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MINISTRY OF AGRICULTURE AND FORESRY
GENERAL DIRECTORATE OF WATER MANAGEMENT

Water Efficiency Campaign

Water Efficiency Guidance Document Series

METAL DOOR AND WINDOW MANUFACTURING

NACE CODE: 25.12

ANKARA 2023

It was commissioned by the Ministry of Agriculture and Forestry, General Directorate of Water Management to the Contractor İO Environmental Solutions R&D Ltd. Şti.

Content

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

1 Introduction

Our country is located in the Mediterranean basin, where the effects of global climate change are strongly felt, and it is considered one of the regions that will be most affected by the adverse impacts of climate change. Projections regarding how water resources in our basins may be affected by climate change in the future indicate that our water resources could decrease by up to 25% over the next century.

In 2022, the annual per capita availability of usable water in Türkiye was 1,313 m^3. With the increasing impacts of human pressures and climate change, this amount is expected to fall below 1,000 m^3 per person after 2030. If necessary measures are not taken, Türkiye may soon face water scarcity, bringing with it numerous social and economic challenges. As evidenced by the results of future projections, the risk of drought and water scarcity awaiting our country makes it essential to use our existing water resources efficiently and sustainably.

The concept of water efficiency can be defined as "using the minimum amount of water in the production of a product or service." The water efficiency approach emphasizes the rational, equitable, efficient, and effective use of water across all sectors, including drinking water, agriculture, industry, and household use, while safeguarding water in terms of both quantity and quality. This approach considers the needs not only of people but also of ecosystems and all living beings.

The increasing demand for water resources, changing precipitation and temperature patterns due to climate change, and the rising trends in population, urbanization, and pollution make the equitable and balanced distribution of water resources among users increasingly crucial. Therefore, it has become necessary to establish a roadmap based on efficiency and optimization for the sustainable management and conservation of these limited water resources.

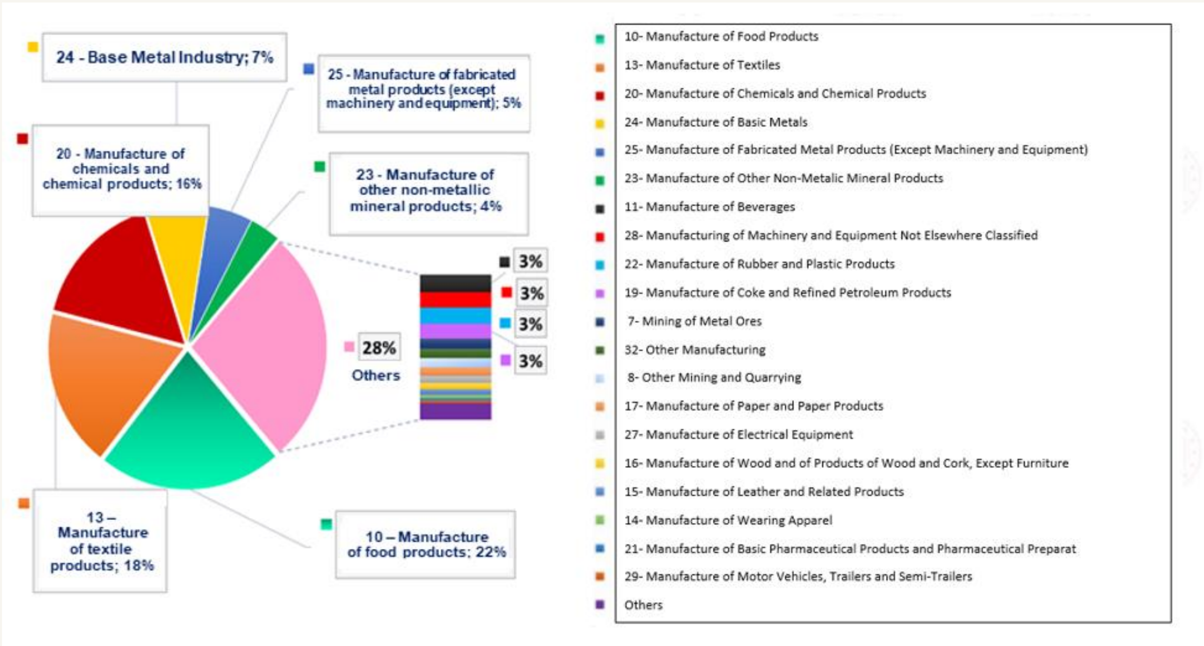
In the sustainable development vision set by the United Nations, targets such as Goal 7: Ensuring Environmental Sustainability among the Millennium Development Goals and Goal 9: Industry, Innovation, and Infrastructure and Goal 12: Responsible Consumption and Production among the Sustainable Development Goals emphasize the efficient, fair, and sustainable use of resources—particularly water—as well as eco-friendly production and consumption practices that consider future generations' well-being. In line with the European Green Deal, which aims to achieve carbon neutrality and establish a clean, circular economic model, Türkiye’s European Green Deal Action Plan outlines actions to promote water and resource efficiency in production and consumption, particularly within the industrial sector, as well as across other fields to reduce environmental impacts.

The “Industrial Emissions Directive (IED),” one of the most important components of European Union environmental legislation from an industrial perspective, includes measures necessary for the integrated control, prevention, or reduction of discharges/emissions into the receiving environment, such as air, water, and soil, originating from industrial activities. The directive presents Best Available Techniques (BAT) to systematically facilitate the applicability of clean production processes and to eliminate difficulties encountered in practice. Considering costs and benefits, BATs represent the most effective application techniques for high-level environmental protection. In accordance with the directive, Reference Documents (BAT-BREF) have been prepared, detailing BATs for each sector. These BREF documents provide a general framework that includes BATs, good management practices, technical measures of a general preventive nature, chemical use and management, techniques for various production processes, wastewater management, emission management, and waste management.

