T.R.
MINISTRY OF AGRICULTURE
AND FORESTRY
GENERAL DIRECTORATE OF
WATER MANAGEMENT

Water Efficiency
Campaign

Water Efficiency Guidance Document Series

MANUFACTURE OF STEAM GENERATORS, EXCLUDING CENTRAL HEATING HOT WATER BOILERS

NACE CODE: 25.30

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Tarım ve Orman Bakanlığı, Su Yönetimi Genel Müdürlüğü tarafından Yüklenici io Çevre Çözümleri Ar-Ge Ltd. Şti. ‘ne hazırlattırılmıştır.

Her hakkı saklıdır.
Bu doküman ve içeriği Su Yönetimi Genel Müdürlüğünün izni alınmadan kullanılamaz ve çoğaltılamaz.

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Abbreviations

WTP	Wastewater Treatment Plant
EU	European Union
SSM	Suspended Solid Matter
BREF	Best Available Techniques Reference Document
EMS	Environmental Management System
MoEUCC	Republic of Turkey Ministry of Environment, Urbanization and Climate Change
NOM	Natural Organic Matter
EMAS	Eco Management and Audit Program Directive
EPA	United States Environmental Protection Agency
IPPC	Industrial Pollution Prevention and Control
ISO	International Organization for Standardization
BAT	Best Available Techniques
NACE	Statistical Classification of Economic Activities
GSWM	General Directorate of Water Management
RO	Reverse Osmosis
MAF	Ministry of Agriculture and Forestry of the Republic of Turkey
TurkStat	Turkish Statistical Institute
NF	Nanofiltration
MF	Microfiltration
UF	Ultrafiltration
GW	Groundwater
SW	Surface Water

1 Introduction

Our country, located in the Mediterranean basin where the effects of global climate change are intensely felt, is recognized as one of the regions that will be most impacted by its adverse effects. Projections regarding the future impact of climate change on the water resources in our basins indicate that our water resources could decrease by up to 25% over the next century.

As of 2022, the per capita annual available water in our country is 1,313 m³, but due to human pressures and the effects of climate change, it is expected to fall below 1,000 m³ per capita after 2030. Without taking necessary precautions, Türkiye is at risk of becoming a water-scarce country in the near future, which would bring about numerous social and economic challenges. As demonstrated by future projections, the drought and water scarcity risks that lie ahead make it imperative to use our existing water resources efficiently and sustainably.

The concept of water efficiency can be defined as "the use of the minimum amount of water needed for the production of a product or service." The approach to water efficiency emphasizes the rational, cooperative, fair, efficient, and effective use of water across all sectors—including drinking water, agriculture, industry, and households—while preserving water in terms of both quantity and quality and considering not only human needs but also the ecosystem's requirements.

With the increasing demand on water resources, changes in precipitation and temperature patterns due to climate change, and rising population, urbanization, and pollution, it has become even more critical to distribute available water resources among users in a fair and balanced manner. Therefore, a roadmap that prioritizes efficiency and optimization has become necessary to ensure that limited water resources are preserved and used under sustainable management practices.

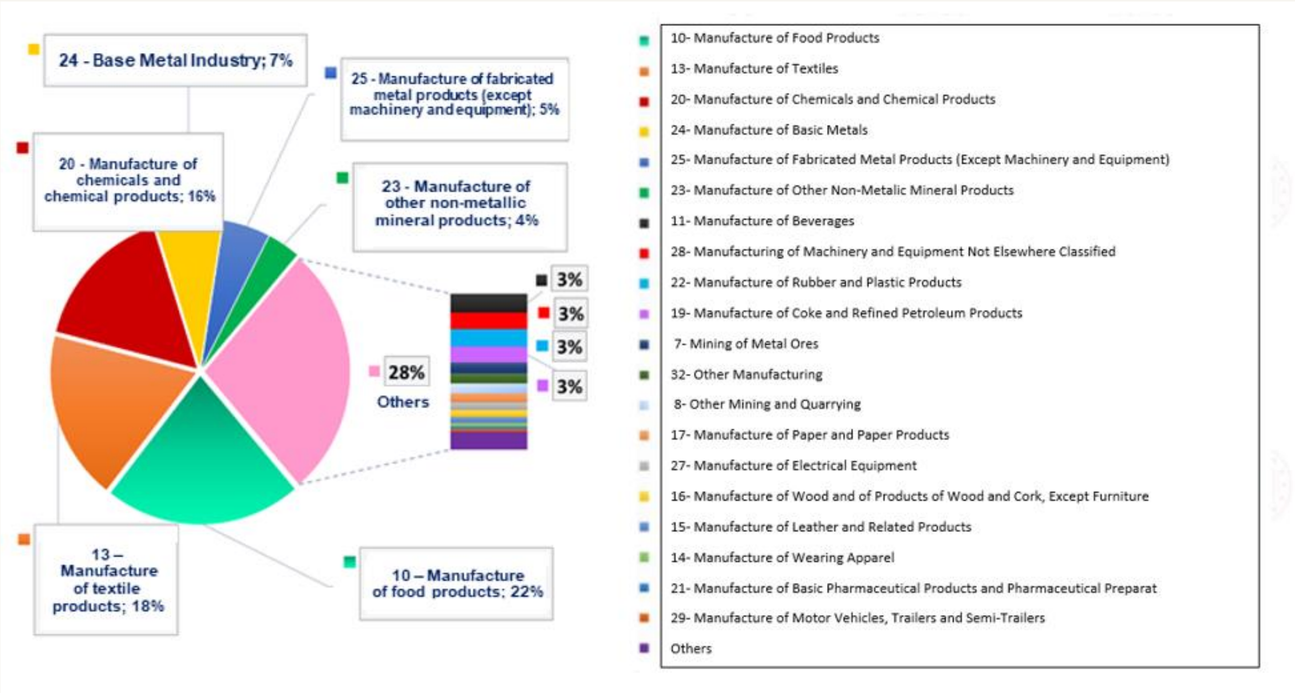
In the sustainable development vision set forth by the United Nations, the Millennium Development Goal 7 on Ensuring Environmental Sustainability and Sustainable Development Goals, specifically Goal 9 on Industry, Innovation, and Infrastructure and Goal 12 on Responsible Production and Consumption, emphasize the efficient, fair, and sustainable use of resources—particularly water—as well as environmentally friendly production and consumption practices mindful of future generations.

