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MINISTRY OF AGRICULTURE AND FORESTRY
GENERAL DIRECTORATE OF WATER MANAGEMENT

Water Efficiency Campaign

Water Efficiency Guidance Documents Series

SERVICE ACTIVITIES INCIDENTAL TO AIR TRANSPORTATION

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Contents

Abbreviations

WTP	Wastewater Treatment Plant
EU	European Union
SSM	Suspended Solid Matter
BATRD	Best Available Techniques Reference Document
EMS	Environmental Management System
MEUCC	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 water scarce country 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 the limited water resources with 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.

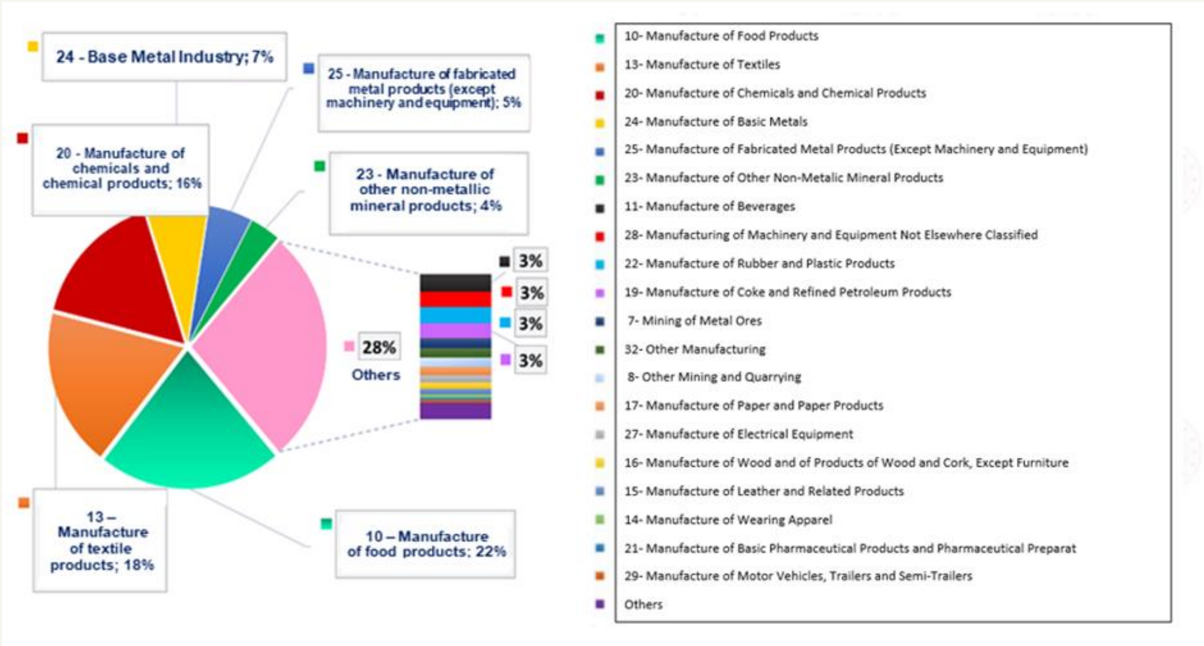
In the European Green Deal Action Plan prepared by our country within the scope of the European Green Deal Action Plan, in which member countries agreed on the objectives such as implementing a clean, circular economy model with a carbon neutral target, expanding the efficient use of resources and reducing 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 were 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 best available techniques (BAT) and sectoral reference documents (BREF), water efficiency, clean production, water footprint, etc. published by the European Union.



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 motor vehicles, trailers (trailers) and semi-trailers (semi-trailers) (3 four-digit

- 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)

Including the sub-production area represented by NACE Code)

- 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)

