the efficiency of our steam plant operations."

Solution

The Energy Team worked with GE to analyze the total cost of purchasing and treating water used to produce the 218 million pounds of steam that the plant uses each year. Municipal water, chemically softened and dealkalized, was the source of 100% of the boiler make-up water.

GE recommended a reverse osmosis (RO) system to replace the water softeners and chloride anion dealkalizers. RO is a mechanical process involving the reversal of flow through a semi-permeable membrane from a high salinity, or concentrated, solution to the high purity, or "permeate," stream on the opposite side of the membrane. Pressure is used as the driving force for the separation.

A "turn key" system was commissioned in the Rexdale plant in January 2005. The RO system not only softens and purifies municipal water, but it also re-uses process water captured throughout the plant for use as boiler make-up, significantly reducing the consumption of municipal water. The "concentrate" waste from the RO process is used in the

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plant's cooling tower and evaporative condenser for ammonia.

Results

The higher quality RO feed water allows the boilers to operate at 100 feedwater cycles instead of 10, dramatically increasing energy efficiency. Blowdown has been reduced by more than 80%, with a bleed off of only 1%.

"The results of the RO project have greatly exceeded our expectations, and they are easily measured," says Dittburner. "In the first year of operation, we calculated that the project produced a net savings of $378,166 [based on 2006 prices], even after accounting for the full cost of operating and maintaining the RO system. We calculate that the RO system will pay for itself in less than 16 months."

By converting to the RO system, the plant is consuming 13 million gallons less of municipal water ($68,000) and 8% less natural gas ($299,000). The plant is also saving $11,700 in boiler chemicals and $22,000 in commodity softening chemicals, allowing 240,000 less pounds of chemicals into the sanitary sewer.

These costs savings do not include the benefits of eliminating the backbreaking work of handling 3,976 bags of salt, each weighing 44 lbs, and the related labor and storage costs.

The RO system also qualified the Rexdale plant for a $50,000 incentive grant from the city of Toronto for decreased water consumption and a $14,000 incentive grant from local gas utility, Enbridge Consumers Gas.

According to Dittburner, "The RO project is easily justified by the direct financial benefit to Unilever, but we are also proud of the environmental benefits. The project has led to our producing 1.6 million fewer kilograms of CO2, as well as reductions in methane and nitrous oxides. We are also consuming far less chemicals and reducing the environmental impact of producing and transporting those chemicals."

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