The European Green Deal, which member countries have agreed upon to realize a carbon-neutral, circular economy model, aims to expand the efficient use of resources and reduce environmental impacts. In alignment with these goals, Türkiye has established a European Green Deal Action Plan that outlines actions to promote water and resource efficiency in various fields, particularly in industry, as part of production and consumption.

The "Industrial Emissions Directive (IED)," one of the most significant components of European Union environmental legislation for industry, encompasses measures to control, prevent, or reduce discharges/emissions into receiving environments, including air, water, and soil, from industrial activities using an integrated approach. In the Directive, Best Available Techniques (BAT) are introduced to systematically implement cleaner production processes and address practical difficulties encountered in application. BAT represents the most effective application techniques aimed at high-level environmental protection, considering both costs and benefits. Under the Directive, sector-specific Reference Documents (BAT-BREF) have been prepared, detailing BAT for each sector. These BREF documents provide a general framework for BAT, including good management practices, general preventive techniques, chemical use and management, techniques for various production processes, wastewater management, emission management, and waste management.
The Ministry of Agriculture and Forestry, through the General Directorate of Water Management, is conducting activities aimed at promoting efficient practices and raising public awareness in urban, agricultural, industrial, and individual water use. Within the framework of the "Water Efficiency Strategy Document and Action Plan (2023-2033) in Adapting to Changing Climate," which came into force with Presidential Circular No. 2023/9, water efficiency action plans targeting all sectors and stakeholders have been prepared. The Industrial Water Efficiency Action Plan specifies 12 actions for the 2023-2033 period, with responsible and relevant institutions designated for each action. The responsibilities of the General Directorate of Water Management within this Action Plan include conducting studies to identify specific water usage ranges and quality requirements for subsectors in industry, organizing sector-specific technical training programs and workshops, and preparing water efficiency guidance documents.

Meanwhile, within the "Project on Industrial Water Use Efficiency According to NACE Codes," conducted by the General Directorate of Water Management under the Ministry of Agriculture and Forestry, sector-specific best practices for water efficiency in industry tailored to Türkiye have been identified. As a result, sector-specific guidance documents and action plans classified according to NACE codes have been developed, outlining recommended measures to improve water use efficiency in high water-consuming sectors operating in Türkiye.

As in the rest of the world, the sectors with the highest water consumption in Türkiye are the food, textile, chemical, and primary metal sectors. Under these studies, field visits were carried out in 35 main sectors and 152 sub-sectors, including facilities that represent a variety of capacities and production types with high water consumption under NACE codes in Türkiye, especially in the food, textile, chemical, and primary metal industries. Data were collected on water supply, sectoral water use, wastewater generation, and recovery practices, and information was provided on topics such as BAT and sectoral reference documents (BREF) published by the European Union, water efficiency, clean production, and water footprint



The distribution of water usage by sector in industry in Türkiye

As a result of the studies, specific water consumption and potential savings rates were identified for 152 different four-digit NACE codes with high water consumption. Water efficiency guideline documents were prepared by considering the EU Best Available Techniques (BAT) and other clean production techniques. Within these guidelines, 500 techniques (BAT) for water efficiency were examined under four main groups: (i) Good Management Practices, (ii) General Preventive Measures, (iii) Auxiliary Process Measures, and (iv) Sector-Specific Measures.

During the determination of BATs for each sector within the scope of the project, environmental benefits, operational data, technical specifications-requirements, and applicability criteria were considered. The determination of BATs was not limited to BREF documents alone; global literature data, real case analyses, innovative practices, and sector representatives' reports were also thoroughly examined, and sectoral BAT lists were created. In order to evaluate the suitability of the prepared BAT lists for the local industrial infrastructure and capacity of our country, BAT lists specific to each NACE code were scored by enterprises based on criteria such as water savings, economic savings, environmental benefits, applicability, and cross-media effects. The final BAT lists were determined using the scoring results. Sectoral water efficiency guidelines based on NACE codes were created using water and wastewater data from the visited facilities and the final BAT lists identified by considering local dynamics specific to our country, as highlighted by sectoral stakeholders.