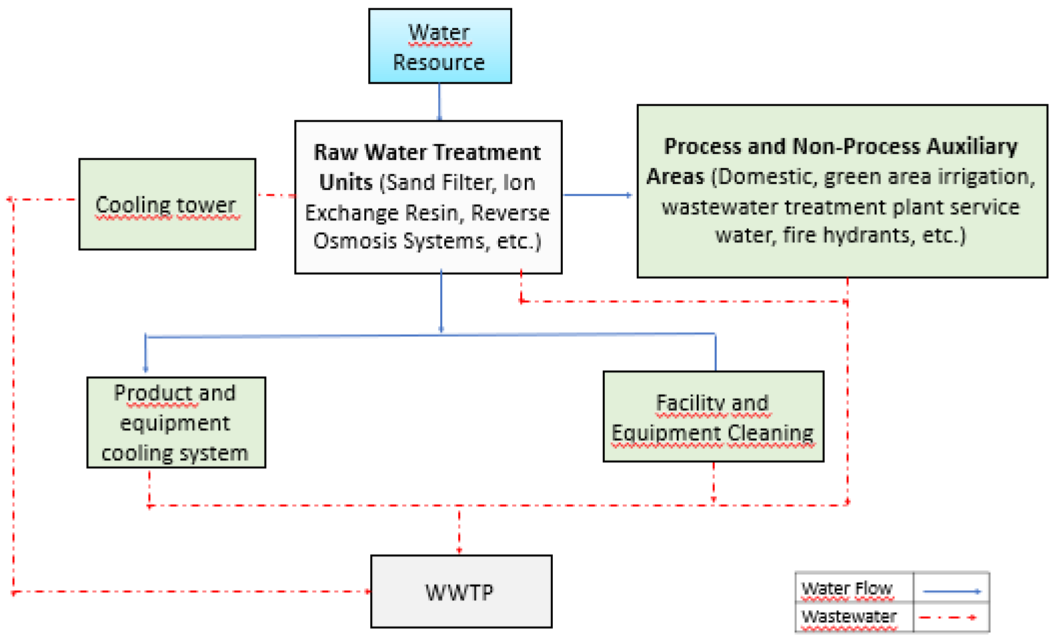
Storage and supporting activities for transport

Under the sector of storage and supporting activities for transport, the sub-production branches for which guidance documents have been prepared are as follows

52.23	Service activities incidental to air transportation

2.1 Service Activities Incidental To Air Transportation (NACE 52.23)

Water flow diagram for the air transport supporting service activities sector



	Minimum	Maximum
Specific Water Consumption of Facilities Visited Within the Project Scope (L/kWh)	7,5	
Reference Specific Water Consumption (L/kWh)	9	30

A significant portion of the water consumed in service activities incidental to air transportation is used in cooling systems. If there are raw water preparation units such as activated carbon filter, ion exchange resin, reverse osmosis used to produce soft water, significant water consumption is also realised for filter washing, resin regeneration and membrane cleaning processes.

The reference specific water consumption value in the sector of service activities incidental to air transportation is in the range of 9 - 30 L/passenger. The specific water consumption of the production line analysed within the scope of the study is 7.5 L/passenger. With the implementation of sector-specific measures, good management practices and measures in the form of General Water Efficiency BATs and measures related to auxiliary processes, it is possible to achieve water savings of 47 - 73% in the sector.

52.23 Service Activities Incidental to Air Transportation Priority water efficiency implementation techniques recommended within the scope of NACE code are presented in the table below.

NACE Code	NACE Code Description		Prioritised Sectoral Water Efficiency Techniques
52.23	Service activities incidental to air transportation		**Sector Specific Measures**
		1.	Providing flow with a mixture of water and air by using tap aerators, and installing flow restriction devices on taps that cannot be equipped with aerators
		2.	Wastewater treatment plant effluent is treated by coagulation, flocculation, sand filtering and activated carbon filtering after being blended with rainwater or well water to obtain good quality water to be used in cooling tower (Galeão Airport, Brazil)
		3.	Replacement of conventional sanitary fittings with more efficient ones, e.g. fittings with two-stage flushing mechanisms or waterless urinals
		4.	Grey water collected from aircraft catering facilities and terminal building kitchens is treated together with water from aircraft washing activities and used in irrigation systems (Hong Kong Airport, China)
		5.	Rainwater drainage system discharges rainwater from aprons, de-icing areas, roads, car parks and roofs, collects it in ponds and feeds it to the irrigation system, fire control system and toilet flushes through separate systems (Frankfurt International Airport, Germany)
		6.	Use of rainwater collected from terminal roofs or satellite buildings to dilute crude glycol for de-icing aircraft or runways (Heathrow Airport, London)
		7.	Irrigation only when necessary, using sensors to monitor soil moisture instead of timed or manually controlled devices
		8.	Use of reclaimed water or rainwater for car and aircraft washing
		9.	Use of treated wastewater for car washing and sending wastewater from car washing to treatment plant (Dubai Airport, UAE)
		10.	Treatment of wastewater with membrane bioreactor system and utilisation in green area irrigation and fire control (Qingdao Airport, China)
		11.	Use of seawater in siphons and cooling systems at airports close to the sea (Hong Kong Airport, China)
		12.	Reducing irrigation requirements by using appropriate plant material by making soil / climate analysis in landscape areas
		13.	Use of sanitary, kitchen and restaurant wastewater for landscape irrigation or fire control after activated sludge system + disinfection (Fiumicino Airport, Rome)
		14.	Use of leak detection programme and advanced real-time water demand monitoring system
		15.	Treatment of wastewater from restaurant kitchens in passenger terminals and feeding it to toilet flushing systems (Narita Airport, Japan)

