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

Water Efficiency Campaign

Water Efficiency Guidance Documents Series

MANUFACTURE OF PLACTICS IN PRIMARY FORM

NACE CODE: 20.16

ANKARA 2023

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

Table of Contents

	Abbreviations	4
1	Introduction	5
2	Scope of the Study	8
2.1	Manufacture of Plactisc in Primary Form	10
2.1.1	Sector Specific Measures	15
2.1.2	Good Management Practices	18
2.1.3	General Water Efficiency BATs	22
2.1.4	Precautions for Auxiliary Processes	31
	Bibliography	38

Abbreviations

WTP	Wastewater Treatment Plant
EU	European Union
SSM	Suspended Solid Matter
BREF	Best Available Techniques Reference Document
EMS	Environmental Management System
MEUCC	Republic of Turkey 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 Turkey Ministry of Agriculture and Forestry
TSI	Turkish Statistical Institute
NF	Nanofiltration
MF	Microfiltration
UF	Ultrafiltration
GW	Groundwater
SW	Surface Water

1 Introduction

Our country 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 Turkey 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 Turkey 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.

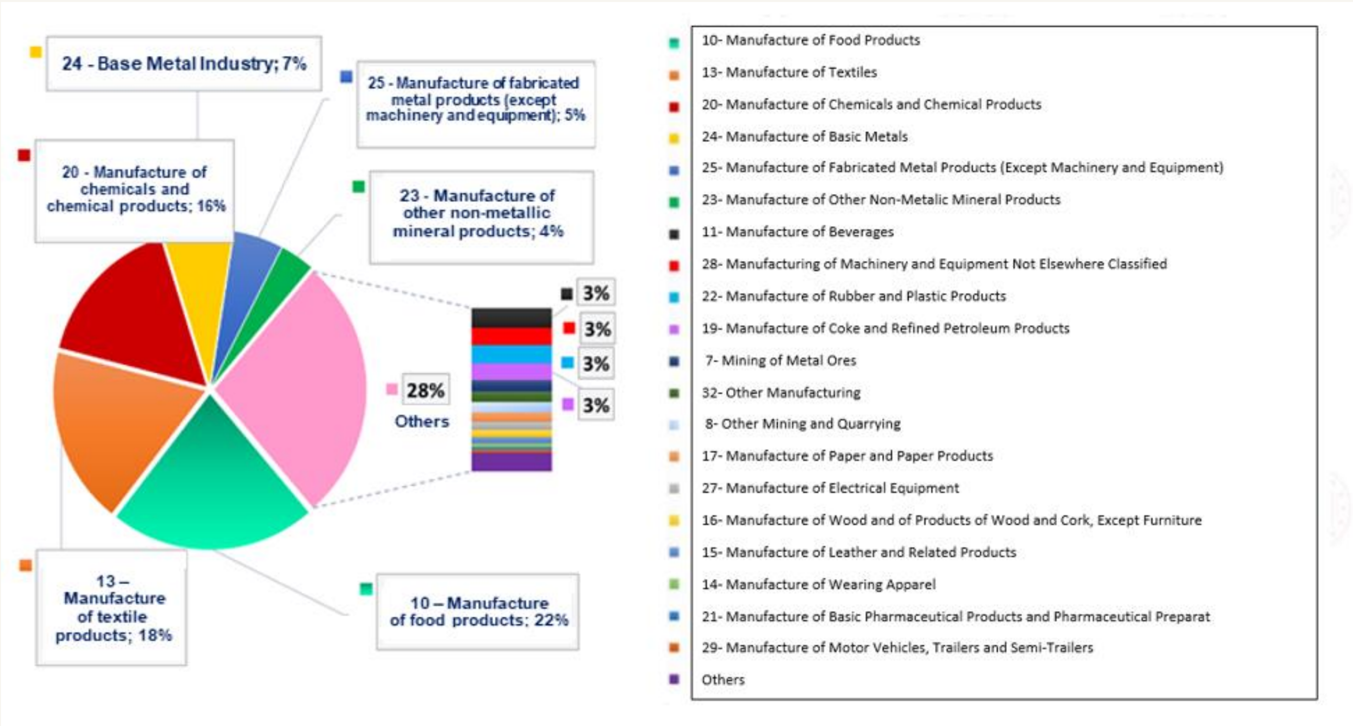
In the European Green Deal Action Plan prepared by our country within the scope of the European Green Deal Action Plan, in which member countries agreed on the objectives such as implementing a clean, circular economy model with a carbon neutral target, expanding the efficient use of resources and reducing 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 Measures, (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)

