

Water efficiency in industrial facilities

THE WATER SAVING POTENTIAL

By improving water efficiency, industry can:

- Safeguard its license to operate
- Reduce purchasing, treatment, and discharge costs
- Avoid disruptions in production
- Demonstrate social responsibility.

Industry's share of overall water use in the Arab world is relatively small. However, following similar trends in the agricultural and municipal sectors, industrial demand for water is also rising. In parallel, there is an increased understanding of the negative impact of industrial pollution on water resources. Consequently, the industrial sector will be competing for access to water while pressures on the sector to protect water resources from pollution are mounting. The consequences of responsible or irresponsible use of water resources are increasingly becoming strategically important.

Industrial facilities have a good potential for raising their water efficiency rates. Experience from around the world shows that adopting a systematic approach to water efficiency often results in reduced water consumption by 20-50%, and up to 90% when more advanced measures are implemented. **Table 3.1** lists a number of industrial efficiency measures and their associated water-saving potential.

Although there is a growing awareness of the strategic importance of water, the number of industries in the MENA region that manage water in a systemic and holistic way is limited. Water management in the majority of industries is limited to ensuring the provision of water. In some instances there are efforts to control or treat effluents. In rare cases where water efficiency efforts are implemented, they tend to be unorganized and ad hoc, often leading to sub-optimal results. These disappointing results may make management more inclined to withhold its support for any future efficiency projects. In short, potential exists within the industrial sector in the Arab region to substantially boost water productivity.

| Efficiency measures | Potential savings (%) |
|--------------------------------------|-----------------------|
| Closed loop reuse | ~ 90% |
| Closed loop recycling with treatment | ~ 60% |
| Automatic shut-off valves | ~ 15% |
| Counter-current rinsing | ~ 40% |
| High-pressure, low-volume upgrades | ~ 20% |
| Reuse of wash water | ~ 50% |

Table 3.1: Water-saving potential in industry

WATER USE BREAKDOWN IN INDUSTRY

In industrial facilities, water is used in a wide range of activities. The value of water as a utility is illustrated by the following common uses:

- 💧 Incorporation in the final product
- 💧 Washing or rinsing of raw materials, intermediates, or final products
- 💧 Preparation of solvents or slurries
- 💧 Cleaning of equipment and space
- 💧 Removing or providing heat
- 💧 Meeting hygienic and domestic needs
- 💧 Irrigation of landscape space.

To develop a comprehensive view of water use in a facility, an initial review needs to be conducted as prescribed by the five-step systematic approach delineated in Chapter 2. In complex operations, concentrating on water intensive processes or streams that have particularly high concentrations of pollutants is a good starting point for the efficiency program.

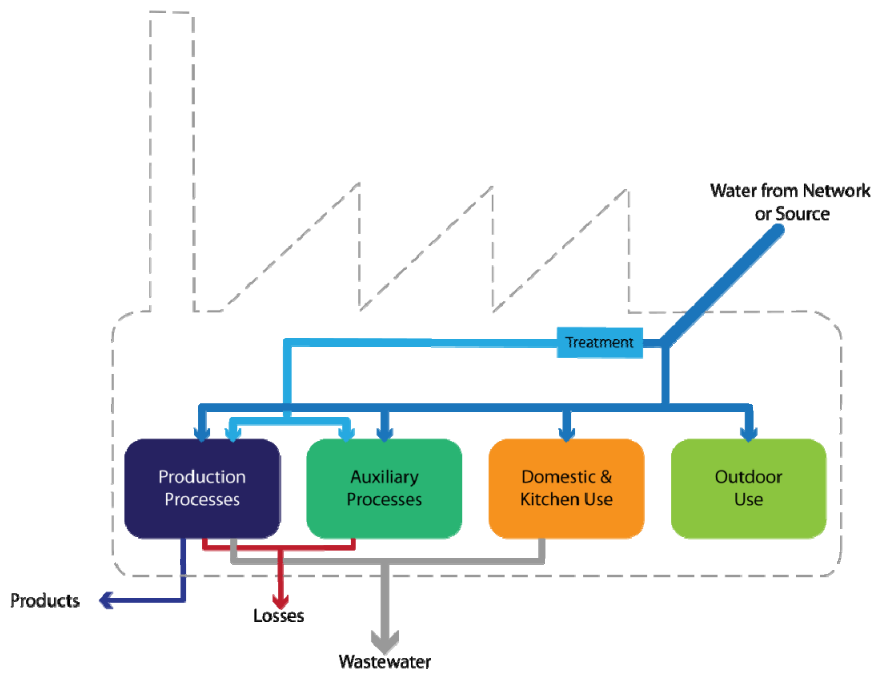


Figure 3.1: Water use in industry

Figure 3.1 is a diagram of water use typical for an industrial facility. The breakdown of water flows by process steps requires identifying and measuring quantitative and qualitative parameters for water used and lost as well as for any effluents generated. The following checklist suggests a number of questions to consider during the initial review and monitoring steps.