NACE Code	NACE Code Description		Prioritised Sectoral Water Efficiency Techniques
52.23	Service activities incidental to air transportation		**Good Management Practices**
		1.	Use integrated wastewater management and treatment strategy to reduce wastewater quantity and pollutant load
		2.	Establishment of environmental management system
		3.	Preparing a water efficiency action plan to reduce water use and prevent water pollution
		4.	Good production planning to optimise water consumption
		5.	Determination of water efficiency targets
			General Water Efficiency BATs
		1.	Minimising spillages and leakages
		2.	Recovery of water from rinsing solutions and reuse of recovered water in processes appropriate to its quality
		3.	Use of automatic hardware and equipment (sensors, smart hand washing systems, etc.) to save water at water usage points such as showers/toilets etc.
		4.	Identification and minimisation of water losses
		5.	Construction of closed storage and impermeable waste/scrap sites to prevent the transport of toxic or hazardous chemicals for the aquatic environment
		6.	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
		7.	Prevention of mixing of clean water flows with polluted water flows
		8.	Use of closed loop water cycles in appropriate processes
		9.	Use of computer aided control systems in production processes
		10.	Untreated reuse of relatively clean wastewater from washing, rinsing and equipment cleaning in production processes
		11.	Separate collection and treatment of grey water in the facility and its use in areas (green area irrigation, floor washing, etc.) that do not require high water quality
		12.	Avoid the need to rinse between activities using compatible chemicals in sequential processes

NACE Code	NACE Code Descriptio	Prioritised Sectoral Water Efficiency Techniques
52.23	Service activities incidental to air transportation	**Precautions for Auxiliary Processes**
		1. Saving water by reusing steam boiler condensate
		2. Ensuring water saving by insulation of steam and water lines (hot and cold) and preventing water and steam losses in pipes, valves and connection points in the lines and monitoring them with a computer system
		3. Re-use of the liquid formed by condensation from the ventilation system
		4. Avoiding unnecessary cooling processes by identifying processes that need wet cooling
		5. Reducing water consumption by increasing the number of cycles in closed loop cooling systems and improving the quality of make-up water
		6. Reduction of evaporation losses in closed loop cooling water
		7. Increasing the number of cycles by using corrosion and scale inhibitors in systems with closed water cycle
		8. Prevention of flash steam losses due to boiler discharge
		9. Use of air-cooling systems instead of water cooling in cooling systems
		10. Installation of water softening systems for the healthy operation of cooling water recovery systems
		11. Local dry air cooling in some periods of the year when the cooling requirement is low
		12. Collecting the water generated by surface runoff with a separate collection system and using it for purposes such as cooling water, process water, etc.
		13. Reducing the amount of blowdown by using degassers in steam boilers
		14. Minimisation of boiler discharge water (blowdown) in steam boilers
		15. Re-use of energy generated from the steam condenser

A total of 47 techniques have been proposed in this sector.

For the NACE Code of Service Activities Incidental To Air Transportation;

(i) Sector Specific Measures,
(ii) Good Management Practices,
(iii) General Water Efficiency BATs and
(iv) Measures for auxiliary processes are given under separate headings.

2.1.1 Sector Specific Measures

- ***Treatment of wastewater with membrane bioreactor system and utilisation in green area irrigation and fire control (Qingdao Airport, China)***

The global trend in the treatment and reuse of domestic wastewater has led to the increasing adoption of similar practices at airports (Carvalho et al., 2013). At Qingdoo Airport in China, membrane bioreactors are used for wastewater treatment. The airport has a wastewater treatment capacity of 1,000 m3/day. The treated wastewater is used for maintenance of the airport complex, afforestation, green area irrigation and fire control systems (Liu et al., 2007).