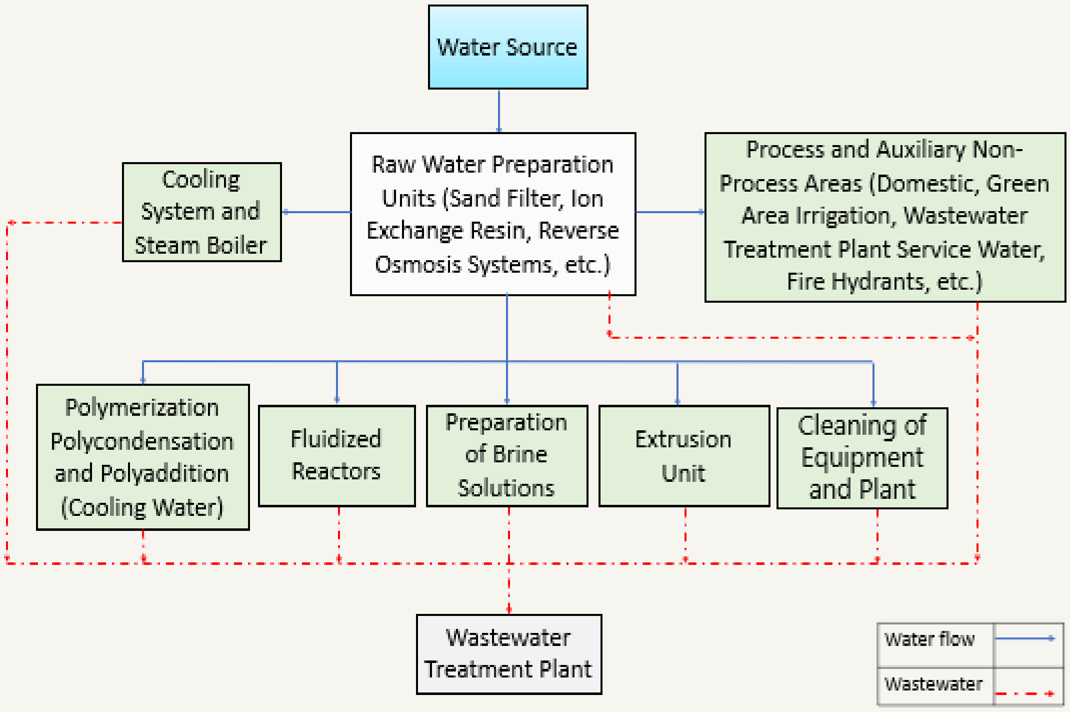
Manufacture of chemicals and chemical products

Under the chemicals and chemical products manufacturing sector, the sub-production branches for which guidance documents have been prepared are as follows

20.11	Manufacture of industrial gases
20.12	Manufacture of dyestuffs and pigments
20.13	Manufacture of other inorganic basic chemicals
20.14	Manufacture of other organic basic chemicals
20.15	Manufacture of chemical fertilisers and nitrogen compounds
20.16	Manufacture of plastic raw materials in primary form
20.17	Manufacture of synthetic rubber in primary form
20.20	Manufacture of pesticides and other agro-chemical products
20.30	Manufacture of paints, varnishes and similar coating materials, printing inks and pastes
20.41	Manufacture of soaps and detergents, cleaning and polishing agents
20.42	Manufacture of perfumes, cosmetics and personal care products
20.59	Manufacture of other chemical products not elsewhere classified
20.60	Manufacture of man-made or synthetic fibres

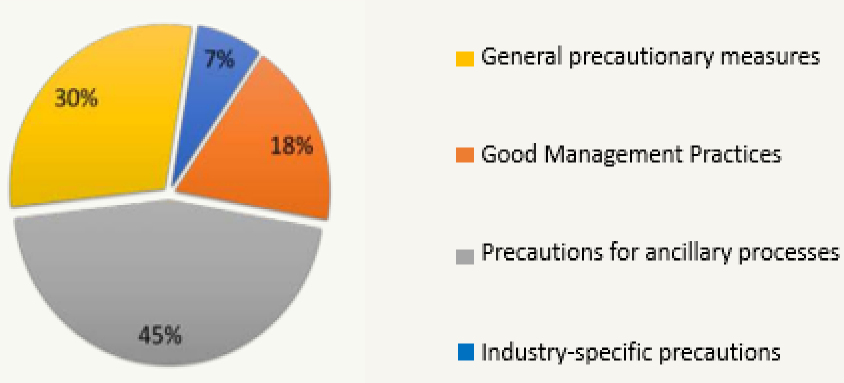
2.1 Manufacture of Plastics in Primary Form (NACE 20.16)