2 Scope of the Study

- The guide documents prepared within the framework of water efficiency measures in industry include the following main sectors:
- Plant and animal production, hunting, and related service activities (including 6 sub-production areas represented by four-digit NACE codes)
- Fishing and aquaculture (including 1 sub-production area represented by a four-digit NACE code)
- Extraction of coal and lignite (including 2 sub-production areas represented by four-digit NACE codes)
- Support activities for mining (including 1 sub-production area represented by a four-digit NACE code)
- Mining of metal ores (including 2 sub-production areas represented by four-digit NACE codes)
- Other mining and quarrying (including 2 sub-production areas represented by four-digit NACE codes)
- Manufacturing of food products (including 22 sub-production areas represented by four-digit NACE codes)
- Manufacturing of beverages (including 4 sub-production areas represented by four-digit NACE codes)
- Manufacturing of tobacco products (including 1 sub-production area represented by a four-digit NACE code)
- Manufacturing of textile products (including 9 sub-production areas represented by four-digit NACE codes)
- Manufacturing of clothing (including 1 sub-production area represented by a four-digit NACE code)
- Manufacturing of leather and related products (including 3 sub-production areas represented by four-digit NACE codes)
- Manufacturing of wood, wood products, and cork (excluding furniture); manufacturing of woven goods made from straw, hay, and similar materials (including 5 sub-production areas represented by four-digit NACE codes)
- Manufacturing of paper and paper products (including 3 sub-production areas represented by four-digit NACE codes)
- Manufacturing of coke and refined petroleum products (including 1 sub-production area represented by a four-digit NACE code)
- Manufacturing of chemicals and chemical products (including 13 sub-production areas represented by four-digit NACE codes)
- Manufacturing of basic pharmaceutical products and pharmaceutical preparations (including 1 sub-production area represented by a four-digit NACE code)
- Manufacturing of rubber and plastic products (including 6 sub-production areas represented by four-digit NACE codes)
- Manufacturing of other non-metallic mineral products (including 12 sub-production areas represented by four-digit NACE codes)
- Basic metals industry (including 11 sub-production areas represented by four-digit NACE codes)
- Manufacturing of fabricated metal products (excluding machinery and equipment) (including 12 sub-production areas represented by four-digit NACE codes)
- Manufacturing of computers, electronic, and optical products (including 2 sub-production areas represented by four-digit NACE codes)
- Manufacturing of electrical equipment (including 7 sub-production areas represented by four-digit NACE codes)

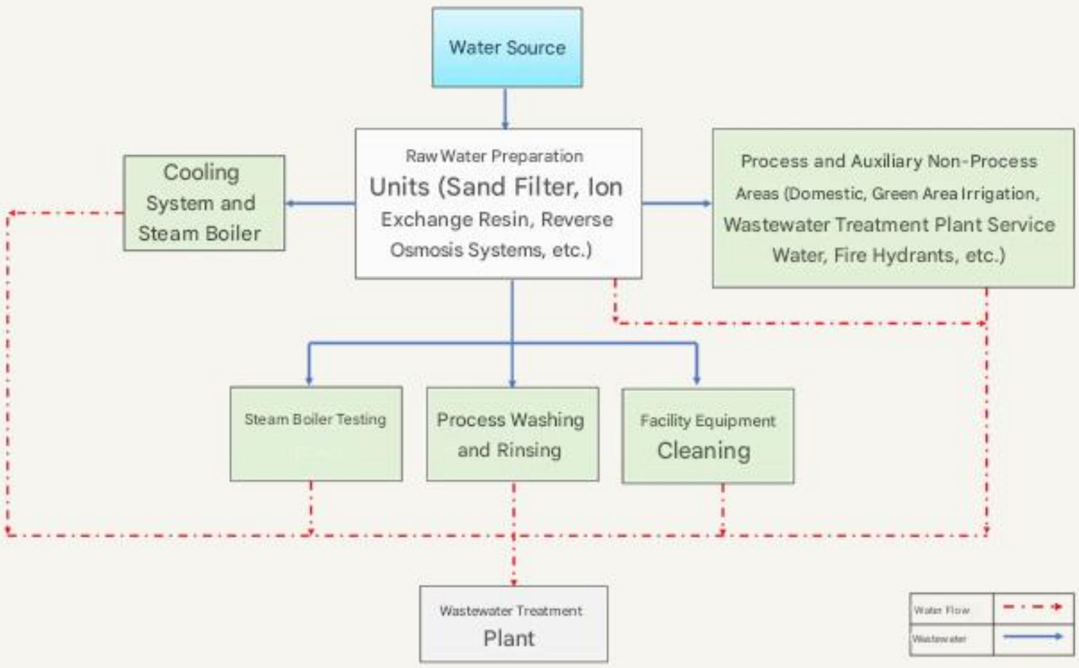
- Manufacturing of machinery and equipment not classified elsewhere (including 8 sub-production areas represented by four-digit NACE codes)
- Manufacturing of motor vehicles, trailers, and semi-trailers (including 3 sub-production areas represented by four-digit NACE codes)
- Manufacturing of other transportation equipment (including 2 sub-production areas represented by four-digit NACE codes)
- Other manufacturing (including 2 sub-production areas represented by four-digit NACE codes)
- Installation and repair of machinery and equipment (including 2 sub-production areas represented by four-digit NACE codes)
- Production and distribution of electricity, gas, steam, and air conditioning systems (including 2 sub-production areas represented by four-digit NACE codes)
- Waste collection, treatment, and disposal activities; recovery of materials (including 1 sub-production area represented by a four-digit NACE code)
- Construction of buildings outside structures (including 1 sub-production area represented by a four-digit NACE code)
- Storage and supporting activities for transportation (including 1 sub-production area represented by a four-digit NACE code)
- Accommodation (including 1 sub-production area represented by a four-digit NACE code)
- Education (including 1 sub-production area represented by a four-digit NACE code)
- Sports activities, entertainment, and recreation activities (including 1 sub-production area represented by a four-digit NACE code)