The General Directorate of Water Management of the Ministry of Agriculture and Forestry is conducting studies aimed at promoting efficient practices in urban, agricultural, industrial, and individual water uses, as well as increasing societal awareness. Under the “Water Efficiency Strategy Document and Action Plan (2023-2033)” which came into force with the Presidential General Circular 2023/9, action plans addressing all sectors and stakeholders have been prepared. In the Industrial Water Efficiency Action Plan, a total of 12 actions have been identified for the 2023-2033 period, and responsible and relevant institutions have been designated for these actions. Within this action plan, actions such as determining specific ranges of water usage and quality requirements by subsector in industry, organizing technical training programs and workshops on a sectoral basis, and preparing water efficiency guidance documents are defined under the responsibility of the General Directorate of Water Management.

On the other hand, the "Industrial Water Use Efficiency Project by NACE Codes," conducted by the General Directorate of Water Management, has identified sector-specific best practices for improving water efficiency in industry. As a result of this study, sectoral guidance documents and action plans have been prepared, classified by NACE codes, containing recommended measures to improve water use efficiency in high water-consuming sectors operating in Türkiye.

Like many countries around the world, the sectors with the highest share in water consumption in Türkiye are food, textiles, chemicals, and primary metals. As part of the study, field visits were conducted in businesses representing 152 subsectors across 35 main sectors, including food, textiles, chemicals, and primary metals, characterized by high water consumption according to NACE Codes. Data on water supply, sectoral water usage, wastewater generation, and recovery were collected, and information was provided on existing best available techniques (BAT) published by the European Union, water efficiency, clean production, water footprint, and other relevant topics.



As a result of the studies, specific water consumption and potential savings rates for processes in 152 different four-digit NACE codes with high water consumption have been determined. Water efficiency guidance documents have been prepared, taking into account the EU's Best Available Techniques (BAT) and other clean production techniques. Within these guides, approximately 500 techniques related to water efficiency are examined under four main categories (i) Good Management Practices, (ii) General Preventive Measures, (iii) Measures Related to Auxiliary Processes, (iv) Sector-Specific Measures.

During the identification phase of BATs for each sector in the project, considerations included environmental benefits, operational data, technical specifications/requirements, and feasibility criteria. The determination of BATs was not limited to BREF documents; various data sources, including up-to-date global literature, real case studies, innovative applications, and reports from industry representatives, were thoroughly examined to create sector-specific BAT lists. To evaluate the suitability of the established BAT lists for Türkiye's local industrial infrastructure and capacity, specific BAT lists were prepared for each NACE code. These lists were prioritized by businesses based on criteria such as water savings, economic savings, environmental benefits, feasibility, and cross-media effects. The scoring results were used to determine the final BAT lists. Based on the water and wastewater data collected from the visited facilities and the final BAT lists developed with consideration of the local dynamics unique to Türkiye, sectoral water efficiency guides have been created on a NACE code basis.

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)

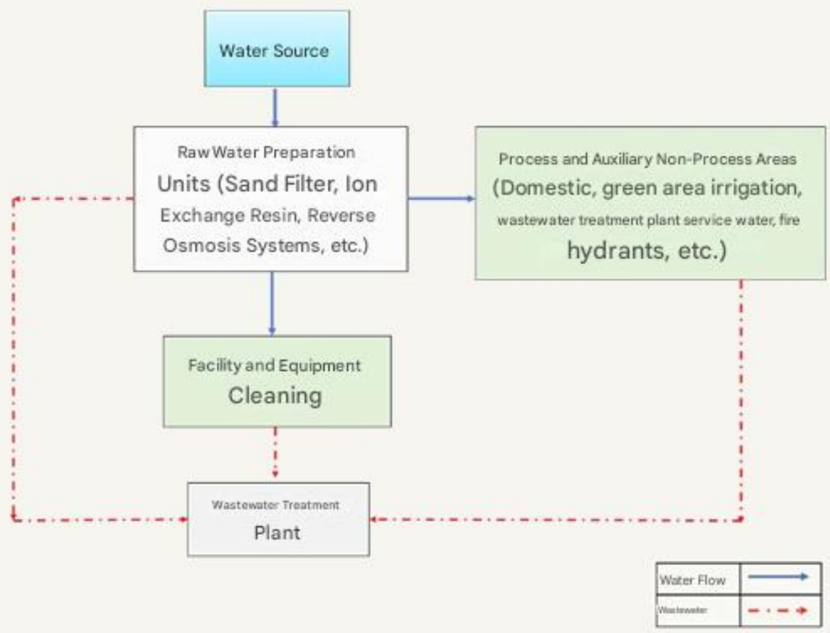
- Manufacturing of machinery and equipment not classified elsewhere (including 8 sub-production areas represented by four-digit NACE codes)
- Manufacturing of motor vehicles, trailers, and semi-trailers (including 3 sub-production areas represented by four-digit NACE codes)
- Manufacturing of other transportation 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

