



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



Water Efficiency Guide Documents Series

MANUFACTURE OF GAME AND TOYS

NACE CODE: 32.40

Ankara 2023

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

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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 Türkiye Ministry of Environment, Urbanisation and Climate Change
NOM	Natural Organic Matter
EMAS	Eco-Management and Audit Programme Directive
EPA	United States Environmental Protection Agency
IPPC	Industrial Pollution Prevention and Control
ISO	International Standards Organisation
BAT	Best Available Techniques
NACE	Statistical Classification of Economic Activities
GDWM	General Directorate of Water Management
RO	Reverse Osmosis
MAF	Republic of Türkiye Ministry of Agriculture and Forestry
TurkStat	Turkish Statistical Institute
NF	Nanofiltration
MF	Microfiltration
UF	Ultrafiltration
GW	Groundwater
SW	Surface Water

1 Introduction

Türkiye is located in the Mediterranean basin, where the effects of global climate change are felt intensely, and is considered to be among the regions that will be most affected by the negative effects of climate change. Projections on how our water resources in our basins will be affected in the future due to climate change show that our water resources may decrease by up to 25 per cent in the next hundred years.

For the year 2022, the annual amount of water available per capita in Türkiye is 1,313 m³, and it is expected that the annual amount of water available per capita will fall below 1,000 cubic metres after 2030 due to human pressures and the effects of climate change. If the necessary measures are not taken, it is obvious that Türkiye will become a country suffering from water scarcity in the very near future and will bring many negative social and economic consequences. As can be understood from the results of future projections, the risk of drought and water scarcity awaiting our country necessitates the efficient and sustainable use of our existing water resources.

The concept of water efficiency can be defined as *"using the least amount of water in the production of a product or service"*. The water efficiency approach is based on the rational, sharing, equitable, efficient and effective use of water in all sectors, especially in drinking water, agriculture, industry and household use, in a way that protects water in terms of quantity and quality and takes into account not only the needs of humans but also the needs of all living things with ecosystem sensitivity.

With the increasing demand for water resources, the change in precipitation and temperature regimes as a result of climate change, the increase in population, urbanisation and pollution, the fair and balanced distribution of usable water resources among users is becoming more and more important every day. For this reason, it has become a necessity to create a road map based on efficiency and optimisation in order to protect and use limited water resources through sustainable management practices.

In the vision of sustainable development set by the United Nations, *Goal 7: Ensuring Environmental Sustainability* from the Millennium Development Goals and *Goal 9: Industry, Innovation and Infrastructure* and *Goal 12: Responsible Production and Consumption* from the Sustainable Development Goals include issues such as efficient, fair and sustainable use of resources, especially water, environmentally friendly production and consumption with the concern of future generations.

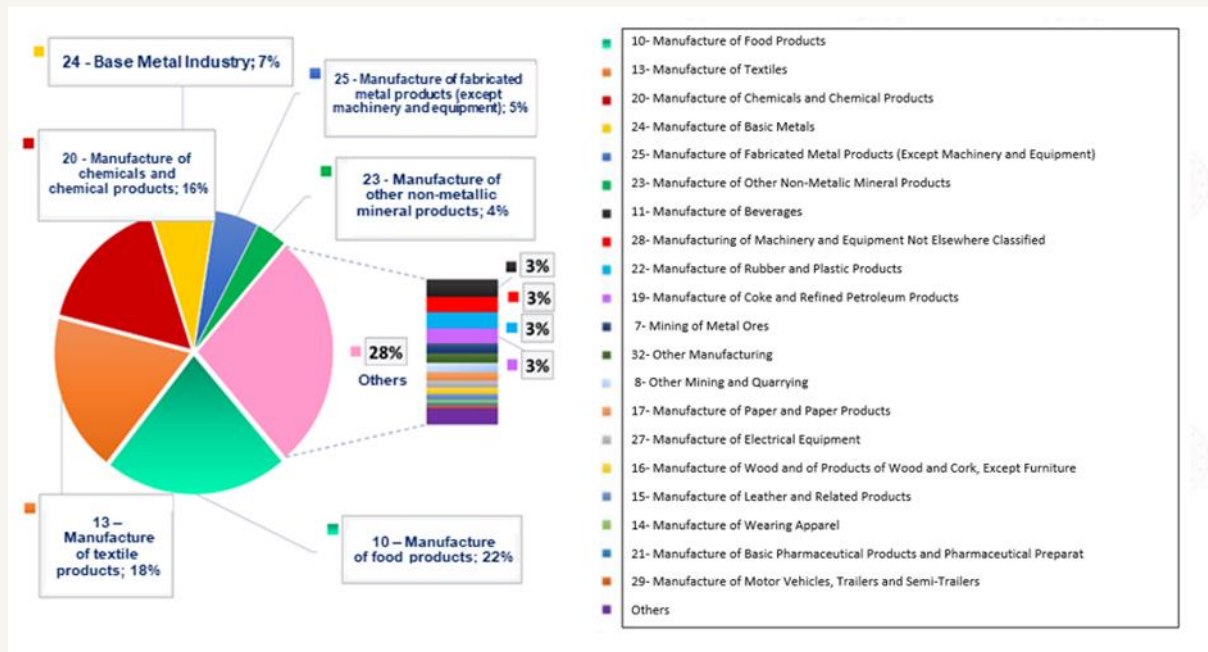
In the European Green Deal Action Plan prepared by our country within the scope of the European Green Deal Action Plan, in which member countries agreed on the objectives such as implementing a clean, circular economy model with a carbon neutral target, expanding the efficient use of resources and reducing environmental impacts, actions emphasising water and resource efficiency in production and consumption in various fields, especially in industry, have been determined.