It is recommended to strengthen the pre-treatment in order to reduce membrane fouling in the installed system. MBR effluent is suitable for various consumption in terms of quality and can be used for afforestation, fire fighting and landscaping areas (Liu et al., 2007).

https://www.airport-technology.com/wp-content/uploads/sites/14/2021/09/Featured-Image-Qingdao-Jiaodong-International-Airport.jpeg

Landscaping and Green Space Application at Qingdao Airport

- ***Use of treated wastewater for car washing and sending wastewater from car washing to the treatment plant (Dubai Airport, UAE)***

Dubai Airport has a wastewater treatment plant with a daily treatment capacity of 80 m³ and an oil-water separator system. Wastewater treatment plant effluent is reclaimed and used for washing vehicles and engineering works. All vehicles operated by the Engineering Services Department are cleaned using recycled water and all drainage water is sent back to the wastewater treatment plant. Domestic wastewater is treated and reused for green area irrigation in the airport complex to minimise water consumption (Carvalho et al., 2013).

- ***Use of sanitary, kitchen and restaurant wastewater for landscape irrigation or fire control after activated sludge system + disinfection (Fiumicino Airport, Rome)***

  As an example of this method, at Fiumicino Airport in Rome, grey water from terminal restaurants and the company responsible for the preparation of food served on board is collected and treated together with domestic wastewater using an activated sludge/biological treatment system after physical treatment to remove the oil. The treated grey water is subjected to ultraviolet disinfection and reused in landscape irrigation, air conditioning systems and fire control systems (Carvalho et al., 2013).

- ***Wastewater treatment plant effluent is treated by coagulation, flocculation, sand filtering and activated carbon filtering after being blended with rainwater or well water to obtain good quality water to be used in cooling tower (Galeão Airport, Brazil)***

  At Galeao Airport in Brazil, wastewater treatment plant effluent is subjected to physical pre-treatment with sand filtration, coagulation, activated carbon filtration processes. Afterwards, reverse osmosis membranes are used to obtain good quality water that can be used in cooling towers.


Galeao Airport Physical Treatment System and Reverse Osmosis Membranes

- ***Use of reclaimed water or rainwater for car and aircraft washing***

  The "Sustainable Airports Handbook" was published by the Chicago Department of Aviation in 2018 and the best techniques that can be applied at airports are presented. With this technique, recycled water or rainwater is used for vehicle and aircraft washing, reducing the amount of drinking water needed for vehicle washing (CDA, 2018).

- ***Use of rainwater collected from terminal roofs or satellite buildings to dilute crude glycol for de-icing aircraft or runway (Heathrow Airport, London)*** Approximately 85% of the rainwater collected at London Heathrow Airport is reused.
  potential of the terminal and satellite buildings. Collected from the roofs of terminal and satellite buildings
  rainwater can be used for dilution of "raw" glycol in the de-icing process. With this water, water needs other than drinking water can be met (AMEC, 2014).

- ***Rainwater drainage system discharges rainwater from aprons, de-icing areas, roads, car parks and roofs, collects it in ponds and feeds it to the irrigation system, fire control system and toilet flushes through separate systems (Frankfurt International Airport, Germany)***

  Frankfurt International Airport has a rainwater pond at the west end of the runway system to collect rainwater. During winter, rainwater from taxiways, runways and de-icing area is temporarily stored in these ponds. The collected rainwater is treated depending on the COD concentration (Born & Ermel, 2007). The collected water is used for green area irrigation, fire control system and toilet flushes (Fraport AG, 2019).

https://born-ermel.eu/files/bornermel/uploads/bilder/Teaserboxen185x145/Referenzen/Abwasser/03_Abwasserableitung/flug_Fraport_RHB_K.png

Frankfurt International Airport Rainwater Retention Pond

- ***Treatment of wastewater from restaurant kitchens in passenger terminals and feeding it to toilet flushing systems (Narita Airport, Japan)***

  Within the scope of this method, wastewater from restaurants in the terminals of Narita Airport is treated and reused as flushing water in airport toilets. In addition to water saving in terminals, drinking water use was reduced by using treated rainwater and grey water from kitchens. With the studies carried out, drinking water use was reduced by 9.1% (28.1 L/passenger) in 2019 (NAA, 2021).

- ***Irrigation only when necessary, using sensors to monitor soil moisture instead of timed or manually controlled devices***

  A soil moisture monitoring system is recommended to reduce the dependence on manual control and timed devices in irrigation systems and also to detect leaks (CDA, 2018).