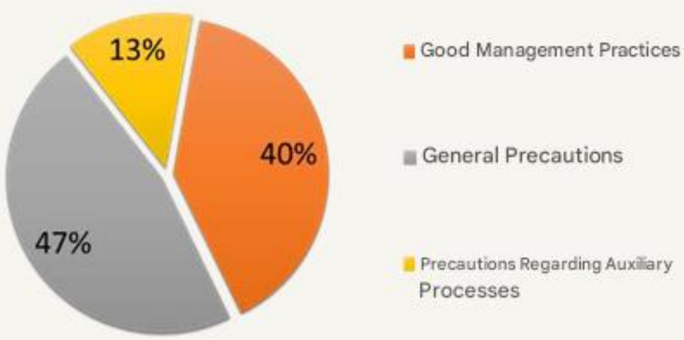
2.1 Metal Door and Windows Manufacturing (NACE 25.12)

Metal Door and Window Manufacturing Industry Water Flow Diagram



	Minimum	Maximum
Specific Water Consumption of Facilities Visited within the Scope of the Project (L/kg product)	0.002	
Reference Specific Water Consumption (L/kg product)	6	42

Percentage Distribution of Water Efficiency Practices



In the manufacturing of metal doors and windows, cut metal parts are cleaned with a suitable cleaning agent. Adhesive is applied to both sides of the cut surfaces, and corner blocks are assembled. The corners with blocks are mounted together. The glass carrier and insulation block are placed in the mounted frame. Then, wedge seals are installed. After determining the positions where assembly will take place, the screwing process is carried out. Final inspections of the completed product are conducted, and it is packaged.

In facilities manufacturing metal doors and windows, there is no water usage in the basic production processes. However, significant amounts of water are consumed for filter washing, resin regeneration, and membrane cleaning processes in raw water preparation units, such as sand filters, ion exchange resins, and reverse osmosis, which are used to produce soft water for production processes in the sector.

The specific reference water consumption in the metal door and window manufacturing sector ranges from 6 to 42 L/kg. In the production branch analyzed within the scope of the study, the specific water consumption is extremely low at 0.002 L/kg, while the domestic specific water consumption is 46.45 L/person.day. With the implementation of good management practices, general measures, and measures related to auxiliary processes, it is possible to achieve a water recovery rate of 54% to 77% in the sector.

25.12 The proposed priority water efficiency application techniques under the NACE code for Metal Door and Window Manufacturing are presented in the table below.

NACE Code	Description		Prioritized Sectoral Water Efficiency Techniques
25.12	Manufacture of Metal Doors and Windows		**Good Management Practices**
		1.	Use of an integrated wastewater management and treatment strategy to reduce wastewater quantity and pollutant load
		2.	Establishment of an environmental management system
		3.	Preparation of water flow diagrams and mass balance for water
		4.	Development of a water efficiency action plan to reduce water usage and prevent water pollution
		5.	Providing technical training to personnel for reducing and optimizing water usage
		6.	Proper production planning to optimize water consumption
		7.	Monitoring the quantity and quality of water used and the resulting wastewater in production and auxiliary processes, and integrating this information into the environmental management system
			General Preventive Measures
		1.	Minimization of spills and leaks
		2.	Recovery of water from rinsing solutions and reuse of recovered water in suitable processes
		3.	Use of automatic devices and equipment (sensors, smart handwashing systems, etc.) that save water at water usage points such as showers/toilets
		4.	Use of pressure washing systems for equipment cleaning and general cleaning processes
		5.	Avoiding the use of drinking water in production lines
		6.	Using cooling water as process water in other processes
		7.	Detection and reduction of water losses
		8.	Use of automatic control-shutoff valves to optimize water usage
		9.	Documenting production procedures to prevent water and energy waste and ensuring they are used by employees
		10.	Creating closed storage and impermeable waste/scrap areas to prevent the transport of toxic or hazardous chemicals in aquatic environments
		11.	Preventing the storage, keeping, and mixing of substances that pose risks to aquatic environments (such as oils, emulsions, binders) with wastewater after use
		12.	Preventing the mixing of clean water streams with contaminated water streams

NACE Code	Description		Prioritized Sectoral Water Efficiency Techniques
25.12	Manufacture of Metal Doors and Windows	13.	Characterization of wastewater quantities and qualities at all wastewater generation points to identify wastewater flows that can be reused, either treated or untreated
		14.	Use of closed-loop water circulation in suitable processes
		15.	Use of computer-aided control systems in production processes
		16.	Reuse of relatively clean wastewater generated from washing, rinsing, and equipment cleaning without treatment in production processes
		17.	Separate collection and treatment of greywater in the facility for use in areas that do not require high water quality (e.g., irrigation of green areas, floor cleaning, etc.)
		18.	Implementation of time optimization in production and organization of all processes to be completed in the shortest time possible
		19.	Collection of rainwater for use as an alternative water source for facility cleaning or suitable areas
			Measures Related to Auxiliary Processes
		1.	Replacement of old equipment in the ventilation system with ion exchange resins based on reverse osmosis principles (systems producing demineralized water) and reuse of water
		2.	Reuse of the liquid formed by condensation from the ventilation system
		3.	Identification of processes needing wet cooling to avoid unnecessary cooling operations
		4.	Reduction of water consumption by increasing the cycle numbers and improving the quality of makeup water in closed-circuit cooling systems
		5.	Implementation of closed-circuit cooling systems to reduce water usage
		A total of 31 technical recommendations have been proposed in this sector.	

For the Metal Door and Window Manufacturing NACE Code;

(i) Good Management Practices,
(ii) General Measures, and
(iii) Measures Related to Auxiliary Processes are presented 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 organizations to develop, implement, and monitor their environmental policies. Establishing an EMS improves decision-making processes among organizations regarding raw materials, water-wastewater infrastructure, planned production processes, and different treatment techniques. Environmental management organizes how to manage the demands for resource procurement and waste discharge with the highest economic efficiency, without compromising product quality and with the least possible impact on the environment.