The "Industrial Emissions Directive (EED)", which is one of the most important components of the European Union environmental legislation in terms of industry, includes measures to be taken for the control, prevention or reduction of discharges/emissions from industrial activities to the receiving environment, including air, water and soil, with an integrated approach. In the Directive, Best Available Techniques (BAT) are presented in order to systematise the applicability of cleaner production processes and to eliminate difficulties in implementation. BATs are the most effective implementation techniques for a high level of environmental protection, taking into account their costs and benefits. In accordance with the Directive, Reference Documents (BAT-BREF) have been prepared for each sector in which BATs are explained in detail. In BREF documents, BATs are presented in a general framework such as good management practices, techniques as general measures, chemical use and management, techniques for various production processes, wastewater management, emission management and waste management.

The Ministry of Agriculture and Forestry, General Directorate of Water Management carries out activities aimed at disseminating efficient practices in urban, agricultural, industrial and individual water use and raising social awareness. Water efficiency action plans addressing all sectors and stakeholders have been prepared within the scope of **the "Water Efficiency Strategy Document and Action Plan (2023-2033) within the Framework of Adaptation to a Changing Climate"**, which entered into force with the Presidential Circular No. 2023/9. In the Industrial Water Efficiency Action Plan, a total of 12 actions have been determined for the period 2023-2033 and responsible and relevant institutions have been assigned for these actions. Within the scope of the Action Plan, the General Directorate of Water Management is responsible for carrying out studies to determine specific water use ranges and quality requirements on the basis of sub-sectors in industry, organising technical training programmes and workshops on sectoral basis and preparing water efficiency guidance documents.

On the other hand, with the **"Industrial Water Use Efficiency Project by NACE Codes"** carried out by the General Directorate of Water Management of the Ministry of Agriculture and Forestry, the best sectoral techniques specific to our country were determined within the scope of studies on improving water efficiency in industry. As a result of the study, sectoral guidance documents and action plans categorised by NACE codes, including the measures recommended for improving water use efficiency in sectors with high water consumption operating in our country, were prepared.

As in the world, the sectors with the highest share in water consumption in our country are food, textile, chemical and basic metal sectors. Within the scope of the studies, field visits were carried out in enterprises representing 152 sub-sectors in 35 main sectors, especially food, textile, chemical and basic metal industries, which represent production areas with different capacities and diversity within the scope of NACE Codes operating in our country and with high water consumption, and data on water supply, sectoral water use, wastewater generation, recycling were obtained and information was provided on the best available techniques (BAT) and sectoral reference documents (BREF) published by the European Union, water efficiency, clean production, water footprint, etc.



Sectoral distribution of water use in industry in Türkiye

As a result of the studies, specific water consumption and potential saving rates for the processes of enterprises for 152 different 4-digit NACE codes with high water consumption were determined, and water efficiency guidance documents were prepared by taking into account the EU best available techniques (BAT) and other cleaner production techniques. Within the guidelines, 500 techniques (BAT) for water efficiency;

(i) Good Management Practices, (ii) General Water Efficiency BATs, (iii) Measures Related to Auxiliary Processes and (iv) Sector Specific Measures.

Within the scope of the project, environmental benefits, operational data, technical specifications-requirements and applicability criteria were taken into consideration during the determination of BATs for each sector. In the determination of BATs, not only BREF documents were not limited, but also different data sources such as current literature data on a global scale, real case analyses, innovative practices, reports of sector representatives were examined in detail and sectoral BAT lists were created. In order to evaluate the suitability of the BAT lists created for the local industrial infrastructure and capacity of our country, the BAT lists prepared specifically for each NACE code were prioritised by the enterprises by scoring them on the criteria of water saving, economic savings, environmental benefit, applicability, cross-media impact and the final BAT lists were determined using the scoring results. Water and wastewater data of the facilities visited within the scope of the project and the final BAT lists, which were prioritised by sectoral stakeholders and determined by taking into account the local dynamics specific to our country, were used to create sectoral water efficiency guides on the basis of NACE code.