- ***Grey water collected from aircraft catering facilities and terminal building kitchens is treated together with water from aircraft washing activities and used in irrigation systems (Hong Kong Airport, China)***

  At Hong Kong Airport, grey water collected from catering facilities and terminal building kitchens is collected and treated together with water from aircraft washing activities. The treated water is reused for green area irrigation (Carvalho et al., 2013).

  A membrane biological reactor has also been installed at the airport to improve the quality of treated water. Grey water passes through dissolved air flotation, membrane bioreactor, submerged biological aeration filter and UV disinfection stages. Up to 800 m3 of water obtained from this plant is used for green area irrigation (Kilburn, M, 2013).

- ***Reducing irrigation requirements by using appropriate plant material by making soil / climate analysis in landscape areas***

  The "Sustainable Airports Handbook" was published by the Chicago Department of Aviation in 2018 and sets out the best techniques that can be applied at airports. One of these techniques is to conduct a soil/climate analysis to determine the appropriate plant material and landscape design with native or adapted plants to reduce or eliminate irrigation requirements. Soil and climate analysis is recommended to determine the appropriate landscape strategy (CDA, 2018).

- ***Replacement of conventional sanitary fittings with more efficient ones, e.g. fittings with two-stage flushing mechanisms or waterless urinals***

  To reduce the amount of wastewater, it is recommended to use high-efficiency dry systems such as composting toilet systems and waterless urinals (CDA, 2018). At Frankfurt Airport, the installation of waterless urinals in taps saved 4.2 million litres of drinking water annually (Carvalho et al., 2013).

- ***Providing flow with a mixture of water and air by using tap aerators, and installing flow restriction devices on taps that cannot be equipped with aerators***

  At Frankfurt Airport, thousands of cubic metres of water are saved each year through the use of flow limiting equipment in taps (Carvalho et al., 2013).

- ***Use of leak detection programme and advanced real-time water demand monitoring system***

  Initiatives such as leakage control and water demand monitoring are widely used at airports. Sydney, London Heathrow and Manchester Airports have leak detection programmes (Carvalho et al., 2013). At Paris Airport, the drinking water distribution network is continuously monitored for both leakage control and water quality, and operational data is transmitted to an information technology centre using fibre optic cables. In the event of a leak, an emergency telephone is signposted to take action quickly (Carvalho et al., 2013).

- ***Use of seawater in siphons and cooling systems at airports close to the sea (Hong Kong Airport, China)***

  One of the alternative water sources at airports is sea water. It is utilised for airports close to the coast. For example, 41% of the water demand of Hong Kong Airport is met from seawater. A large portion of this water is used in the cooling system (HKIA, 2011).

2.1.2 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 MAM, 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.

- ***Use integrated wastewater management and treatment strategy to reduce wastewater quantity and pollutant load***

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

  On-site reuse of treated wastewater not only improves the quality of water bodies, but also reduces the demand for freshwater. It is therefore very important to identify appropriate treatment strategies for different reuse objectives.

  In integrated industrial wastewater treatment, different aspects such as wastewater collection system, treatment process and reuse target are evaluated together (Naghedi et al., 2020). For industrial wastewater recovery, methods such as SWOT method (strengths, weaknesses, opportunities and threats), PESTEL method (political, economic, social, technological, environmental and legal factors), decision tree can be combined with expert opinions to determine the integrated wastewater management framework (Naghedi et al., 2020). The integration of Analytic Hierarchy Process (AHP) and CoCoSo techniques can be used to determine priorities based on multiple criteria for industrial wastewater management processes (Adar et al., 2021).

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

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

Industrial Wastewater Treatment Plant

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

  In industrial production processes, planning by using the least process in the process from raw material to product is an effective practice for reducing labour costs, resource use costs and environmental impacts and ensuring efficiency (TUBITAK MAM,2016;MAF,2021). Production planning in industrial plants, taking into account the water efficiency factor, reduces water consumption and wastewater amount. Modification of production processes in industrial plants or combining some processes provides significant benefits in terms of water efficiency and time planning (MAF, 2021).