The most commonly used Environmental Management Standard is ISO 14001. Alternatives include the Eco-Management and Audit Scheme Directive (EMAS) (761/2001). This standard has been developed for the assessment, improvement, and reporting of companies' environmental performance. It is one of the leading practices under the EU legislation regarding eco-efficiency (clean production), and participation is voluntary (TUBİTAK MAM, 2016; MoAF, 2021). The benefits of establishing and implementing an Environmental Management System are as follows:

- Economic benefits can be obtained by improving business performance (Christopher, 1998).
- By adopting International Organization for Standardization (ISO) standards, better compliance with global legal and regulatory requirements is achieved (Christopher, 1998).
- The risks of penalties related to environmental responsibilities are minimized, while reductions in waste quantity, resource consumption, and operating costs are achieved (Delmas, 2009).
- The use of internationally recognized environmental standards eliminates the need for multiple registrations and certifications for businesses operating in different locations around the world (Hutchens Jr., 2017).
- Particularly in recent years, consumers have emphasized the importance of improving companies' internal control processes. The implementation of environmental management systems provides a competitive advantage over companies that do not adopt the standard. Furthermore, it contributes to organizations' better positioning in international fields/markets (Potoski & Prakash, 2005).

The benefits listed above are contingent upon numerous factors, such as the production process, management practices, resource utilization, and potential environmental impacts (MoAF, 2021). By preparing annual inventory reports with similar content to the Environmental Management System (EMS) and monitoring the quantity and quality of inputs and outputs in production processes, water consumption can be reduced by approximately 3-5% (Öztürk, 2014). The total duration for developing and implementing the EMS is estimated to take 8-12 months (ISO 14001 User Manual, 2015).

Industrial organizations 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 the associated environmental impacts. Additionally, the ISO 46001 Water Efficiency Management Systems Standard assists industrial organizations in achieving water savings and reducing operational costs. It helps organizations develop their water efficiency policies through monitoring, benchmarking, and review activities.

- ***Using Integrated Wastewater Management and Treatment Strategies to Reduce Wastewater Quantity and Pollutant Load***

Wastewater management should adopt a holistic approach from the production of wastewater to its final disposal and must encompass functional elements such as composition, collection, treatment (including sludge disposal), and reuse. The selection of appropriate 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 suitable treatment strategies for different reuse objectives is crucial.

In integrated industrial wastewater treatment, different aspects such as the wastewater collection system, treatment process, and reuse objectives are evaluated together (Naghedi et al., 2020). Methods like the 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 Analytic Hierarchy Process (AHP) and Combined Compromise Solution (CoCoSo) techniques can be utilized to determine criteria-based priorities for industrial wastewater management processes (Adar et al., 2021).

The implementation of integrated wastewater management strategies can achieve an average reduction of up to 25% in water consumption, wastewater quantity, and the pollution loads of wastewater. The potential payback period for this implementation varies between 1 to 10 years (MoAF, 2021).

Endüstriyel Atıksu Arıtma Tesisi

- ***Reducing and Optimizing Water Use through Technical Training for Personnel***

  This measure aims to enhance personnel training and awareness to achieve water conservation and water recovery, thereby reducing water consumption and costs while ensuring water efficiency. In industrial facilities, the lack of necessary technical knowledge among personnel can lead to significant water usage and wastewater generation issues. For example, it is crucial that cooling tower operators, who represent a significant portion of water consumption in industrial operations, are adequately trained and possess the necessary technical knowledge. Personnel must also have sufficient technical expertise in applications such as determining water quality requirements in production processes and measuring water and wastewater quantities (MoAF, 2021). Therefore, providing training on reducing and optimizing water use and water conservation policies is of great importance. Involving personnel in water conservation efforts, creating regular reports on water usage amounts before and after initiatives aimed at water efficiency, and sharing these reports with staff all support participation and motivation in the process. The technical, economic, and environmental benefits gained from personnel training yield results in the medium to long term (TUBİTAK MAM, 2016; MoAF, 2021).

- ***Monitoring the Quantity and Quality of Water Used and Wastewater Generated in Production and Auxiliary Processes, and Adapting This Information to the Environmental Management System***

  Industrial facilities utilize resources, and inefficiencies and environmental problems resulting from resource use 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 quantity and quality based on processes, in conjunction with other good management practices (such as personnel training and establishing an environmental management system), can lead to reductions of 6-10% in energy consumption and up to 25% in water consumption and wastewater quantities (Öztürk, 2014).

  The main stages for monitoring the quantity and quality of water and wastewater are as follows:

  - Utilizing monitoring equipment (such as meters) to track water, energy, etc. consumption based on processes,
  - Establishing monitoring procedures,
  - Identifying all inputs and outputs related to the production process (raw materials, chemicals, water, products, wastewater, sludge, solid waste, hazardous waste, and by-products), monitoring them in terms of quantity and quality, documenting, comparatively evaluating, and reporting them,
  - Monitoring raw material losses in production processes where raw materials are transformed into products and taking measures against these losses (MoEUC, 2020e).

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

  In industrial production processes, planning the transformation of a raw material into a product with minimal process use is an effective practice for reducing labor costs, resource usage costs, and environmental impacts, while ensuring efficiency (TUBİTAK MAM, 2016; MoAF, 2021). When production planning in industrial facilities takes water efficiency into account, it 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 scheduling (MoAF, 2021).