2 Scope of the Study

Guidance documents prepared within the scope of water efficiency measures in industry cover the following main sectors:

- Crop and animal production and hunting and related service activities (including sub-production area represented by 6 four-digit NACE codes)
- Fisheries and aquaculture (including sub-production area represented by 1 four-digit NACE Code)
- Coal and lignite extraction (including sub-production area represented by 2 four-digit NACE codes)
- Service activities in support of mining (including sub-production area represented by 1 four-digit NACE Code)
- Metal ores mining (including the sub-production area represented by 2 four-digit NACE codes)
- Other mining and quarrying (including the sub-production area represented by 2 four-digit NACE codes)
- Manufacture of food products (including 22 sub-production areas represented by four-digit NACE codes)
- Manufacture of beverages (including the sub-production area represented by 4 four-digit NACE codes)
- Manufacture of tobacco products (including sub-production area represented by 1 four-digit NACE Code)
- Manufacture of textile products (including 9 sub-production areas represented by four-digit NACE codes)
- Manufacture of articles of clothing (including sub-production area represented by 1 four-digit NACE Code)
- Manufacture of leather and related products (including sub-production area represented by 3 four-digit NACE codes)
- Manufacture of wood, wood products and cork products (except furniture); manufacture of articles made of thatch, straw and similar materials (including sub-production area represented by 5 four-digit NACE Codes)
- Manufacture of paper and paper products (including sub-production area represented by 3 four-digit NACE codes)
- Manufacture of coke and refined petroleum products (including sub-production area represented by 1 four-digit NACE Code)
- Manufacture of chemicals and chemical products (including 13 sub-production areas represented by four-digit NACE codes)
- Manufacture of basic pharmaceutical products and pharmaceutical ingredients (including sub-production area represented by 1 four-digit NACE Code)
- Manufacture of rubber and plastic products (including sub-production area represented by 6 four-digit NACE codes)
- Manufacture of other non-metallic mineral products (including 12 sub-production areas represented by four-digit NACE codes)
- Basic metal industry (including 11 sub-production areas represented by four-digit NACE codes)
- Manufacture of fabricated metal products (except machinery and equipment) (including 12 sub-production areas represented by four-digit NACE codes)
- Manufacture of computers, electronic and optical products (including sub-production area represented by 2 four-digit NACE codes)
- Manufacture of electrical equipment (including sub-production area represented by 7 four-digit NACE codes)

- Manufacture of machinery and equipment not elsewhere classified (including sub-production area represented by 8 four-digit NACE codes)
- Manufacture of motor vehicles, trailers (semi-trailers) and semi-trailers (semi-trailers) (including sub-production area represented by 3 four-digit NACE codes)
- Manufacture of other transport equipment (including sub-production area represented by 2 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 sub-production area represented by 2 four-digit NACE codes)
- Electricity, gas, steam and ventilation system production and distribution (including sub-production area represented by 2 four-digit NACE codes)
- Waste collection, reclamation and disposal activities; recovery of materials (including sub-production area represented by 1 four-digit NACE Code)
- Construction of non-building structures (including sub-production area represented by 1 four-digit NACE Code)
- Warehousing and supporting activities for transport (including sub-production area represented by 1 four-digit NACE Code)
- Accommodation (including sub-production area represented by 1 four-digit NACE Code)
- Educational Activities (Higher Education Campuses) (including sub-production area represented by 1 four-digit NACE Code)
- Sporting activities, leisure and recreation activities (including sub-production area represented by 1 four-digit NACE Code)

Other Manufacturing

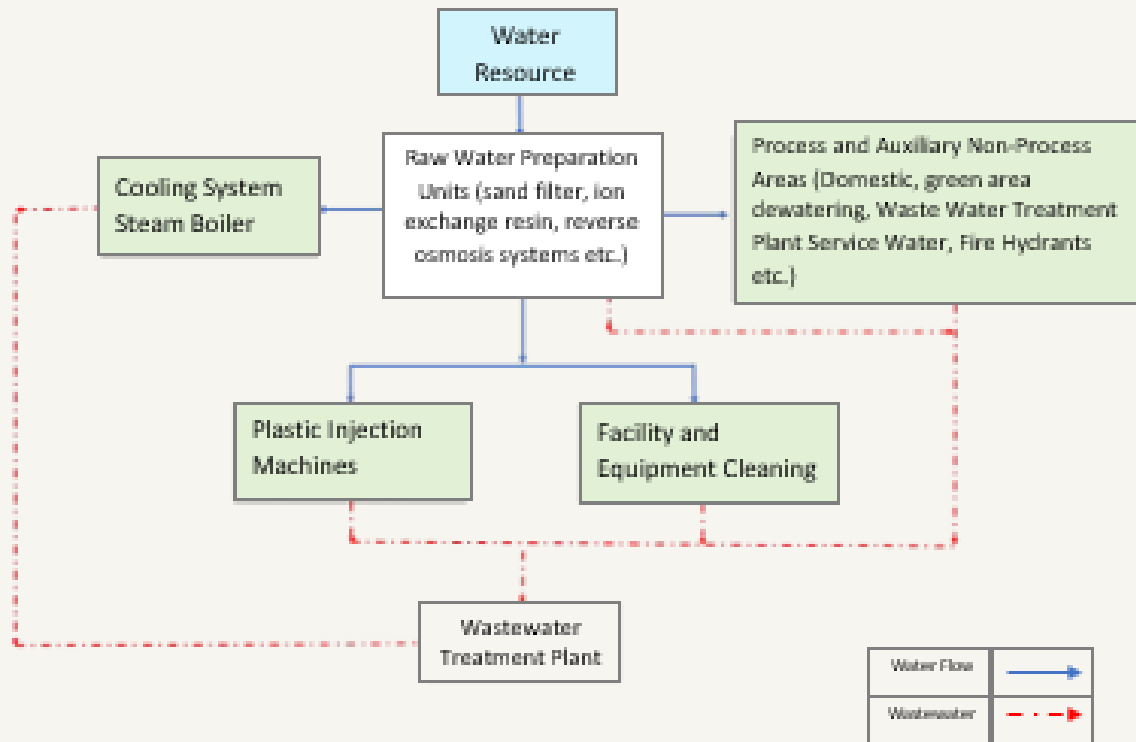
Under the Other Manufacturing sector, the sub-production branches for which guidance documents have been prepared are as follows:

32.12 Manufacture of jewellery and similar articles

32.40 Manufacture of games and toys

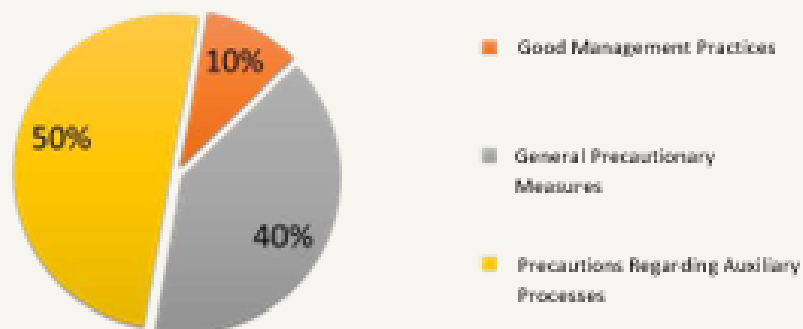
2.1 Game and Toy Manufacturing (NACE 32.40)

Game and Toy Manufacturing Sector Water Flow Diagram



	Minimum	Maximum
Specific water consumption of the facilities visited within the scope of the Project (L/kg product)	0,01	
Reference specific water consumption (L/kg product)	0,01	0,05

Percentage Distribution of Water Efficiency Practices



In game and toy manufacturing, the raw material is given the shape of the mould. The plastic product, which comes out at high temperature due to the very high pressure process, passes to the cooling stage. Ready products are checked. Products that pass the control stage without any problems are packaged.

Water is used in plastic injection moulding machines in facilities manufacturing games and toys. Machine and product cooling water is consumed in the facilities. The water used in product cooling is used recirculated and is added as it decreases as a result of evaporation. Significant water consumption is also realised for filter washing, resin regeneration and membrane cleaning processes in raw water preparation units such as activated carbon filter, ion exchange resin, reverse osmosis, which are used to produce soft water for use in production processes in the sector. Water consumption also occurs in auxiliary units such as cooling tower and steam boilers.

The reference specific water consumption in the games and toys manufacturing sector is in the range of 0.01 - 0.05 L/kg. The specific water consumption of the production line analysed within the scope of the study is 0.01 L/kg. With the implementation of good management practices, general water efficiency BATs and measures related to auxiliary processes, it is possible to achieve 44 - 45% water saving in the sector.



https://www.globalpiyasa.com/lib/Urun/670/8eed68a911c840e106d3f9b58cd37d63_1.jpg

Plastic Injection Moulding Machine

32.40 Priority water efficiency implementation techniques recommended within the scope of Game and Toy Manufacturing NACE code are presented in the table below.

NACE Code	NACE Code Description	Prioritised Sectoral Water Efficiency Techniques
32.40	Manufacture of games and toys	<p>Good Management Practices</p> <ol style="list-style-type: none"> 1. Establishment of environmental management system 2. Preparation of water flow diagrams and mass balances for water 3. Preparing a water efficiency action plan to reduce water use and prevent water pollution 4. Providing technical trainings to the staff for the reduction and optimisation of water use 5. Good production planning to optimise water consumption 6. Determination of water efficiency targets 7. Monitoring the quantity and quality of water used in production processes and auxiliary processes and the wastewater generated and adapting this information to the environmental management system <p>General Water Efficiency BATs</p> <ol style="list-style-type: none"> 1. Minimising spillages and leakages 2. Use of automatic hardware and equipment (sensors, smart hand washing systems, etc.) that will save water at water usage points such as showers/toilets etc. 3. Identification and minimisation of water losses 4. Construction of closed storage and impermeable waste/scrap sites to prevent the transport of toxic or hazardous chemicals for the aquatic environment 5. Preservation and storage of substances (such as oils, emulsions, binders) that pose a risk in the aquatic environment and prevention of their mixing with wastewater after use 6. Use of closed loop water cycles in appropriate processes 7. Use of computer aided control systems in production processes 8. Separate collection and treatment of grey water in the facility and its use in areas that do not require high water quality (green area irrigation, floor washing, etc.) 9. Collecting rainwater and using it for facility cleaning or in suitable areas utilisation as an alternative water source

32.40

Manufacture of games and toys

Precautions for Auxiliary Processes

1. Avoiding unnecessary cooling processes by identifying processes that need wet cooling
2. Reduction of evaporation losses in closed loop cooling water
3. Increasing the number of cycles by using corrosion and scale inhibitors in systems with closed water cycle
4. Installation of water softening systems for the healthy operation of cooling water recovery systems
5. Use of a closed-loop cooling system to minimise water use

A total of 21 techniques have been proposed in this sector.