Manufacture of Plastics in Primary Form
Water Flow Chart



	Minimum	Maximum
Specific Water Consumption of the Facilities Visited within the Scope of the Project (L/kg product)	0,3	10,3
Reference Specific Water Consumption (L/kg product)	1	160

Percentage Distribution of Water Efficiency Applications



20.16 Manufacture of Plastics in Primary Form sector covers the activities that constitute the petrochemical industry together with 20.14 Manufacture of Other Organic Basic Chemicals sector. In the production of plastic raw materials, there are pre-expansion, moulding, cutting-forming and post-production processing processes. In the pre-expansion process, the raw material to be processed is subjected to expansion process. Afterwards, the expanded raw material enters the hardening phase in order to stabilise it and reaches the temperature-pressure balance. After reaching the desired stabilisation, the raw material is subjected to the cutting-forming-process and then packaged and made ready for sale. In addition, low or high density polymers can also be produced by polymerisation and chemical processes in plants that manufacture polymers in primary form.

In polymer production in primary form, water consumption occurs in the polymerisation process. In integrated plants where synthetic polymers are manufactured by polymerisation processes, water consumption occurs in different areas such as brine preparation process in chemical processes, caustic dilution, chemical preparation, cooling water use in basic production processes. In addition, plastic extrusion (extruder) machinery and equipment cooling water is used.

In the 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, significant water consumption is also realised for filter washing, resin regeneration and membrane cleaning processes. Water consumption also occurs in auxiliary units such as cooling tower and steam boilers.

The reference specific water consumption in the sector of manufacturing of plastic raw materials in primary form is in the range of 1 - 160 L/kg. The specific water consumption of the production line analysed within the scope of the study is 0.3 - 10.3 L/kg. With the application of sector-specific techniques, good management practices, measures in the form of general measures and measures related to auxiliary processes
It is possible to provide 26 - 50% water recovery.

20.16 Manufacture of Plastic Raw Materials in Primary Forms Priority water efficiency implementation techniques recommended under the NACE code are presented in the table below.

NACE Code	NACE Code Description		Prioritised Sectoral Water Efficiency Techniques
20.16	Manufacture of plastic raw materials in primary form		**Sector Specific Measures**
		1.	Use of separate collection systems for potential wastewater
		2.	Preference for dry solvents or reuse of aqueous solvents with closed loop systems
		3.	Use of mechanical pumps in closed circuit processes in the production of aromatic chemicals, reduction of blowdown and/or use of dry running pumps
		4.	Separation of organic phases and aqueous phases to prevent the mixing of undissolved organic substances into wastewater
		5.	Reuse of cleaning water from ethylene oxide plant in ethylene glycol production
		6.	Concentration of aqueous streams by distillation technique in ethylene oxide and ethylene glycol plants for the recovery of glycols or partial reuse of water
		7.	Recovery of hydrocarbons by stripping
		8.	Optimal catalyst selection to increase resource efficiency
		9.	Recovery and reuse of organic solvents to improve resource efficiency
		10.	Reducing catalyst losses and preventing its mixing with wastewater
		11.	Sulphate removal from wastewater by anaerobic sulphate reduction
		12.	Use of buffer for upward wastewater flow in the wastewater treatment plant to keep wastewater quality constant
		13.	Disposal of zinc from solutions containing zinc sulphate in wastewater
		14.	Removal of polyvinyl chloride residues from the reactor
		15.	Oxidation of sulphides in the scrubber liquor (scrubber liquid) to sulphates
			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.	Preparation of water flow diagrams and mass balances for water
		4.	Preparing a water efficiency action plan to reduce water use and prevent water pollution
		5.	Providing technical trainings to personnel for the reduction and optimisation of water use
		6.	Good production planning to optimise water consumption
		7.	Determination of water efficiency targets
		8.	Monitoring the water used in production processes and auxiliary processes and the wastewater generated in terms of quantity and quality and monitoring this information in terms of environment management system