- ***Preparing a water efficiency action plan to reduce water use and prevent water pollution***

  It is important for water efficiency to prepare an action plan that includes short, medium and long term actions to be taken in order to reduce water-wastewater quantities and prevent water pollution in industrial facilities. At this point, determination of water needs throughout the facility and in production processes, determination of quality requirements at water use points, wastewater generation points and wastewater characterisation should be carried out (MAF, 2021). At the same time, it is necessary to determine the measures to be implemented to reduce water consumption, wastewater generation and pollution loads, to make their feasibility and to prepare action plans for the short-medium-long term. In this way, water efficiency and sustainable water use are ensured in the facilities (MAF, 2021).

- ***Determination of water efficiency targets***

  The first step in achieving water efficiency in industrial facilities is to set targets (MAF, 2021). For this, a detailed water efficiency analysis should be carried out on the basis of processes. In this way, unnecessary water use, water losses, wrong practices affecting water efficiency, process losses, reusable water-wastewater sources with or without treatment, etc. can be determined. It is also very important to determine the water saving potential and water efficiency targets for each production process and the plant as a whole (MAF, 2021).

2.1.3 General Water Efficiency BATs

- ***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).

- ***Minimising spillages and leakages***

  Both raw material and water losses can occur due to spills and leaks in enterprises. In addition, if wet cleaning methods are used to clean the areas where spillage occurs, 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).

- ***Untreated reuse of relatively clean wastewater from washing, rinsing and equipment cleaning in production processes***

  In industrial plants, relatively clean wastewater such as washing-final rinse wastewater and filter backwash wastewater can be reused without treatment in floor washing and garden irrigation processes that do not require high water quality, saving between 1-5% in raw water consumption. The initial investment costs required for the application are the installation of new pipelines and reserve tanks (Öztürk, 2014).

- ***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 MAM, 2016).

- ***Prevention of mixing of clean water flows with polluted water flows***

  By determining the wastewater generation points in industrial facilities and characterising the wastewater, wastewater with high pollution load and relatively clean wastewater can be collected in separate lines (TUBITAK MAM, 2016; MAF, 2021). In this way, wastewater streams with appropriate quality can be reused with or without treatment. With the separation of wastewater streams, water pollution is reduced, treatment performances are improved, energy consumption can be reduced in relation to the reduction of treatment needs, and emissions are reduced by providing wastewater recovery and recovery of valuable materials. In addition, heat recovery from separated hot wastewater streams is also possible (TUBITAK MAM, 2016; MAF, 2021). Separation of wastewater streams generally requires high investment costs, and where it is possible to recover large amounts of wastewater and energy, costs can be reduced (IPPC BREF, 2006).

- ***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 MAM, 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. These blowdown waters can be reused in appropriate production processes.

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

  Closed and impermeable waste/scrap storage sites can be constructed in industrial facilities in order 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.

- ***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.

- ***Recovery of water from rinsing solutions and reuse of recovered water in processes appropriate to its quality***

  Rinsing wastewaters in industrial plants are relatively clean wastewaters that can be reused without treatment in floor washing and garden irrigation processes that do not require high water quality (Öztürk, 2014). Recycling of rinsing wastewater reduces raw water consumption.
  Savings between 1-5% can be achieved.

- ***Avoid the need to rinse between activities by using compatible chemicals in sequential processes***

  Chemical compatibility is a measure of how stable a substance is when mixed with another substance. If two substances can mix together and undergo a chemical reaction, they are considered incompatible.

  Various chemicals are used in industrial plants to increase washing and rinsing efficiency. The fact that these chemicals are compatible and act as solvents has a positive effect on increasing the efficiency. Therefore, the dirt on the material can be removed in a shorter time and more effectively and the amount of water used in washing processes can be significantly reduced. In this case, even if the amount of wastewater can be reduced, the chemical loads carried by wastewater may increase. These negative effects can be minimised by reusing the solvent-containing wash water used in washing and rinsing processes.

  Water savings of 25-50% can be achieved by reusing wash water. The application may require reserve tanks and new pipelines. In some cases, the washing solution is kept directly in the system and can be used repeatedly until it loses its properties. The investment costs required for both cases can be variable. However, the initial investment cost of the applications can be between 5.000-30.000 TL.

- ***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 MAM, 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 to be obtained (TUBITAK MAM, 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.