For Game and Toy
Manufacturing NACE Code;

- (i) Good Management Practices,
- (ii) General Precautions and
- (iii) Measures for auxiliary processes
are given under separate
headings.

2.1.1 Good Management Practices

- ***Establishment of environmental management system***

Environmental Management Systems (EMS) include the organisational structure, responsibilities, procedures and resources required to develop, implement and monitor the environmental policies of industrial organisations. The establishment of an environmental management system improves the decision-making processes between raw materials, water and wastewater infrastructure, planned production process and different treatment techniques. Environmental management organises how resource supply and waste discharge demands can be managed 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 Directive (EMAS) (761/2001). It has been developed for the assessment, improvement and reporting of the environmental performance of enterprises. It is one of the leading practices within the scope of eco-efficiency (cleaner production) in EU legislation and voluntary participation is provided (TUBITAK MRC, 2016; MAF, 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).
- International Standards Organisation (ISO) standards are adopted to ensure greater compliance with global legal and regulatory requirements (Christopher, 1998).
- While the risks of penalties related to environmental responsibilities are minimised, the amount of waste, resource consumption and operating costs are reduced (Delmas, 2009).
- The use of internationally recognised environmental standards eliminates the need for multiple registrations and certificates for businesses operating in different locations around the world (Hutchens Jr., 2017).
- Especially in recent years, the improvement of the internal control processes of companies is also considered important by consumers. The implementation of environmental management systems provides a competitive advantage against companies that do not adopt the standard. It also contributes to the better position of organisations in international areas / markets (Potoski & Prakash, 2005).

The above-mentioned benefits depend on many factors such as the production process, management practices, resource utilisation and potential environmental impacts (MAF, 2021). Practices such as preparing annual inventory reports with similar content to the environmental management system and monitoring inputs and outputs in terms of quantity and quality in production processes can save 3-5% of water consumption (Öztürk, 2014). The total duration of the development and implementation phases of the EMS takes an estimated 8-12 months (ISO 14001 User Manual, 2015).

Industrial organisations also carry out studies within the scope of ISO 14046 Water Footprint Standard, an international standard that defines the requirements and guidelines for assessing and reporting water footprint. With the implementation of the relevant standard, it is aimed to reduce the use of fresh water required for production and environmental impacts. In addition, ISO 46001 Water Efficiency Management Systems Standard, which helps industrial organisations to save water and reduce operating costs, helps organisations to develop water efficiency policies by conducting monitoring, benchmarking and review studies.

- **Preparation of water flow diagrams and mass balances for water**

Determination of water use and wastewater generation points in industrial plants, establishment of water-wastewater balances in production processes and auxiliary processes other than production processes constitute the basis of many good management practices in general. Establishing process profiles on a plant-wide and production process basis can facilitate the identification of unnecessary water use points and high water use points, the evaluation of water reuse opportunities, process modifications and the identification of water losses (MAF, 2021).

- **Preparation of a water-saving action plan to reduce water use and prevent water pollution**

Preparation of a short, medium and long term action plan in order to reduce water-wastewater quantities and prevent water pollution in industrial facilities is important in terms of water efficiency. At this point, it may be necessary to determine water needs throughout the facility and in production processes, to determine water quality requirements at water use points, to determine wastewater generation points and wastewater characterisation (MAF, 2021). At the same time, it is necessary to determine the techniques to be applied to reduce water consumption, wastewater generation and pollution loads, to make their feasibility and to make action plans for the short-medium-long term. In this way, sustainability of water efficiency in facilities can be ensured (MAF, 2021).

- **Providing technical trainings to personnel for the reduction and optimisation of water use**

- With this measure, water saving and water recovery can be achieved by increasing the training and awareness of the personnel, and water efficiency can be achieved by reducing water consumption and costs. In industrial facilities, problems related to high water consumption and wastewater generation may arise due to the lack of necessary technical knowledge of the personnel. For example, it is important that cooling tower operators, which represent a significant proportion of water consumption in industrial operations, are properly trained and have technical knowledge. Determination of water quality requirements in production processes, measurement of water and wastewater quantities, etc. It is also necessary for the relevant personnel to have sufficient technical knowledge (MAF, 2021). Therefore, it is important to provide training to staff on water use reduction, optimisation and water saving policies. Practices such as involving the staff in water saving studies, creating regular reports on the amount of water use before and after water efficiency initiatives, and sharing these reports with the staff support participation and motivation in the process. The technical, economic and environmental benefits to be obtained through staff training yield results in the medium or long term (TUBITAK MAM, 2016; MAF, 2021).