Checklist

Find answers to the following questions for every major water-using process or area:

- How much water is entering the process/area?
- What is the quality of the water at the point of entry?
- What is the cost of bringing the water to this process/area?
- How much of the water entering the process/area is being incorporated into the final product? How much is rejected with effluent streams?
- What are water losses to air and soil?
- What are the characteristics of the effluent streams?
- What is the cost of managing the effluents?

COMMON APPROACHES TO WATER EFFICIENCY IN INDUSTRY

A number of different possibilities exist for improving water efficiency. **Table 3.2** lists some of the most common approaches in order of increased complexity in process changes.

| Measure | Explanation | Examples |
|--|--|--|
| Improved production planning and sequencing | Re-adjusting the production plans with a focus on minimizing water consumption. | Reduce cleaning needs by minimizing product changes; Starting from lighter shades and moving gradually to darker ones in textile dyeing. |
| Good housekeeping | Introducing more sensible and more resource-conscious routines in operations. | Avoiding spillages; Minimizing the transport of pollutants from one process to the next; Closely monitoring recipes in reaction batches; Performing mechanical cleaning prior to washing with water; Making sure that water does not flow unnecessarily. |
| Process/equipment modifications | Making modifications in processes or equipment, with relevant retrofits, if necessary. | Closing open-ended cooling or heating system; Installing level-controlled valves to avoid overflows; Installing self-shutting, trigger-controlled nozzles on hoses; Lining tank surfaces with a non-stick material. |
| Product/material changes | Changing feedstocks used in production or designing completely new products that lead to reduced water demand and/or less effluent generation. | Switching to water based paints; Using reactive dyes in textile dyeing; Switching over to disposable containers in beverage industry. |
| Replacing equipment/technology | Substituting existing technologies with more effective and efficient ones. | Adopting in-place cleaning systems; Using high-pressure, low-volume cleaning equipment; Operating textile dyeing machinery at lower liquor ratios. |

Table 3.2: Water efficiency approaches in industry

The efficiency gains that are realized through these approaches do however differ in terms of their environmental impacts and financial feasibility. The preventative hierarchy discussed in Chapter 2 (**Figure 2.3**) provides a complementary guiding framework for making the necessary choices.

GOOD PRACTICE GUIDE FOR WATER INTENSIVE OPERATIONS

Leak Detection

Identifying leaks and taking corrective measures for their elimination offers a good starting point for water efficiency in industry. Underground water tanks, heating and cooling systems, water distribution network, and water using fixtures and equipment are areas where leaks are common. While some leakage can be easily spotted, some others may be hidden – like those from underground tanks or piping system inside the walls. If there is continuous monitoring of water use on site, baseline consumption that is observed during times of no activity on site would provide a good indicator of the extent of overall leakage (see [Figure 3.2](#)).

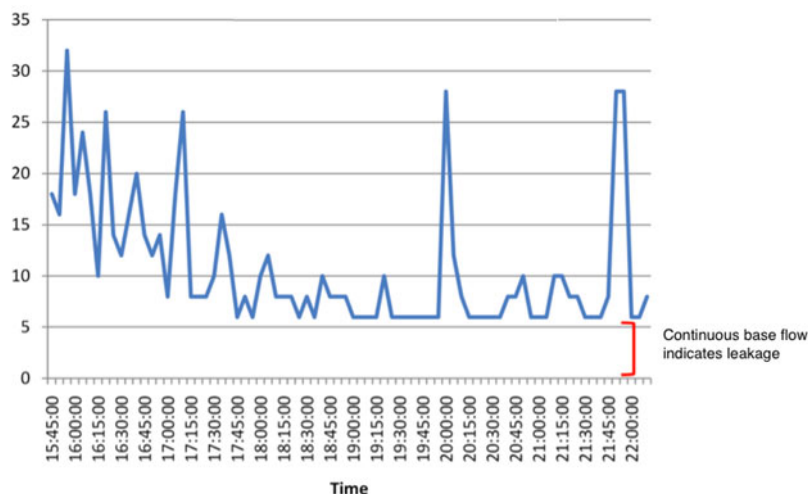


Figure 3.2: Continuous base flow indicates leakage

Measuring the water level during a time where there is no extraction from the tank can help identify leakage from tanks. Moisture, mold growth, or irregularities on surfaces can, on the other hand, be clues of leakage from pipes within the walls.