“Primary Metal Industry" and "Manufacturing of Fabricated Metal Products (excluding machinery and equipment)" sectors include the following sub-production branches for which guidance documents have been prepared:

24.10	Manufacturing of Basic Iron and Steel Products and Ferroalloys
24.20	Manufacturing of Steel Tubes, Pipes, Hollow Profiles, and Similar Connection Parts
24.31	Cold Drawing of Bars
24.32	Cold Rolling of Narrow Strips
24.34	Cold Drawing of Wires
24.41	Production of Precious Metals
24.42	Production of Aluminum
24.51	Iron Casting
24.52	Steel Casting
24.53	Casting of Light Metals
24.54	Casting of Other Non-Ferrous Metals
25.12	Manufacturing of Metal Doors and Windows
25.21	Manufacturing of Central Heating Radiators (Excluding Electric Radiators) and Hot Water Boilers
25.30	Manufacturing of Steam Generators, Excluding Central Heating Hot Water Boilers
25.50	Forging, Pressing, Stamping, and Rolling of Metals; Powder Metallurgy
25.61	Processing and Coating of Metals
25.62	Machining and Shaping of Metals
25.71	Manufacturing of Cutlery Sets and Other Cutting Tools
25.73	Manufacturing of Hand Tools, Tool Machine Tips, Saw Blades, etc.
25.92	Manufacturing of Light Packaging Materials from Metal
25.93	Manufacturing of Wire Products, Chains, and Springs
25.94	Manufacturing of Fasteners and Products for Screw Machines
25.99	Manufacturing of Other Fabricated Metal Products Not Classified Elsewhere

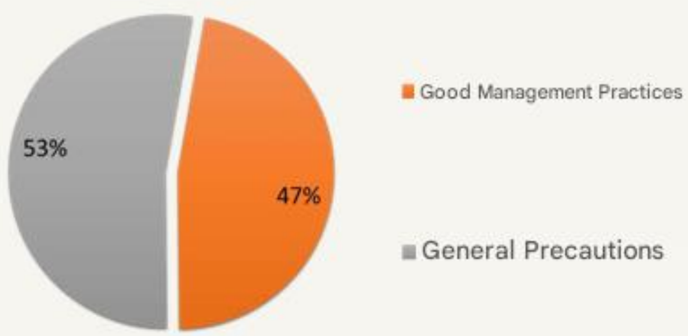
2.1 Manufacturing of Steam Generators, Excluding Central Heating Hot Water Boilers (NACE 25.30)

Steam Generator Manufacturing, Excluding Central Heating Hot Water Boilers (Boilers), Sector Water Flow Diagram



	Minimum	Maximum
Specific Water Consumption of Facilities Visited within the Scope of the Project (L/kg product)	0.01	
Reference Specific Water Consumption (L/kg product)	6	42

Percentage Distribution of Water Efficiency Practices



Water Efficiency Campaign

The sector of manufacturing central heating radiators (excluding electric radiators) and hot water boilers consists of processes such as raw material control, sheet-tube-profile production, inspection-cleaning, painting, and assembly. After the raw materials procured in the sector are inspected, they are processed in the sheet-tube-profile production phase. The resulting semi-finished products undergo measurement, surface smoothness, and functionality checks during the inspection-cleaning process before being cleaned. The semi-finished products that pass the suitability tests are painted during the painting process. Subsequently, the semi-finished products are taken to the assembly section for mechanical, electrical, and electronic assembly. The final products are subjected to mechanical pressure and leakage tests before packaging.

In the manufacturing sector of central heating radiators (excluding electric radiators) and hot water boilers, water consumption occurs for the purpose of testing steam boilers. Water is also consumed in raw water treatment units such as ion exchange resin and reverse osmosis, which are used to produce soft water for production processes. Additionally, water consumption occurs in auxiliary units such as cooling towers and steam boilers.

The specific reference water consumption in the sector of central heating radiators (excluding electric radiators) and hot water boilers ranges from 6 to 42 L/kg. The specific water consumption of the production branch analyzed in this study is 0.01 L/kg. By implementing good management practices and general preventive measures, it is possible to achieve a water savings rate of 60-71% in the sector.

The recommended priority water efficiency application techniques under NACE code 25.30, which pertains to the manufacturing of steam generators excluding central heating hot water boilers, are presented in the table below.