- ***Preparing a Water Efficiency Action Plan to Reduce Water Usage and Prevent Water Pollution***

  Developing an action plan that outlines short, medium, and long-term actions to reduce water and wastewater quantities and prevent water pollution in industrial facilities is crucial for water efficiency. In this context, determining the water needs throughout the facility and in production processes, identifying quality requirements at water usage points, and characterizing points of wastewater generation should be carried out (MoAF, 2021). Additionally, measures to reduce water consumption, wastewater generation, and pollution loads must be identified, their feasibility assessed, and action plans prepared for the short, medium, and long term. This ensures water efficiency and sustainable water use in facilities (MoAF, 2021).

- ***Preparing Water Flow Diagrams and Mass Balances for Water***

  Identifying water usage and wastewater generation points in industrial facilities and creating water-wastewater balances for production processes and auxiliary processes is generally fundamental to many good management practices. Developing process profiles based on facility-wide and production process-specific data facilitates the identification of unnecessary water usage points and high water consumption areas, assesses water recovery opportunities, evaluates process modifications, and identifies water losses (MoAF, 2021).

2.1.2 General Measures

- ***Detection and Reduction of Water Losses***

In industrial production processes, water losses occur in equipment, pumps, and pipelines. Firstly, water losses should be identified, and regular maintenance should be performed on equipment, pumps, and pipelines to prevent leaks (IPPC BREF, 2003). Regular maintenance procedures should pay particular attention to the following aspects:

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

Effective maintenance, cleaning, and loss control practices can provide savings of 1-6% in water consumption (Öztürk, 2014).

- ***Minimizing Spills and Leaks***

Spills and leaks occurring in operations can result in both raw material and water losses. Furthermore, when wet cleaning methods are used to clean spill areas, there may be increases in water consumption, wastewater amounts, and pollution loads of wastewater (MoAF, 2021). To reduce raw material and product losses, spill preventers, flaps, drip trays, and sieves are utilized to minimize spills and splashing losses (IPPC BREF, 2019).

- ***Reuse of Relatively Clean Wastewater from Washing, Rinsing, and Equipment Cleaning***

In industrial facilities, relatively clean wastewater, such as wash-final rinse wastewater and filter backwash wastewater, can be reused without treatment for floor washing and garden irrigation operations that do not require high water quality, resulting in savings of 1-5% in raw water consumption. The initial investment costs necessary for the application include the establishment of new pipelines and reserve tanks (Öztürk, 2014).

- ***Recovery of Water from Rinsing Solutions and Reuse of Recovered Water in Suitable Processes***

In industrial facilities, rinsing wastewater, which is relatively clean, can be reused without treatment for floor washing and garden irrigation processes that do not require high water quality (Öztürk, 2014). Recovering rinsing water can lead to savings of 1-5% in raw water consumption.

- ***Prevention of Clean Water Flows Mixing with Wastewater Flows***

  In industrial facilities, identifying wastewater generation points and characterizing the wastewater allows for the separation of highly polluted wastewater from relatively clean wastewater into separate lines (TUBITAK MAM, 2016; MoAF, 2021). This enables the appropriate quality wastewater flows to be reused either after treatment or without treatment. By separating wastewater flows, water pollution is reduced, treatment performance is improved, energy consumption related to reduced treatment needs is decreased, and emissions are reduced through the recovery of wastewater and valuable materials. Additionally, heat recovery from separated hot wastewater flows is also possible (TUBITAK MAM, 2016; MoAF, 2021). However, the separation of wastewater flows generally requires high investment costs, although cost reductions can be achieved in situations where a large amount of wastewater and energy can be recovered (IPPC BREF, 2006).

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

  Monitoring and controlling water consumption using flow control devices, meters, and computer-assisted monitoring systems provides significant technical, environmental, and economic advantages (Öztürk, 2014). Monitoring the amount of water consumed within the facility and various processes helps to prevent water losses (TUBITAK MAM, 2016). The use of flow meters and counters throughout the facility and in specific production processes, along with automatic shutoff valves and valves in continuously operating machines, requires the development of monitoring and control mechanisms based on water consumption and certain specified quality parameters using computer-assisted systems (TUBITAK MAM, 2016). This application can lead to savings of 20-30% in process-specific water consumption (DEPA, 2002; LCPC, 2010; IPPC BREF, 2003). Monitoring and controlling process water consumption can achieve savings of 3-5% (Öztürk, 2014).

- ***Use of Pressure Washing Systems for Equipment Cleaning, General Cleaning, etc.***

  Water nozzles are commonly used for cleaning equipment and facilities. Effective results can be achieved in reducing water consumption and wastewater pollution loads by using properly positioned and suitable nozzles. The use of active sensors and nozzles at points of high water consumption is crucial for the efficient use of water. Significant water savings can be achieved by replacing mechanical equipment with pressure nozzles (TUBITAK MAM, 2016). In technically suitable processes, the use of optimized nozzles for water pressure contributes to the main environmental benefits of reducing water consumption, wastewater generation, and wastewater pollution load.

- ***Minimizing the Storage, Handling, and Post-Use Mixing of Risky Substances in Aquatic Environments (such as oils, emulsions, binders)***

  To prevent chemicals that pose a risk to aquatic environments, such as oils, emulsions, and binders, from mixing with wastewater flows in industrial facilities, dry cleaning techniques can be used and leaks can be prevented. This helps protect water resources (TUBITAK MAM, 2016).