Heating and Cooling

Providing heat to or removing heat from different processes is a common practice in industrial systems. Cooling needs are particularly important in the Arab region due to the soaring

temperatures of the summer months. Heat exchange systems often use water as an energy carrier. The following measures can assist saving water used for heating or cooling purposes.

Optimizing heating and cooling needs

Providing more cooling or heating than necessary is wasteful. Thus, one simple but often overlooked measure in cooling and heating systems involves performing the right level of heat transfer. There may also be possibilities to use the same water for multiple cooling or heating effects. These possibilities can be identified through proper energy assessments, such a pinch analysis.

Water-free systems

In certain applications, air, mineral oils, or specialty chemicals can be used to transfer heat effectively and economically, thereby eliminating the need to use water. Air-cooled compressors, industrial chillers, and oil based drying units are examples of water-free heating and cooling systems. Applicability and feasibility of using these systems should be investigated.

Re-circulating systems

In single-pass heat transfer systems water or steam usually gets lost – through drainage, evaporation, or condensation. In re-circulating systems heating and cooling take place in a heat exchanger designed to permit water to re-circulate in a closed system that includes either cooling towers or chillers for cooling purposes and a boiler for heating. The fraction of water that can potentially be saved by adopting re-circulating systems can be as high as 90%.

Effective water monitoring and maintenance program

In re-circulating systems water gradually gets enriched in impurities, which cause corrosion, scale formation, deposition, and biological growth on heat transfer surfaces. As a result, the heat transfer rate becomes less effective, requiring additional water and energy. To control the level of impurities, certain fraction of the water circulating in the system is regularly taken out (or blown down) and replaced with fresh (makeup) water. At the same time, chemicals designed to reduce scale formation, corrosion, and biological growth can be added to the circulating water to improve effective heat transfer and reduce the need for blow-down.

By properly monitoring the concentration of undesired impurities and adjusting blow-down rates accordingly, it is possible to generate major savings. A conductivity meter is highly desirable for this purpose. In cooling systems, considerable amounts of water can get wasted due to overflow if there is wear in the seal and float valve unit of the make-up line, or when this unit is not properly adjusted. By regularly checking the condition of this unit and making sure that it is properly adjusted, water consumption can be reduced.

Recycling of blow-down

Blow-down from re-circulating units can be returned to acceptable quality by applying an appropriate treatment to remove the impurities. For large heating and cooling systems, treatment and reuse of the blow-down could be a feasible alternative.

Good practice

Blow-down recycling in steel production - Jeddah

In a steel plant in Jeddah, blow-down from cooling towers is treated with the use of chemical precipitation and rapid sand filters. Treated water is then put back to the cooling system. With this practice, the company saves 800 m³ of water on a daily basis.

Central heating or cooling

Where industrial plants are adjacently located in a particular area – as commonly the case in industrial districts or parks – centralized heating or cooling serving clustered plants can be a sensible option as opposed to each plant owning its own heating and cooling system. These plants have better potential to operate more efficiently since the savings may enable them to employ more advanced and efficient technologies.

Leak detection

For heating systems, leak avoidance is particularly important as it helps not only save water but also energy. Particularly in heating systems operated with a high-pressure steam, leaks can be common. The losses from individual leaking spots may appear small, however, leaks can add up to substantial amounts in larger plants. By following a proper monitoring and maintenance program, leaks can be minimized and thereby both water and energy can be saved.



Besides wasting water splash, losses can be a source of pollution.

Cooling Towers

Controlled evaporation with variable speed fans

Evaporation is the main mechanism for cooling the water, but it is also the main source of water loss. Using variable speed drives for cooling water fans allows the cooling effect to be adjusted according to the load requirements resulting in minimum losses due to evaporation and reduced water use.

Minimizing splash losses

Splash losses occur when the water accidentally escapes from the sides of the cooling tower due to bad design, damaged or missing louvers, or strong wind. Splash-out together with drift can account for up to 7% of total water losses from cooling towers. Splash can be reduced by proper maintenance of the side panels, with the use of anti-splash louvers, splash mats, or wind breaks. While minimizing water losses, these installations will reduce the contamination of cooling water by dust, which is a common problem in desert environments.

Minimizing drift losses

Small droplets of water escape the cooling tower in the form of drift. Drift losses can typically account for 0.02% of the recirculation rate. By installing drift eliminators or arrestors, drift losses can be reduced. Besides saving water, reducing drift also reduces chemical use.

Use of alternative water sources

Water used for cooling purposes does not need to be of the highest quality. For example, treated wastewater can be acceptable for cooling purposes – either directly or after simple treatment. Moreover, the blow-down from cooling towers can also find alternative uses – such as pass-through cooling water or fire water.