NACE Code	Description	Prioritized Sectoral Water Efficiency Techniques	
25.30	Manufacturing of Steam Generators, Excluding Central Heating Hot Water Boilers		**Good Management Practices**
		1.	Utilizing an integrated wastewater management and treatment strategy to reduce wastewater volume and pollutant load. Establishing an environmental management system.
		2.	Preparing water flow diagrams and mass balance calculations for water.
		3.	Developing a water efficiency action plan to reduce water use and prevent water pollution.
		4.	Providing technical training to personnel for the reduction and optimization of water usage.
		5.	Effectively planning production to optimize water consumption.
		6.	Setting water efficiency targets.
		7.	Monitoring the quantity and quality of water used in production processes and auxiliary processes, and integrating this information into the environmental management system.
		8.	Utilizing an integrated wastewater management and treatment strategy to reduce wastewater volume and pollutant load.
			General Measures
		1.	Minimizing spills and leaks.
		2.	Recovering water from rinsing solutions and reusing the reclaimed water in suitable processes.
		3.	Implementing automatic devices and equipment (sensors, smart handwashing systems, etc.) at water usage points like showers and toilets to conserve water.
		4.	Avoiding the use of drinking water in production lines.
		5.	Detecting and reducing water losses.
		6.	Using automatic control and shut-off valves to optimize water usage.
		7.	Reusing backwash waters from pressurized filtration prior to water softening at appropriate points.

NACE Code	Description	Prioritized Sectoral Water Efficiency Techniques
25.30	Manufacturing of Steam Generators, Excluding Central Heating Hot Water Boilers	8. Optimizing the frequency and duration of regeneration (including rinses) in water softening systems.
		9. Implementing closed storage and impermeable waste/scrap areas to prevent the transport of toxic or hazardous chemicals in aquatic environments.
		10. Preventing the storage, handling, and mixing of substances that pose a risk in aquatic environments (such as oils, emulsions, and binders) with wastewater after use.
		11. Collecting and treating greywater separately on-site and using it in areas that do not require high water quality (such as irrigation of green spaces, floor washing, etc.).
In total, 19 technical recommendations have been proposed for this sector.		

For Steam Generator Manufacturing, Excluding Central Heating Hot Water Boilers (NACE Code):**

(i) Good Management Practices,
(ii) General Preventive Measures are provided under separate headings.

2.1.1 Good Management Practices

Establishment of an Environmental Management System

Environmental Management Systems (EMS) include the necessary organizational structure, responsibilities, procedures, and resources for industrial enterprises to develop, implement, and monitor their environmental policies. The establishment of an EMS improves decision-making processes among institutions regarding raw materials, water-wastewater infrastructure, planned production processes, and various treatment techniques. Environmental management organizes how to manage resource procurement and waste discharge requests with the highest economic efficiency, without compromising product quality, and with the least possible impact on the environment.

The most widely used Environmental Management Standard is ISO 14001. Alternatives include the Eco-Management and Audit Scheme (EMAS) Directive (761/2001), which has been developed for evaluating, improving, and reporting the environmental performance of businesses. It is one of the leading practices under EU legislation concerning eco-efficiency (clean production) and is participated in voluntarily (TUBİTAK MAM, 2016; MoAF, 2021). The benefits of establishing and implementing an Environmental Management System include:

- Economic benefits can be achieved through improved business performance (Christopher, 1998).
- Adopting International Organization for Standardization (ISO) standards increases compliance with global legal and regulatory requirements (Christopher, 1998).
- While minimizing the risks of penalties related to environmental responsibilities, reductions in waste quantity, resource consumption, and operating costs are achieved (Delmas, 2009).
- Using internationally recognized environmental standards eliminates the need for multiple registrations and certifications for businesses operating in different locations worldwide (Hutchens Jr., 2017).
- Especially in recent years, the improvement of internal control processes by companies is also valued by consumers. The implementation of environmental management systems provides a competitive advantage over companies that do not adopt the standard. Additionally, it contributes to institutions gaining a better position in international arenas/markets (Potoski & Prakash, 2005).

The benefits listed above depend on numerous factors such as production processes, management practices, resource use, and potential environmental impacts (MoAF, 2021). Implementing practices like preparing annual inventory reports with similar content to the EMS and monitoring the quantity and quality of inputs and outputs in production processes can lead to savings of 3-5% in water consumption (Öztürk, 2014). The total duration for the development and implementation phases of the EMS is estimated to take 8-12 months (ISO 14001 User Manual, 2015).

Industrial enterprises are also working under the ISO 14046 Water Footprint Standard, which defines the requirements and guidelines for assessing and reporting water footprints. The application of this standard aims to reduce the use of freshwater necessary for production and its environmental impacts. Additionally, the ISO 46001 Water Efficiency Management Systems Standard assists industrial enterprises in achieving water savings and reducing operating costs by enabling monitoring, benchmarking, and reviewing efforts that help develop their water efficiency policies.

- ***Use of Integrated Wastewater Management and Treatment Strategies to Reduce Wastewater Volume and Pollutant Load***

Wastewater management should adopt a holistic approach that encompasses the entire process from wastewater generation to final disposal, including functional elements such as composition, collection, treatment (including sludge disposal), and reuse. The selection of suitable treatment technologies for industrial wastewater depends on integrated factors such as land availability, desired quality of treated water, and compliance with national and local regulations (Abbassi & Al Baz, 2008).