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

In the manufacturing sector, different sub-sectors can utilize water of varying qualities according to their production needs. Typically, raw water sourced from underground water resources is treated and then used in production processes in industrial facilities. However, in some cases, despite being costly, drinking water may be used directly in production processes, or raw waters may be treated with chlorine compounds before being utilized. Water containing residual chlorine can react with organic compounds present in the water (natural organic matter (DOM)), resulting in harmful disinfection byproducts for living organisms (Özdemir & Toröz, 2010; Oğur et al.; MoAF, 2021). The use of drinking water containing residual chlorine compounds or raw waters disinfected with chlorine compounds should be avoided as much as possible. Instead of chlorination for disinfecting raw waters, methods with high oxidation capabilities such as ultraviolet (UV), ultrasound (US), or ozone can be employed. To enhance the technical, economic, and environmental benefits of this application, it is essential to determine and utilize the required water quality parameters for each production process, which helps reduce unnecessary water procurement and treatment costs. This practice can lead to reductions in water, energy, and chemical costs (TUBITAK MAM, 2016).

- ***Collecting Rainwater for Use in Facility Cleaning or as an Alternative Water Source in Suitable Areas***

In today's context of dwindling water resources, rainwater harvesting is increasingly preferred, especially in regions with low rainfall. Various technologies and systems for rainwater collection and distribution are available, including cistern systems, ground infiltration, surface collection, and filtration systems. If the rainwater collected through special drainage systems meets the required quality standards, it can be used for production processes, garden irrigation, cleaning tanks and equipment, surface cleaning, etc. (Tanık et al., 2015).

In various cases, rainwater collected from industrial facility rooftops has been stored and used within the building and in landscape areas, achieving a 50% water savings in landscape irrigation (Yaman, 2009). To enhance soil permeability and allow rainwater to infiltrate and absorb into the ground, perforated stones and green areas can be preferred (Yaman, 2009). Rainwater collected from building rooftops can be used for vehicle washing and garden irrigation. After usage, collected waters can be biologically treated and recovered at a rate of 95% for reuse (Şahin, 2010).

- ***Using Cooling Water as Process Water in Other Processes***

Water cooling systems are commonly used in processes that heavily utilize thermal energy and require cooling. Heat recovery can be achieved through the use of heat exchangers during the return of cooling water, which helps prevent the contamination of cooling water and increases the return rates of cooling water, leading to water and energy savings (TUBITAK MAM, 2016; MoAF, 2021). Additionally, when cooling waters are collected separately, it is often possible to use the collected waters for cooling purposes or to re-evaluate them in suitable processes (EC, 2009). The reuse of cooling waters can achieve a 2-9% savings in total water consumption (Greer et al., 2013). Energy consumption can also be reduced by up to 10% (Öztürk E., 2014; MoAF, 2021).

- ***Documenting and Utilizing Production Procedures to Prevent Water and Energy Waste***

  To achieve efficient production in an enterprise, effective procedures must be implemented to identify, assess potential problems and resources, and control production stages (Ayan, 2010). By determining and applying appropriate procedures in production processes, resources (such as raw materials, water, energy, chemicals, personnel, and time) can be utilized more efficiently, ensuring reliability and quality in the production processes (Ayan, 2010). The presence of documented production procedures in the production processes contributes to developing the capability for rapid response in evaluating business performance and solving problems (TUBİTAK MAM, 2016; MoAF, 2021). Effectively applying and monitoring procedures created for production processes is one of the most effective ways to ensure product quality, obtain feedback, and develop solutions (Ayan, 2010). Documenting, effectively implementing, and monitoring production procedures is a good management practice and an effective tool for structuring and ensuring the continuity of the clean production approach and environmental management system. Along with potential benefits, the cost of implementation and economic gains may vary from sector to sector or depending on the structure of the facility (TUBİTAK MAM, 2016; MoAF, 2021). While the establishment and monitoring of production procedures are not costly, the payback period may be short when considering the savings and benefits it provides (TUBİTAK MAM, 2016; MoAF, 2021).

- ***Preventing the Transportation of Toxic or Hazardous Chemicals to Aquatic Environments through Closed Storage and Impermeable Waste/ Scrap Areas***

  Closed and impermeable waste/scrap storage areas can be constructed in industrial facilities to prevent the transportation of toxic or hazardous chemicals to receiving environments. This practice is already being implemented under existing environmental regulations in our country. In ongoing field studies, a separate collection channel can be created for toxic or hazardous material storage areas in industrial facilities, enabling the separate collection of leakage waters and preventing them from mixing with natural water environments.

- ***Using Automatic Equipment and Devices (Sensors, Smart Handwashing Systems, etc.) to Save Water in Shower/Toilet and Other Water Use Points***

  Water is crucial in many sectors of the manufacturing industry, both for production processes and for ensuring that personnel meet necessary hygiene standards. While water consumption in industrial facilities can be achieved in various ways, savings can also be realized by using equipment such as sensor taps and smart handwashing systems in areas where personnel use water. Smart handwashing systems not only conserve water but also ensure resource efficiency by correctly adjusting the mixture of water, soap, and air.

- ***Collecting and Treating Greywater Separately in the Facility for Use in Areas Requiring Low Water Quality (Irrigating Green Areas, Cleaning Floors, etc.)***

  The wastewater generated in industrial facilities consists not only of industrial wastewater from production processes but also includes wastewater from showers, sinks, kitchens, etc. Wastewater from areas such as showers, sinks, and kitchens is referred to as greywater. By treating these greywaters through various treatment processes, water savings can be achieved by using them in areas that do not require high water quality.