- **Good production planning to optimise water consumption**

In industrial production processes, planning a raw material using the least process until it is transformed into a product can be an effective application in terms of reducing labour costs, resource use costs, efficiency and environmental impacts (TUBITAK MRC2016; MAF, 2021). Production planning in industrial plants, taking into account the water efficiency factor, can provide varying reductions in water consumption and wastewater amounts. In some industrial plants, modifying the production flow or combining some processes can provide significant benefits in terms of water efficiency and time planning (MAF, 2021).

- **Determination of water efficiency targets**

One of the first steps in ensuring water efficiency in industrial facilities is to set targets (MAF, 2021). For this, firstly, a detailed water efficiency analysis should be carried out. Thus, unnecessary water use, water losses, wrong practices affecting water efficiency, process losses, reusable water-wastewater resources with or without treatment, etc. can be determined. Therefore, a water saving potential and water efficiency targets can be determined for each production process and the entire facility (MAF, 2021).

- **Monitoring the quantity and quality of water and wastewater in production processes and auxiliary processes, and adapting this information to the environmental management system**

There is resource utilisation in industrial facilities, and inefficiency and environmental problems resulting from resource utilisation may arise from input-output flows. Therefore, it is necessary to monitor the quantity and quality of water and wastewater in production processes and auxiliary processes (TUBITAK MRC, 2016; MAF, 2021). Process-based quantity and quality monitoring, together with other good management practices (personnel training, establishment of an environmental management system, etc.), can enable reductions of 6-10% in energy consumption and up to 25% in water consumption and wastewater quantities (Öztürk E., 2014).

Monitoring of water and wastewater in terms of quantity and quality should include, but not be limited to, the following stages

- Use of monitoring equipment (such as counters) to monitor water, energy, etc. consumption on the basis of processes
- Establishment of monitoring procedures
- Determining the usage/exit points of all inputs and outputs (raw materials, chemicals, water, products, wastewater, sludge, solid waste, hazardous waste and by-products) related to the production process, monitoring, documenting, comparative evaluation and reporting in terms of quantity and quality
- Monitoring raw material losses in production processes where raw materials are transformed into products and taking measures against raw material losses (MoEU, 2020e).

2.1.2 General Water Efficiency BATs

- ***Use of closed loop water cycles in appropriate processes***

Refrigerants are chemical compounds with certain thermodynamic properties that take heat from the substances to be cooled and cool them, affecting the performance of the cooling process (Kuprasertwong et al., 2021).

Water is used as a refrigerant in many processes in the manufacturing industry and in many processes led by the product cooling process. During this cooling process, water can be reused through cooling tower or central cooling systems. If unwanted microbial growth occurs in the cooling water, it can be controlled by adding chemicals to the recirculation water (TUBITAK MRC, 2016).

By reusing cooling water in processes such as cleaning, water consumption and the amount of wastewater generated are reduced. However, the need for energy for cooling and recirculation of cooling water is a side interaction.

Heat recovery is also provided by the use of heat exchangers in cooling water. Generally, closed loop systems are used in plants where aqueous cooling systems are used. However, cooling system blowdowns are discharged directly to the wastewater treatment plant channel. This blowdown water can be reused in appropriate production processes.

- ***Preservation and storage of substances (such as oils, emulsions, binders) that pose a risk in the aquatic environment and prevention of their mixing with wastewater after use***

In industrial plants, water recovery is achieved by using dry cleaning techniques and preventing leaks to prevent the mixing of chemicals that pose a risk to the aquatic environment such as oils, emulsions and binders into wastewater streams (TUBITAK MRC, 2016).

- ***Construction of closed storage and impermeable waste/scrap sites to prevent the transport of toxic or hazardous chemicals for the aquatic environment***

In industrial facilities, closed and impermeable waste/scrap storage sites can be constructed to prevent the transport of toxic or hazardous chemicals for the aquatic environment to receiving environments. This practice is already being implemented in our country within the scope of existing environmental regulations. Within the scope of the field studies carried out, a separate collection channel can be constructed in the storage areas of toxic or hazardous substances in industrial facilities and the leachate can be collected separately and prevented from mixing into natural water environments.

- **Use of computer aided control systems in production processes**

Since inefficient resource utilisation and environmental problems in industrial facilities are directly related to input-output flows, it is necessary to define the process inputs and outputs in the best way for production processes (TUBITAK MRC, 2016). Thus, it becomes possible to develop measures to improve resource efficiency, economic and environmental performance. The organisation of input-output inventories is considered as a prerequisite for continuous improvement. While such management practices require the participation of technical staff and senior management, they pay for themselves in a short time with the work of various experts (IPPC BREF, 2003). It is necessary to use measurement equipment on the basis of application processes and to carry out some routine analyses/measurements specific to the processes. Utilising computerised monitoring systems as much as possible in order to maximise the efficiency of the application increases the technical, economic and environmental benefits (TUBITAK MRC, 2016).