The reuse of treated wastewater not only improves the quality of water bodies but also reduces the demand for freshwater. Therefore, identifying appropriate treatment strategies for different reuse objectives is crucial.

In integrated industrial wastewater treatment, various aspects such as the wastewater collection system, treatment process, and reuse objectives are evaluated together (Naghedi et al., 2020). Methods such as SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats), PESTEL analysis (Political, Economic, Social, Technological, Environmental, and Legal factors), and decision trees can be combined with expert opinions to establish an integrated wastewater management framework (Naghedi et al., 2020). The integration of Analytical Hierarchy Process (AHP) and Combined Compromise Solution (CoCoSo) techniques can be used to determine priority criteria based on multiple factors for industrial wastewater management processes (Adar et al., 2021).

By implementing integrated wastewater management strategies, an average reduction of up to 25% can be achieved in water consumption, wastewater volume, and the pollutant loads of wastewater. The potential payback period for such applications ranges from 1 to 10 years (MoAF, 2021).


http://www.asw-eg.com/en/images/products/116567Water-Sewage-Treatment-System-With-Plant-And-Facility.jpg

Industrial Wastewater Treatment Plant

- ***Technical Training for Personnel to Reduce and Optimize Water Use***

  This measure enhances personnel training and awareness to achieve water conservation and recovery, thereby reducing water consumption and costs while improving water efficiency. In industrial facilities, issues related to high water usage and wastewater generation can arise due to personnel lacking the necessary technical knowledge. For instance, it is essential to properly train cooling tower operators, who represent a significant portion of water consumption in industrial operations, to ensure they possess the necessary technical skills. Relevant staff must also have adequate technical knowledge for determining water quality requirements, measuring water and wastewater quantities, and other related practices (MoAF, 2021). Therefore, it is crucial to provide training to personnel regarding water use reduction, optimization, and water conservation policies. Involving staff in water-saving initiatives and creating regular reports on water usage before and after these initiatives, which are shared with personnel, supports participation and motivation in the process. The technical, economic, and environmental benefits derived from personnel training yield results in the medium to long term (TUBİTAK MAM, 2016; MoAF, 2021).

- ***Monitoring Water Use and Wastewater Characteristics in Production and Auxiliary Processes***

  Industrial facilities have resource usages, and the inefficiencies and environmental problems that arise from resource consumption can stem from input-output flows. Therefore, it is necessary to monitor the quantity and quality of water used and wastewater generated in production and auxiliary processes (TUBİTAK MAM, 2016; MoAF, 2021). Monitoring based on process quantity and quality can lead to reductions in energy consumption by 6-10%, as well as water consumption and wastewater generation by up to 25% when combined with other good management practices (such as personnel training and establishing an environmental management system) (Öztürk, 2014).

  The main steps for monitoring water and wastewater quantities and qualities include:

  - Utilizing monitoring devices (such as meters) to track water, energy, and other consumptions at the process level,
  - Creating procedures for consistent monitoring across processes,
  - Identifying and documenting all inputs (raw materials, chemicals, water) and outputs (products, wastewater, sludge, solid waste, hazardous waste, by-products), determining their usage/output points, monitoring them in terms of quantity and quality, documenting them, comparing them, and reporting,
  - Monitoring raw material losses in production processes where raw materials are converted into products and taking measures against these losses (MoEUC, 2020e).

- ***Optimizing Water Consumption Through Effective Production Planning***

  Planning industrial production processes to minimize the use of resources up to the point where a raw material is transformed into a product is an effective practice for reducing labor costs, resource usage costs, environmental impacts, and ensuring efficiency (TUBİTAK MAM, 2016; MoAF, 2021). Taking water efficiency factors into account in production planning within industrial facilities reduces water consumption and wastewater generation. Modifying production processes or combining certain processes in industrial facilities provides significant benefits in terms of water efficiency and time management (MoAF, 2021).

- ***Developing a Water Efficiency Action Plan to Reduce Water Use and Prevent Water Pollution***

  Preparing an action plan that outlines short, medium, and long-term strategies to reduce water and wastewater quantities and prevent water pollution is crucial for water efficiency in industrial facilities. At this stage, it is essential to determine the water needs across the facility and within production processes, establish quality requirements at water usage points, and identify wastewater generation points along with wastewater characterization (MoAF, 2021). Additionally, identifying the measures to reduce water consumption, wastewater generation, and pollution loads, conducting feasibility studies, and preparing action plans for the short, medium, and long term are necessary. This approach ensures water efficiency and sustainable water usage within the facilities (MoAF, 2021).

- ***Setting Water Efficiency Targets***

  The first step to achieving water efficiency in industrial facilities is to establish clear targets (MoAF, 2021). To do this, a detailed water efficiency analysis based on processes must be conducted. This will help identify unnecessary water use, water losses, improper practices affecting water efficiency, process losses, and reusable water and wastewater sources that can be treated or used without treatment. It is also crucial to determine the water conservation potential and water efficiency targets for each production process and across the facility as a whole (MoAF, 2021)

Preparing Water Flow Diagrams and Mass Balances for Water

Identifying points of water use and wastewater generation in industrial facilities and creating water-wastewater balances for production processes and auxiliary processes form the foundation for many good management practices. Developing process profiles for the entire facility and on a process-by-process basis facilitates the identification of unnecessary water use points and high water consumption areas, evaluating water recovery opportunities, process modifications, and detecting water losses (MoAF, 2021).