- ***Using Cooling Water as Process Water in Other Processes***

Cooling systems utilizing water are commonly employed in processes that require significant thermal energy and cooling. The use of heat exchangers during the return of cooling water allows for heat recovery, preventing the contamination of cooling water, and increasing the return rates of cooling water, thus achieving savings in both water and energy (TUBİTAK MAM, 2016; MoAF, 2021). Additionally, when cooling waters are collected separately, it is generally possible to use the collected waters for cooling purposes or to recycle them in appropriate processes (EC, 2009). By reusing cooling water, a savings of 2-9% in total water consumption can be achieved (Greer et al., 2013). In terms of energy consumption, savings of up to 10% can be realized (Öztürk, 2014; MoAF, 2021).

- ***Utilizing Closed Loop Water Circulation in Appropriate Processes***

Refrigerants are chemical compounds with specific thermodynamic properties that affect the performance of the cooling process by absorbing heat from the materials being cooled (Kuprasertwong et al., 2021). Water is commonly used as a refrigerant in many processes in the manufacturing industry, particularly in product cooling operations. During this cooling process, water can be reused through cooling towers or central cooling systems. If undesirable microbial growth occurs in the cooling water, it can be controlled by adding chemicals to the recirculated water (TUBİTAK MAM, 2016).

By reusing cooling water in processes such as cleaning, water consumption and the amount of wastewater generated can be reduced. However, the need for energy for cooling and recirculating cooling waters emerges as a side effect. Heat recovery is also facilitated through the use of heat exchangers in cooling waters. Generally, closed loop systems are used in facilities with water cooling systems. However, blowdown from the cooling system is discharged directly into the wastewater treatment plant channel. The discharged blowdown water can be reused in suitable production processes.

- ***Implementing Time Optimization in Production and Organizing All Processes to Complete in the Shortest Possible Time***

In industrial production processes, planning the transformation of raw materials into products with minimal processes is an effective practice for reducing labor costs, resource utilization costs, and environmental impacts while enhancing efficiency. In this context, it may be necessary to revise production processes to minimize the number of process steps (TUBİTAK MAM, 2016). Some deficiencies in core production processes may require renewal of the production processes when the desired product quality is not achieved due to inefficiencies and design flaws. Consequently, in such cases, the resource usage required for manufacturing a unit quantity of product, as well as the resulting waste, emissions, and solid waste, may increase. Time optimization in production processes is an effective practice (TUBİTAK MAM, 2016).

- ***Utilizing Computer-Aided Control Systems in Production Processes***

In industrial facilities, inefficient resource use and environmental problems are directly linked to input-output flows, necessitating the optimal definition of process inputs and outputs specific to production processes (TUBİTAK MAM, 2016). This enables the development of measures to enhance resource efficiency, as well as economic and environmental performance. Organizing input-output inventories is considered a prerequisite for continuous improvement. Such management practices require the participation of technical personnel and upper management, while they quickly pay for themselves through the work of various experts (IPPC BREF, 2003). It is essential to use measurement equipment based on application processes and to conduct routine analyses/measurements specific to those processes. To maximize the benefits of the application, it is crucial to leverage computerized monitoring systems as much as possible, which enhances the technical, economic, and environmental benefits obtained (TUBİTAK MAM, 2016).

- ***Characterizing the Quantity and Quality of Wastewater at All Generation Points to Identify Reusable Wastewater Streams***

In industrial facilities, identifying and characterizing wastewater generation points allows for the potential reuse of various wastewater streams, either treated or untreated (Öztürk, 2014; TUBİTAK MAM, 2016; MoAF, 2021). In this context, filter backwash waters, total organic (TO) concentrates, blowdown waters, condensate waters, and relatively clean wash and rinse waters can be reused without treatment in the same or different processes and in areas that do not require high water quality (such as facility and equipment cleaning). Additionally, wastewater streams that cannot be reused directly can be treated using appropriate treatment technologies and then reused in production processes.

Membrane filtration processes are an integral part of many wastewater reuse systems. Nanofiltration (NF) and reverse osmosis (RO) filtration systems are employed for industrial wastewater recovery. Microfiltration (MF) and ultrafiltration (UF) are generally used for the pre-treatment of water before it undergoes NF or RO processes (Singh et al., 2014).

2.1.3 Measures Related to Auxiliary Processes

Measures Related to Cooling Systems

- ***Identifying Processes Requiring Wet Cooling to Avoid Unnecessary Cooling Operations***

  The boundaries of the facility affect design parameters such as the height of cooling towers. In situations where it is necessary to reduce the tower height, hybrid cooling systems can be implemented. Hybrid cooling systems are a combination of evaporative and non-evaporative (wet and dry) cooling systems. A hybrid cooling tower can operate entirely as a wet cooling tower or as a combined wet/dry cooling tower, depending on the ambient temperature (TUBİTAK MAM, 2016). In regions where sufficient cooling water is not available or where water costs are high, evaluating dry cooling systems or hybrid cooling systems can be an effective solution to reduce the amount of supplemental cooling water (TUBİTAK MAM, 2016).

- ***Increasing the Number of Cycles in Closed Loop Cooling Systems to Improve the Quality of Makeup Water and Reduce Water Consumption***

  Water is used as a coolant in many processes within the manufacturing industry, including the cooling of products. The cooling process is carried out by recirculating water through cooling towers or central cooling systems. If undesirable microbial growth occurs in the cooling water, chemical additives can be used to control it in the recirculation water (TUBİTAK MAM, 2016). By effectively conditioning the recirculation process, the number of cycles can be increased. This can lead to a reduction in the amount of fresh water supplied to the system, resulting in water conservation. Additionally, proper conditioning of the makeup water can also increase the number of cycles (MoAF, 2021)..