Washing and Rinsing

In some process operations considerable amounts of water might be needed for washing or rinsing of the final or intermediate products. In such cases, the following measures can be effective for improving water efficiency.

Counter-current rinsing

Conventional rinsing systems are based on a single-flow arrangement and use large amounts of water. Often, products to be rinsed are immersed completely in fresh water, after which the contents of the tank are drained. Alternative configurations that are more efficient while also being as effective should be explored. In counter-current rinsing systems, water flows through a series of connected rinse tanks, in opposite direction to the flow of the product to be rinsed, as demonstrated in **Figure 3.3**. With a sufficient number of tanks and a proper flow rate, counter-current rinsing systems use substantially less water, while also being as effective as single-flow systems.



Counter-current rinsing can typically be used in electroplating operations.

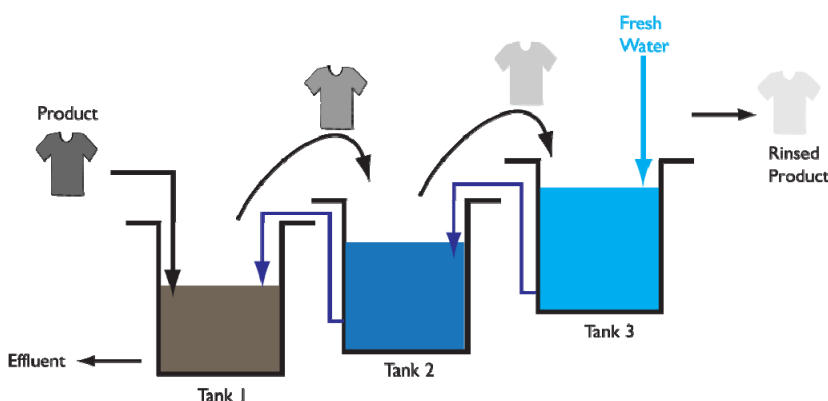


Figure 3.3: Counter current rinsing

Mechanical pre-rinsing

When rinsing is necessary in order to remove a solution from the product – such as in electroplating or in textile dyeing - certain measures can be taken to reduce the carry-over of excess solution. These may include allowing the solution to drip away by gravity, or assisting its removal through vacuum, blown-air, or centrifugation. Since such methods reduce the amount of solution carried over to the rinsing tanks, the same rinsing water can be used for a larger volume of product. While saving rinsing water, these measures can also reduce unnecessary chemical waste and prolong the usable time of reaction baths.

Using chemicals and heat

In certain rinsing operations, the process of removing unwanted substances from the product can be assisted with the use of chemicals or energy, thereby saving water. In such cases, water saving benefits need to be weighed against the cost of introducing chemicals and/or energy.

Equipment and Space Cleaning

Mechanical pre-cleaning

In equipment and space cleaning, the amount of required water can be substantially reduced by removing as much of the substances as possible by mechanical means – such as brushes, scrappers, rubber wipes, or pucks (for pipes). While reducing the water consumption, in certain cases the use of mechanical cleaning methods can also allow for the recovery of products that would otherwise be washed away by cleaning water.

Cleaning in Place (CiP)

CiP is a method used for cleaning the interior surfaces of pipes, vessels, process equipment, and associated fittings, without disassembly. It is particularly useful for industries requiring high levels of hygiene and therefore frequent cleaning – such as beverages, dairy, processed foods, cosmetics, and so on. In such systems, a sequence of acidic and basic solutions and rinsing water is passed through the equipment to be cleaned. Because it allows different number of re-circulations for different solution and rinsing batches, CiP consumes significantly less water compared to conventional once-through cleaning systems. In addition, CiP systems are faster, less labor intensive, and pose less chemical exposure risk to people.

High-pressure, low-volume systems

These systems usually apply a pressurized stream of water, or an air-water mixture, flowing at a high velocity through a specially designed nozzle. Commonly applied for equipment and space cleaning, these systems can provide the same, or even better, cleaning effect by using as much as 50% less water.



A triggered self shut-off nozzle

Use of triggered, self shut-off nozzles

In space and equipment cleaning using ordinary hoses, significant amounts of water can be lost as the “on-off” valve is often fitted on an outlet far away from the place of use. Fitting triggered self shut-off nozzles at the discharge ends of hoses offers effective and low-cost alternative for reducing water use.

Use of steam or hot water

Similar to product rinsing, equipment and space cleaning can be assisted by the use of chemical detergents or higher temperature water. Again, the additional costs of chemicals and/or energy need to be weighed against the benefits of reduced water use.