2.1.2 General Measures

- ***Detecting and Reducing Water Losses***

In industrial production processes, water losses occur in equipment, pumps, and pipelines. First, it is essential to identify these water losses and prevent leaks by ensuring that equipment, pumps, and pipelines are regularly maintained and kept in good condition (IPPC BREF, 2003). Regular maintenance procedures should focus on the following:

- Adding pumps, valves, level switches, pressure, and flow regulators to the maintenance checklist,
- Conducting inspections not only in the water system but also in heat transfer and chemical distribution systems, as well as for broken and leaking pipes, barrels, pumps, and valves,
- Regularly cleaning filters and pipelines,
- Calibrating measurement equipment such as chemical dosing and distribution devices, thermometers, etc., and routinely checking and monitoring them at established intervals (IPPC BREF, 2003).

Effective maintenance, cleaning, and loss control practices can lead to water savings ranging from 1% to 6% in consumption (Öztürk, 2014).

- ***Minimizing Spills and Leaks***

Spills and leaks in businesses can lead to losses of both raw materials and water. Moreover, when wet cleaning methods are used to clean areas where spills occur, there can be increases in water consumption, wastewater volumes, and the pollution load of those wastewaters (MoAF, 2021). To reduce losses of raw materials and products, measures such as splash guards, drip trays, and screens should be employed to mitigate spills and splashes (IPPC BREF, 2019).

- ***Using Automatic Control-Shutoff Valves to Optimize Water Use***

Monitoring and controlling water consumption through flow control devices, meters, and computer-assisted monitoring systems provide significant technical, environmental, and economic advantages (Öztürk, 2014). Tracking the amount of water consumed within the facility and various processes helps prevent water losses (TUBİTAK MAM, 2016). The use of flow meters and gauges throughout the facility and specific production processes, automatic shutoff valves in continuously operating machines, and computer-assisted systems should be implemented to develop monitoring and control mechanisms based on water consumption and certain quality parameters (TUBİTAK MAM, 2016). With these applications, it is possible to achieve savings of 20-30% in process-specific water consumption (DEPA, 2002; LCPC, 2010; IPPC BREF, 2003). Monitoring and controlling water consumption at the process level can also lead to savings of 3-5% in process water use (Öztürk, 2014).

- ***Avoiding the Use of Drinking Water in Production Lines***

  In various subsectors of the manufacturing industry, water of different qualities can be used according to production needs. Industrial facilities typically use raw water sourced from underground water resources, which is treated before being utilized in production processes. However, in some cases, drinking water is directly used in production processes, even though it can be costly, or raw water is disinfected with chlorine compounds before being used in production. Water containing residual chlorine can react with organic compounds (natural organic matter, or DOM) present in the water, forming harmful disinfection by-products that can negatively impact biological metabolism (Özdemir & Toröz, 2010; Oğur et al.; MoAF, 2021). Therefore, the use of drinking water containing residual chlorine compounds or raw water disinfected with chlorine should be avoided as much as possible. Instead of chlorine disinfection, methods with high oxidation capabilities, such as ultraviolet (UV), ultrasound (US), or ozone, can be used for disinfecting raw water. By identifying and utilizing the necessary water quality parameters for each production process, unnecessary water procurement and treatment costs can be reduced, thereby increasing the technical, economic, and environmental benefits of the application. This practice can lead to reductions in water, energy, and chemical costs (TUBİTAK MAM, 2016).

- ***Implementing Automatic Equipment for Water Conservation at Water Use Points***

  Water is crucial in many sectors of the manufacturing industry, both for production processes and for personnel to meet necessary hygiene standards. In industrial facilities, water consumption for production can be managed in various ways. Additionally, employing equipment like sensor faucets and smart handwashing systems in personnel water usage areas can help achieve water savings. Smart handwashing systems adjust the water, soap, and air mixture in the correct proportions, promoting water conservation while also enhancing resource efficiency.

- ***Separate Collection and Treatment of Gray Water for Use in Areas with Low Water Quality Requirements***