2.1.4 Precautions for Auxiliary Processes

BATs for steam generation

- ***Ensuring water saving by insulation of steam and water lines (hot and cold) and preventing water and steam losses in pipes, valves and connection points in the lines and monitoring them with a computer system*** Failure to design steam lines properly in the facilities, routine maintenance and maintenance of steam lines

repairs, mechanical problems occurring in the lines and the lines are not properly repaired. If the steam lines and hot surfaces are not fully insulated, steam losses may occur. This situation affects both water consumption and energy consumption of the plant. It is necessary to use analysers and control systems with automatic control mechanisms in order to make isolations in areas with steam insulation deficiencies and to continuously monitor steam consumption. Depending on the reduction of steam losses, similar savings can be achieved in fuel consumption and additional soft water consumption in boilers. Since fuel consumption in steam boilers will decrease, waste gas emissions are expected to decrease at the same rate. Since the use of additional soft water used in steam boilers will decrease with the application, regeneration water amounts, salt amounts used in regeneration and reverse osmosis concentrates can also be reduced. Full steam isolation application and automatic control mechanisms to minimise steam losses are used in many plants with intensive steam consumption. With the configuration of the application, fuel savings of 2-4% can be achieved in steam boilers.

In order to prevent losses in production processes; adding the most important parts of the equipment such as pumps, valves, control knobs, pressure, flow regulators to the maintenance check list, inspecting not only water systems but also heating and chemical dispensing systems, drums, pumps and valves, regular cleaning of filters and pipelines, regular calibration of measuring equipment (thermometers, chemical scales, dispensing/dosing systems, etc.) and inspection and cleaning of heat treatment units (including chimneys) at routinely determined periods, effective maintenance-repair, cleaning and loss control practices can reduce water consumption by %.Regular calibration of measuring equipment (thermometers, chemical scales, distribution/dosing systems, etc.) and routine inspection and cleaning of heat treatment units (including chimneys) at specified periods, effective maintenance-repair, cleaning and loss control practices can save 1-6% in water consumption (Hasanbeigi, 2010; Öztürk, 2014; MAF, 2021).

https://hohwatertechnology.com/wp-content/uploads/2021/03/boiler_175594851-1024x688.jpeg

- ***Saving water by reusing steam boiler condensate***

When steam indirect heating techniques are used to transfer thermal energy in production processes, recovery of condensed steam (condensate) is an effective practice in terms of reducing water consumption (IPPC BREF, 2009). With the recovery of condensate water, the average water consumption
5% reduction can be achieved (Greer et al., 2013). In addition, the potential payback period varies between 4-18 months (considering energy savings) (Öztürk, 2014; TUBİTAK MAM, 2016).

- ***Prevention of flash steam losses due to boiler discharge***

When steam indirect heating techniques are used to transfer thermal energy in production processes, it is an effective practice to return the condensed steam (condensate) as much as possible to reduce water consumption (IPPC BREF, 2009). An average of 5% reduction in water consumption can be achieved by recovering condensate water (Greer et al., 2013). In addition, the potential payback period varies between 4-18 months (considering energy savings) (TUBITAK MAM, 2016; Öztürk, 2014).

- ***Minimisation of boiler discharge water (blowdown) in steam boilers***

Boiler blowdown refers to the water wasted from a boiler to prevent the condensation of pollutants during the continuous evaporation of steam. Boiler blowdown can be reduced by 50% with condensate recovery (IPPC BREF, 2009).

In automatic systems, blowdowns in the boilers are continuously monitored and the system is re-analysed with the water taken after the blowdown. In the analysis, data such as dissolved and undissolved particles in the water and water density are processed. If the density for the boiler is above the system limits, the blowdown process is repeated. The system should be automated and the optimum blowdown frequency should be determined. When the blowdown frequency is reduced, the amount of wastewater decreases. Energy and cooling water used for cooling this wastewater is saved (IPPC BREF, 2009). By optimising the steam boiler blowdown process, operating costs are reduced by saving on boiler water consumption, waste costs, treatment and heating.

- ***Re-use of energy generated from the steam condenser***

With a simple modification to the pipework system, the water supplying the water resting/decarbonising unit can be obtained from the outlet of the turbine condenser unit. This water has a sufficient temperature for the resting/decarbonising unit. Therefore, it is not necessary to heat this water by means of the steam produced by the heat exchanger system. Significant vapour recovery can be achieved through this operation. Cooling water consumption can also be reduced (CPRAC, 2021).