NACE Code	NACE Code Description		Prioritised Sectoral Water Efficiency Techniques
20.16	Manufacture of plastic raw materials in primary form		**General Measures**
		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.) that will save water at water usage points such as showers/toilets etc.
		4.	Use of pressure washing systems for equipment cleaning, general cleaning, etc.
		5.	Reducing water consumption by reusing filter wash water in filtration processes, reusing relatively clean cleaning water in production processes and using clean-in-place systems (CIP)
		6.	Avoiding the use of drinking water in production lines
		7.	Use of cooling water as process water in other processes
		8.	Identification and minimisation of water losses
		9.	Use of automatic control-close valves to optimise water use
		10.	Documented production procedures are kept and used by employees to prevent water and energy wastage
		11.	Reuse of pressurised filtration backwash water prior to water softening at appropriate points
		12.	Optimising the frequency and duration of regeneration (including rinses) in water softening systems
		13.	Construction of closed storage and impermeable waste/scrap sites to prevent the transport of toxic or hazardous chemicals for the aquatic environment
		14.	Storage 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
		15.	Where technically feasible, treatment of suitable wastewater and use as steam boiler feed water
		16.	Prevention of mixing of clean water flows with polluted water flows
		17.	Determination of wastewater flows that can be reused with or without treatment by characterising the wastewater quantities and qualities at all wastewater generation points
		18.	Use of closed loop water cycles in appropriate processes
		19.	Use of computer aided control systems in production processes
		20.	Washing, rinsing and equipment cleaning in production processes clean wastewater without treatment

NACE Code	NACE Code Description		Prioritised Sectoral Water Efficiency Techniques
20.16	Manufacture of plastic raw materials in	21.	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.)
		22.	Implementation of time optimisation in production and arrangement of all processes to be completed as soon as possible
		23.	Collecting rainwater and utilising it as an alternative water source in facility cleaning or in suitable areas
		24.	Reuse of nanofiltration (NF) or reverse osmosis (RO) concentrates with or without treatment depending on their characterisation
			Precautions for Auxiliary Processes
		1.	Water saving by reuse of steam boiler condensate Water saving by insulation
		2.	of steam and water lines (hot and cold), Prevention of water and steam losses in pipes, valves and connection points in the lines and monitoring with computer system
		3.	Avoiding unnecessary cooling processes by identifying processes that need wet cooling
		4.	Reducing water consumption by increasing the number of cycles in closed loop cooling systems and improving the quality of make-up water
		5.	Reduction of evaporation losses in closed loop cooling water
		6.	Water recovery with tower cooling application in non-closed loop systems
		7.	Increasing the number of cycles by using corrosion and scale inhibitors in systems with closed water cycle
		8.	Prevention of flash steam losses caused by boiler unloading
		9.	Utilisation of hot water produced in the cogeneration system in processes for heating purposes
		10.	Utilisation of cold water produced in the cogeneration system in cooling processes
		11.	Use of air cooling systems instead of water cooling in cooling systems
		12.	Installation of water softening systems for the healthy operation of cooling water recovery systems
		13.	Use of a closed-loop cooling system to minimise water use
		14.	Local dry air cooling in some periods of the year when the cooling requirement is low
		15.	Reducing the amount of blowdown by using degassers in steam boilers
		16.	Minimisation of boiler discharge water (blowdown) in steam boilers
		17.	Re-use of the energy generated from the steam condenser

A total of 64 techniques have been proposed in this sector.

For the NACE Code for Manufacture of Plastic Raw Materials in Primary Form;

(i) Sector Specific Measures,

(ii) Good Management Practices,

(iii) General Precautions and

(iv) Measures for auxiliary processes are given under separate headings.

2.1.1 Sector Specific Measures

- ***Disposal of zinc from solutions containing zinc sulphate in wastewater***

  It is possible to dispose of zinc in wastewater from solutions containing zinc sulphate by a two- or three-stage process of neutralisation, precipitation as hydroxide, concentration in a sludge thickener and dewatering. Zinc (Zn) from other solutions containing zinc sulphate (ZnSO4) is eliminated by two- or three-stage neutralisation of the wastewater by increasing the pH from 4 to 10 with milk of lime. Zinc is precipitated as zinc hydroxide (Zn(OH)2) and separated in pre-precipitation. This sludge, consisting of zinc hydroxide and lime, is concentrated and dewatered in centrifuges or chamber filter presses. In the second stage, it can provide further precipitation. While the treatment of Zn from wastewater by this method provides environmental benefits, the sludge from the precipitation has to be disposed of (IPPC BREF, 2007f).

- ***Cleaning of polyvinyl chloride residues from the reactor***

  In order to reduce the residues from the reactors, the reactor should be washed and cleaned with water. The water used for cleaning the reactors is transferred to the stripping system and reused (MoEnvUIDU, 2006).

- ***Use of separate collection systems for potential wastewater***

  As a measure of high general applicability in all polymer plants, it is recommended to use separate waste collection systems for potentially contaminated water released from leaks and other sources, including cooling water and surface runoff from process plant areas (MoEUİDB, 2006).