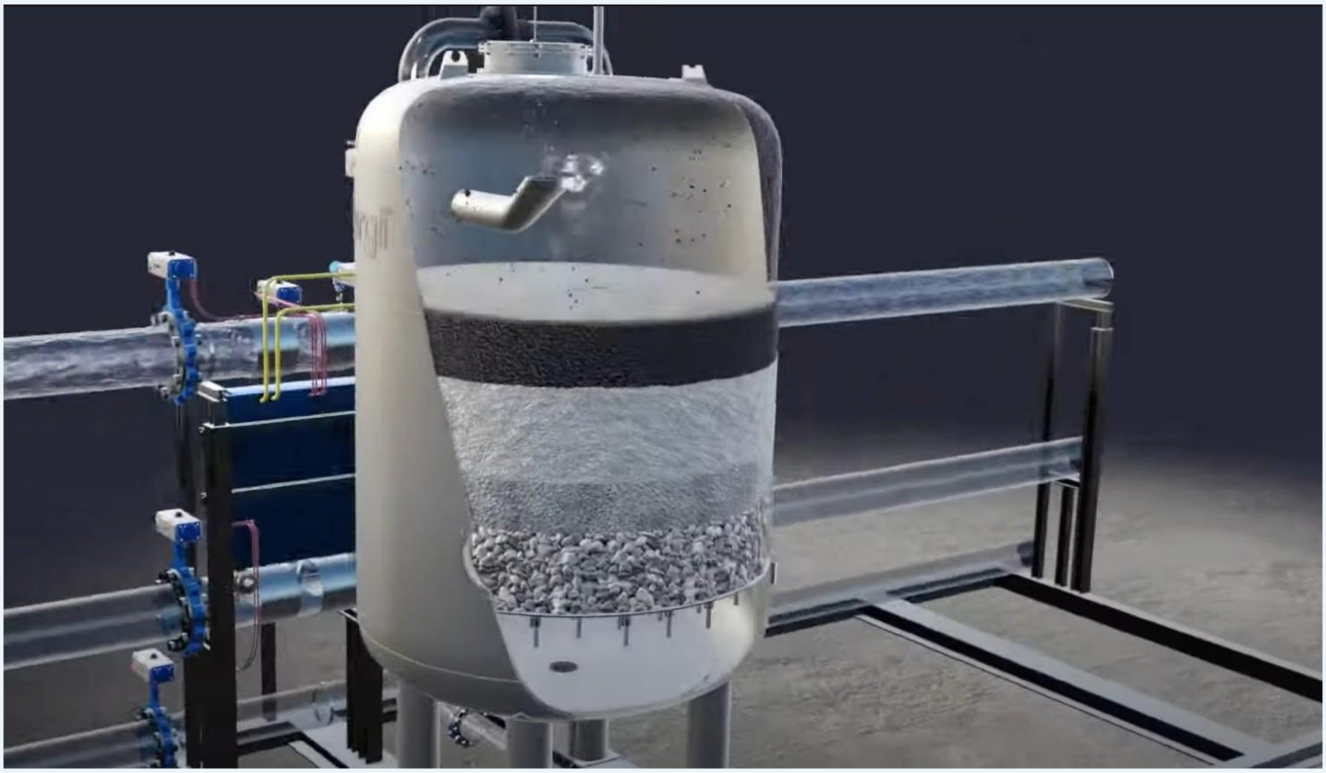
  In industrial facilities, wastewater is not only generated from production processes but also from showers, sinks, kitchens, and similar areas. The wastewater from showers, sinks, kitchens, and other sources is referred to as gray water. By treating this gray water through various treatment processes and using it in areas that do not require high water quality (such as irrigation of green spaces and cleaning of floors), significant water savings can be achieved.

- ***Optimizing the Frequency and Duration of Regeneration in Water Softening Systems***

One of the most commonly used methods for softening raw water in industrial facilities is the use of cation exchange resins, which require regular regeneration. The regeneration process typically involves three steps: pre-washing the resin with raw water, regenerating with brine, and performing a final rinse. The regeneration intervals are determined based on the hardness of the water; higher hardness levels necessitate more frequent regeneration in the water softening systems.

During the regeneration process, wastewater from washing, regenerating, and rinsing is often disposed of directly. However, if the washing and final rinse water is of raw water quality, it can be redirected to the raw water reservoir or reused in processes that do not require high water quality, such as facility cleaning and irrigation of green spaces (MoAF, 2021).

Determining the optimal regeneration frequency is crucial in regeneration systems. While regeneration in water softening systems can be adjusted based on supplier recommendations or the flow rate and duration of the softening system, this frequency also varies with the calcium concentration in the raw water. Therefore, online hardness measurement is implemented to determine the regeneration frequency. This approach not only allows for the optimization of regeneration frequencies but also prevents unnecessary washing, rinsing, or backwashing with brine through the use of online hardness sensors.



Water Sortening Systems

- ***Reusing Backwash Water from Pressurized Filtration Before Water Softening***

  Many industrial processes require softened water with low concentrations of calcium and magnesium. Water softening systems remove calcium, magnesium, and other metal cations from hard water, resulting in soft water.

  Reusing backwash water from pressurized filtration systems at appropriate points leads to significant water savings. This practice aligns with methods such as "reusing filter backwash water in production processes and employing in-situ cleaning systems to reduce overall water consumption."

- ***Preventing the Contamination of Wastewater with Risky Substances***

  To prevent the introduction of risky substances like oils, emulsions, and binders into wastewater streams in industrial facilities, dry cleaning techniques can be implemented, and leaks can be effectively controlled. This approach contributes to the protection of water resources (TUBİTAK MAM, 2016).

- ***Closed Storage and Impermeable Waste Disposal Areas for Toxic Chemicals***

  To prevent the transportation of toxic or hazardous chemicals to receiving environments, industrial facilities can implement closed and impermeable waste disposal areas. This practice is already in place under existing environmental regulations in our country. Through fieldwork, separate collection channels can be established for storage areas containing toxic or hazardous substances, ensuring that any potential leakages are collected separately and do not mix with natural water bodies.

- ***Recovery of Water from Rinsing Solutions***

  In industrial settings, rinse wastewater is typically less contaminated and can be reused without treatment for activities that do not require high water quality, such as floor washing and garden irrigation (Öztürk, 2014). By recovering rinse water, it is possible to achieve a 1-5% reduction in raw water consumption.

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