- ***Reducing the amount of blowdown by using degassers in steam boilers***

Free oxygen dissolved in the feed water of steam boilers and hot water boilers and carbon dioxide formed by the decomposition of carbonates in boilers can cause corrosion in the form of pores, rusting and melting in steam boilers, steam appliances and especially in installations. The effects of these gases increase as the fresh feed water ratio and system operating pressure increase. If these dissolved gases are not removed from the boiler feed water, the useful life of these systems is shortened, corrosion and various deformations may occur. These gases also cause excessive corrosion in carbon dioxide coils, steam devices and condensate pipes. Boiler feed water must be purified from dissolved gases such as oxygen and carbon dioxide by passing through degasser. Degasser systems are mechanical systems that provide the evaporation of dissolved gases from the water by supplying air to the water with a fan. Dissolved gas removal can be increased by increasing the water and air contact surface in the degasser system. In this way, while corrosion formation is reduced, boiler efficiency is increased (TUBITAK MAM, 2016; MAF, 2021).

BATs for cooling systems

- ***Reducing water consumption by increasing the number of cycles in closed loop cooling systems and improving the quality of make-up water***

Water is used as a refrigerant in many processes such as production processes of the manufacturing industry and cooling of products. Water is recirculated through cooling tower or central cooling systems and cooling process is carried out. If an unwanted microbial growth occurs in the cooling water, it can be controlled by adding chemicals to the recirculation water (TUBITAK MAM, 2016). The number of cycles can be increased with good chemical conditioning in the recirculation process. In this way, the amount of fresh water fed to the system will also decrease and savings in water consumption can be achieved. In addition, the number of cycles can be increased with good conditioning of the cooling make-up water (MAF, 2021).

- ***Local dry air cooling in some periods of the year when the cooling requirement is low***

In cases where the cooling requirement is low, it will be advantageous to organise a system that can save water by cooling with dry air.

- ***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 (MoAF, 2021).

- ***Use of air cooling systems instead of water cooling in cooling systems***

  Industrial cooling systems are used for cooling heated products, processes and equipment. Closed and open circuit cooling systems can be used for this purpose, as well as industrial cooling systems using a fluid (gas or liquid) or dry air (IPPC BREF, 2001b; MAF, 2021). Air cooling systems consist of finned pipe elements, condenser and air fans (IPPC BREF, 2001b; MAF, 2021). Air cooling systems can have different operating principles. In industrial air cooling systems, the heated closed circuit coolant is cooled by air in condensers and heat exchangers (IPPC BREF, 2001b; MAF, 2021). In water cooling systems, the heated water is taken into a cooling tower and the water is cooled in drip systems. However, although water-cooled systems operate in closed circuit, a significant amount of evaporation occurs. In addition, some water is discharged as blowdown in cooling systems. Water is also lost in this way (IPPC BREF, 2001b; MAF, 2021). The use of air cooling systems instead of water in cooling systems is effective in reducing evaporation losses and also in reducing the risk of contamination of cooling water (IPPC BREF, 2001b; MAF, 2021). However, the capacity of air cooling systems is low. On the other hand, although air cooling systems do not use water, electricity is consumed for the operation of air fans. Air cooling systems have a wide range of applications. In addition, air cooling systems require alarger surface area than water cooling systems and may have higher costs (IPPC BREF, 2001b; MAF, 2021).

- ***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 MAM, 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 MAM, 2016).

- ***Collecting the water generated by surface runoff with a separate collection system and using it for purposes such as cooling water, process water, etc.***

  In most industrial plants, wastewater is generated from process or non-process areas. The wastewater generated can be treated and reused in appropriate places. Savings can be achieved at varying rates in various industrial plants by reusing the wastewater generated in the plant after treatment. Water generated by surface runoff can be collected with a separate collection system and used as cooling water (MAF, 2021).

- ***Increasing the number of cycles* by using corrosion and scale inhibitors in systems with closed water cycles** Chiller towers andevaporative condensers, air conditioning and industrial process cooling systems
are efficient and low-cost systems that remove the heat (IPPC BREF, 2001b; MAF, 2021). In these systems, more than 95% of the circulating water can be recovered (TUBITAK MAM, 2016). In cooling systems, impurities remain in the recirculating water due to the evaporation of a portion of the recirculating water and 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 MAM, 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 MAM, 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 MAM, 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).

- ***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 MAM, 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 MAM, 2016).

BATs for ventilation and air conditioning systems

- ***Re-use of the liquid formed by condensation from the ventilation system***

  Condensate with good water quality can be produced in the system during the aeration cycle. For example, in a plant in Spain, condensate from the aeration system with a conductivity of about 200 µS is collected in a tank and used to wash the automatic galvanising line (MedClean, n.d.).

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