- ***Utilizing Closed Loop Cooling Systems to Reduce Water Usage***

  Closed loop cooling systems significantly reduce water consumption compared to open loop systems, which have a higher water usage. In closed loop systems, water is typically recirculated within the same system, requiring the addition of cooling water equivalent to the amount of water that evaporates. By optimizing cooling systems, evaporation losses can also be minimized.

Measures Related to Ventilation and Air Conditioning Systems

- ***Reusing Liquid Generated from Condensation in the Ventilation System***
  During the ventilation cycle, condensate water of good quality can be produced in the system. For example, at a facility in Spain, condensate water with approximately 200 µS conductivity from the ventilation system is collected in a tank and used to wash the automatic galvanizing line (MedClean, n.d.).

- ***Replacing Old Equipment in the Ventilation System with Ion Exchange Resins Based on Reverse Osmosis Principles and Reusing Water***
  In the ventilation system, ion exchange resins are used to bring the conductivity of the final discharge water to an acceptable level for equipment cleaning. For instance, by replacing equipment in the ventilation system with ion exchange resins at a facility in Spain, discharge water with a conductivity value of approximately 1000 µS is obtained and reused in the system (MedClean, n.d.).

References

- Abbassi, B., & Al Baz, I. (2008). Integrated Wastewater Management: A Review. https://doi.org/10.1007/978-3-540-74492-4_3
- Adar, E., Delice, E.K., & Adar, T. (2021). Prioritizing of Industrial Wastewater Management Processes Using an Integrated AHP–CoCoSo Model: Comparative and Sensitivity Analyses. International Journal of Environmental Science and Technology.
- Christopher, S. (1998). ISO 14001 and Beyond: Environmental Management Systems in the Real World.
- Ministry of Environment, Urbanization and Climate Change (MoEUC). (2020). Clean Production Practices Project in Specific Sectors. General Directorate of Environmental Management.
- Delmas, M. (2009). Erratum to "Stakeholders and Competitive Advantage: The Case of ISO 14001." doi:10.1111/j.1937-5956.2004.tb00226.x
- Danish Environmental Protection Agency (DEPA). (2002). Danish Experience, Best Available Techniques in the Clothing and Textile Industry.
- Hutchens Jr., S. (2017). Using ISO 9001 or ISO 14001 to Gain a Competitive Advantage.
- IPPC BREF. (2003). Reference Document on Best Available Techniques for the Textiles Industry. Retrieved from https://eippcb.jrc.ec.europa.eu/reference
- IPPC BREF. (2006). Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Surface Treatment of Metals and Plastics. European Commission (EC).
- IPPC BREF. (2019). Best Available Techniques (BAT) Reference Document for the Food, Drink and Milk Industries. Retrieved from https://eippcb.jrc.ec.europa.eu/reference
- ISO 14001 User Manual (2015). Generic ISO 14001 EMS Templates User Manual.
- Lebanese Cleaner Production Center (LCPC). (2010). Cleaner Production Guide for Textile Industries.
- MedClean. (n.d.). Pollution Prevention Case Studies No: 46.
- Naghedi, R., Moghaddam, M., & Piadeh, F. (2020). Creating Functional Group Alternatives in Integrated Industrial Wastewater Recycling System: A Case Study of Toos Industrial Park (Iran). Journal of Cleaner Production.
- Oğur, R., Tekbaş, Ö.F., & Hasde, M. (n.d.). Chlorination Guide: Chlorination of Drinking and Utility Waters. Ankara: Gülhane Military Medical Academy, Department of Public Health.
- Özdemir, K., & Toröz, İ. (2010). Monitoring Chlorination By-products in Drinking Water Sources Using Differential UV Spectroscopy. ITU Journal.
- Öztürk, E. (2014). Integrated Pollution Prevention and Control and Clean Production Practices in the Textile Industry. Isparta.
- Potoski, M., & Prakash, A. (2005). Green Clubs and Voluntary Governance: ISO 14001 and Firms' Regulatory Compliance. American Journal of Political Science, 235-248.
- Tanık, A., Öztürk, İ., & Cüceloğlu, G. (2015). Handbook on Reuse of Treated Wastewater and Rainwater Harvesting Systems. Ankara: Union of Municipalities of Türkiye.
- Ministry of Agriculture and Forestry (MoAF). (2021). Technical Assistance Project for Economic Analyses and Water Efficiency Studies in 3 Pilot Basin River Basin Management Plans. Republic of Türkiye Ministry of Agriculture and Forestry.
- Scientific and Technological Research Council of Türkiye, Marmara Research Center (TÜBİTAK MAM). (2016). SANVER Project: Determining Clean Production Opportunities and Applicability in Industry, Final Report.
- Yaman, C. (2009). Siemens Gebze Facilities Green Building. IX National Installation Engineering Congress.
- Şahin, N.İ. (2010). Water Conservation in Buildings (Master's thesis, Istanbul Technical University, Graduate School of Science and Technology, Istanbul).
- European Commission (EC). (2009). Reference Document on Best Available Techniques for Energy Efficiency.

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Reşitpaşa Mah Katar Cd.
Arı Teknokent 1 2/5, D:12, 34469
Sarıyer/İstanbul

(0212) 276 65 48

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