- **Use of automatic hardware and equipment (sensors, smart hand washing systems, etc.) that will save water at water usage points such as showers/toilets etc.**

Water is very important in many sectors of the manufacturing industry, both for production processes and for personnel to meet the necessary hygiene standards. Water consumption in the production processes of industrial facilities can be provided in various ways, as well as water consumption savings can be achieved by using equipment such as sensor faucets and smart hand washing systems in the water usage areas of the personnel. Smart hand washing systems provide resource efficiency in addition to water saving while adjusting the mixture of water, soap and air at the right rate.

- **Separate collection and treatment of grey water in the facility and its use in areas that do not require high water quality (green area irrigation, floor washing, etc.)**

Wastewater generated in industrial facilities is not only industrial wastewater from production processes, but also includes wastewater from showers, sinks, kitchens, etc. Wastewater from shower, sink, kitchen etc. areas is called grey water. Water savings can be achieved by treating these grey waters with various treatment processes and using them in areas that do not require high water quality.



<https://sayachizmet.com/wp-content/uploads/2020/01/SCADA-nedir-1280x720-1.jpg.webp>

Computer Aided Control System

● **Minimising spillages and leakages**

In industries, especially in the food and beverage industry, both raw material and water losses can occur due to spills and leaks. In addition, if wet cleaning methods are used to clean spillage areas, water consumption, wastewater amounts and pollution loads of wastewater may also increase (MAF, 2021). In order to reduce raw material and product losses, spill and splash losses are reduced by using splash guards, flaps, drip trays, sieves (IPPC BREF, 2019).

● **Identification and minimisation of water losses**

Water losses occur in equipment, pumps and pipelines in industrial production processes. Firstly, water losses should be identified and leakages should be prevented by regular maintenance of equipment, pumps and pipelines to keep them in good condition (IPPC BREF, 2003). Regular maintenance procedures should be established, paying particular attention to the following points:

- Adding pumps, valves, level switches, pressure and flow regulators to the maintenance checklist,
- Carrying out inspections not only in the water system, but also in particular in the heat transfer and chemical distribution systems, broken and leaking pipes, barrels, pumps and valves,
- Regular cleaning of filters and pipework,
- Calibrate, routinely check and monitor measuring equipment such as chemical measuring and dispensing devices, thermometers, etc. (IPPC BREF, 2003).

With effective maintenance-repair, cleaning and loss control practices, savings ranging from 1-6% in water consumption can be achieved (Öztürk, 2014).

● **Collecting rainwater and utilising it as an alternative water source in facility cleaning or in suitable areas**

Nowadays, when water resources are decreasing, rainwater harvesting has started to be frequently preferred especially in regions with low rainfall. There are different technologies and systems for rainwater collection and distribution systems. Cistern systems, ground infiltration, surface collection and filter systems are used. Rainwater collected with special drainage systems can be used in production processes, garden irrigation, tank and equipment cleaning, surface cleaning, etc. as long as the water quality is suitable (Tanık et al., 2015).

In an industrial facility, roof rainwater was stored and used inside the building and in landscape areas and 50% water saving was achieved in landscape irrigation (Yaman, 2009). In order to protect groundwater resources and quality, the use of perforated stones and green areas has been increased in order to ensure that the rainwater coming to the site passes and absorbs into the soil on the site (Yaman, 2009). The rain collected from the roof of the building is collected in separate tanks and used for car washing and garden irrigation. It is then biologically treated and reused with a 95% recovery rate (Şahin, 2010).

In industry, it is possible to collect rainwater from a wider area and consumption is much higher. The cost of rainwater recycling is approximately 50.000 Euro and the payback period is approximately 7-8 years (Tanık et al., 2015).

2.1.3 Precautions for Auxiliary Processes

BATs for cooling systems

- **Use of a closed-loop cooling system to minimise water use**

Some water evaporates during the cooling of heated water in cooling systems. Therefore, in closed cycle cooling systems, cooling water is added as much as the amount of evaporated water. Evaporation losses can be prevented by optimising cooling systems. In addition, the amount of blowdown can be reduced by applications such as treatment of the make-up water added to the cooling systems and prevention of biological growth in cooling systems. Within the scope of the field studies carried out, the blowdown water generated in the cooling system is not reused and is discharged directly to the wastewater channel. With the reuse of cooling system blowdown water, water consumption in cooling systems can be reduced.

Savings of up to 50% can be achieved. The initial investment costs required for this application may consist of the establishment of new pipelines and reserve tanks. In this case, it can be predicted that the required initial investment cost will vary between 5,000-20,000 TL (MAF, 2021).



<https://www.chiller.com.tr/wp-content/uploads/2018/04/chiller-sogutma-kapasitesi-hesabi.jpg>

Cooling Systems (Chiller)

- ***Increasing the number of cycles by using corrosion and scale inhibitors in systems with closed water cycle***

Cooling towers and evaporative condensers are efficient and low-cost systems that remove heat from air conditioning and industrial process cooling systems (IPPC BREF, 2001b; MAF, 2021). In these systems, more than 95% of the circulating water can be recovered (TUBITAK MRC, 2016). In cooling systems, impurities remain in the recirculated water due to the evaporation of a portion of the recirculated water and the impurity concentrations gradually increase in each cycle. Impurities that can be included in the cooling system together with air can cause contamination in recirculation water (TUBITAK MRC, 2016). If impurities and contaminants are not effectively controlled, they can cause scaling and corrosion, unwanted biological growth and sludge accumulation. This can become a chronic problem leading to reduced efficiency of heat transfer surfaces and increased operating costs. In this case, it is necessary to implement a water treatment programme specifically designed for the quality of the feed water supplied to the cooling system, the cooling water system construction material and operating conditions. In this context; blowdown control, control of biological growth, corrosion control, avoidance of hard water, use of sludge control chemicals, filtration and screening systems may be appropriate (TUBITAK MRC, 2016). The establishment and periodic implementation of an effective cleaning procedure and programme is also a good management practice for the protection of cooling systems. Corrosion is one of the most important problems in cooling systems. In tower recirculation water, dissolved solids (sulphate, chloride, carbonate, etc.) that cause corrosion as a result of the formation of limestone and deposits on the walls as the degree of hardness increases will cause corrosion on the surface over time. In addition, the formation of deposits reduces energy efficiency by negatively affecting heat transfer. In order to prevent these problems, chemical treatment programme should be applied to prevent scale and corrosion, disinfection with biological activation inhibitor biocide, cooling towers in use should be subjected to chemical and mechanical cleaning at least twice a year to remove deposits, hardness and conductivity values of the make-up water should be as low as possible (IPPC BREF, 2001; Kayabek et al., 2005). In order to improve the quality of the makeup water, it may be necessary to treat (condition) it using an appropriate treatment system. In addition, unwanted microbial growth should be kept under control (IPPC BREF, 2001b; MAF, 2021). Blowdown occurs in cooling systems as well as in steam boilers due to micro-residues and deposits in the cooling water. The deliberate draining of the cooling system to stabilise the increasing concentration of solids in the cooling system is called cooling blowdown. By pre-treatment of cooling water with appropriate methods and continuous monitoring of cooling water quality, biocide usage and blowdown amounts can be reduced (TUBITAK MRC, 2016). Although the investment cost depends on the scale of the application, the payback period for the expected investment costs varies between 3 and 4 years (IPPC BREF, 2001).

- ***Avoiding unnecessary cooling processes by identifying processes that need wet cooling***

The boundaries of the plant site affect design parameters such as cooling tower height. In cases where it is necessary to reduce the tower height, a hybrid cooling system can be applied. Hybrid cooling systems are a combination of evaporative and non-evaporative (wet and dry) cooling systems. Depending on the ambient temperature, the hybrid cooling tower can be operated as a fully wet cooling tower or as a combined wet/dry cooling tower (TUBITAK MRC, 2016). In regions where there is not enough cooling water or where water costs are high, the evaluation of dry cooling systems or hybrid cooling systems can be an effective solution to reduce the amount of cooling booster water (TUBITAK MRC, 2016).

- ***Reduction of evaporation losses in closed loop cooling water***

Some water evaporates during the cooling of heated water in cooling systems. Therefore, in closed cycle cooling systems, cooling water is added as much as the amount of evaporated water. Evaporation losses can be prevented by optimising cooling systems. In addition, the amount of blowdown can be reduced by applications such as treatment of make-up water added to cooling systems and prevention of biological growth in cooling systems. Within the scope of the field studies carried out, the blowdown water formed in the cooling system is generally discharged directly to the wastewater channel. By reusing the cooling system blowdown water, water consumption of cooling systems can be saved up to 50%. Implementation of this measure may require the installation of new pipelines and reserve tanks (MAF, 2021).

- ***Installation of water softening systems for the healthy operation of cooling water recovery systems***

Cooling water is collected separately and used for cooling purposes or recycled in appropriate processes (EC, 2009). A water softening system is required for this system to work properly. Cooling water has suitable water quality for reuse as cleaning and irrigation water. However, since it contains some hardness in its use as cooling water, additional softening is required to prevent corrosion problems that will occur over time. These waters should be subjected to an appropriate disinfection process before being reused as cooling water or in the process. In addition, these waters can be treated with appropriate treatment techniques (membrane filtration, advanced oxidation, chemical precipitation, granular activated carbon adsorption, etc. processes) and reused not only in cooling processes but also in all production processes (TUBITAK MRC, 2016). As the hardness of the cooling water increases, limestone and deposit formation occurs on the walls. The formation of deposits adversely affects heat transfer, reducing energy efficiency and increasing energy costs. With the increase in evaporation in the system, the ion concentration and conductivity value in the water increases. In order to prevent these negativities, chemical treatment of the cooling water to prevent scale and corrosion, disinfection with a biocide that prevents biological activation, chemical and mechanical cleaning of cooling towers at least twice a year and cleaning of deposits, hardness and conductivity values should be kept as low as possible (TUBITAK MRC, 2016).

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