- ***Sulphate removal from wastewater by anaerobic sulphate reduction***

  Under anaerobic conditions, sulphate is reduced to hydrogen sulphide gas by microorganisms. Most of the gas is transferred to the aeration tank with the liquid phase. The rest of the hydrogen sulphide is in the gas phase. Part of the dissolved hydrogen sulphide is recovered for flocculation with zinc. In the aeration zone the H2S is carefully re-oxidised with oxygen in the quantities necessary to obtain basic sulphur. The remaining wastewater is combined with domestic and industrial wastewater and treated (IPPC BREF, 2007f). The potential for wastewater recovery also increases with sulphate removal from wastewater.

- ***Use of mechanical pumps in closed circuit processes in the production of aromatic chemicals, reduction of blowdown and/or use of dry running pumps***

  In the production of aromatic hydrocarbons, the use of mechanical pumping systems in closed-loop processes, keeping blowdown water low or using dry-running pumps reduces the amount of wastewater and organic load (IPPC BREF, 2017b).

- ***Preference for dry solvents or reuse of aqueous solvents using closed loop systems*** By using dry solvents, it is possible to reduce the amount of aromatic compounds and wastewater generated in aromatic extraction units. On the other hand, by reusing aqueous solvents using closed loop systems, it is possible to reduce the amount of aromatic compounds and wastewater generated in aromatic extraction units.
  It is also possible to reduce the amount of wastewater and the amount of aromatic compounds contained in the wastewater. Dry or wet solvents can be used for aromatic extraction. By using dry solvents, the amount of wastewater can be zero or a very low amount of wastewater is generated. If wet solvents are preferred, water can be recovered and reused by using a closed loop recovery system (IPPC BREF, 2017b).

- ***Use of buffer for upward wastewater flow in the wastewater treatment plant to keep wastewater quality constant***
  As a generally applicable measure in all polymer plants, a buffer for upward wastewater flow can be used in the wastewater treatment plant to keep the wastewater quality constant. This technique is applicable to all wastewater generating processes such as PVC1 (polyvinylchloride) and ESBR2 (buried low rate biomethane reactor) (MoEUIDU, 2006).

- ***Separation of organic phases and aqueous phases to prevent the mixing of undissolved organic substances into wastewater***
  Separation of organic phases and aqueous phases under appropriate design and suitable operating conditions (adequate retention time, phase boundary detection and control) to prevent the mixing of undissolved organic matter into the wastewater increases the recovery of hydrocarbons and enables the reuse of the quench water. Hydrocarbons recovered from the quench water from the primary separation stage can be recovered or used as raw material in other chemical processes. In the recovery of organics, the efficiency can be increased through the use of steam, gas stripping or re-boiling. The treated quench water is reused in the dilution vapour production system. To prevent salt accumulation in the system, a quench water discharge stream can be provided downstream of the final wastewater treatment system (IPPC BREF, 2017b).

- ***Reuse of purge water from ethylene oxide plant in ethylene glycol production*** In ethylene oxide and ethylene glycol production, the purge streams from the ethylene oxide plant are not discharged as wastewater but are sent to the ethylene glycol process. The extent to which the purged water can be reused in the ethylene glycol process depends on the ethylene glycol product quality (IPPC BREF, 2017b).

- ***Reducing catalyst losses and preventing its mixing with wastewater***
  The use of a cyclone or a dry catalyst filtration system in the production of ethylene dichloride and vinyl chloride monomers can also reduce the losses of catalysts in the reactor, and hence their mixing with wastewater. This technique is only applicable for plants using fluidised bed design (IPPC BREF, 2017b). The potential for wastewater recovery increases with the reduction of ethylene dichloride and vinyl chloride in the wastewater.

- ***Concentration of aqueous streams by distillation technique in ethylene oxide and ethylene glycol plants for the recovery of glycols or partial reuse of water***

  Distillation is a distillation technique used to separate compounds with different boiling points by partial evaporation and recondensation. In ethylene oxide and ethylene glycol plants, this technique is based on concentrating aqueous streams for recovery or disposal of glycols (e.g. disposal by incineration instead of wastewater discharge) and partial reuse/recovery of water. In this way, wastewater concentration and resource utilisation can be reduced.

  The distillation technique reduces disposal costs and provides economic benefits from recovered glycols. The technique also reduces the high TOC (Total Organic Carbon)/COD (Chemical Oxygen Demand) load. At low concentrations, glycols are easily biodegradable (IPPC BREF, 2017b).

- ***Recovery of hydrocarbons by stripping***

  By stripping, volatile compounds are removed from the aqueous phase by a gas phase (e.g. vapour, nitrogen or air) passed through the liquid. The resulting concentrate is recovered for reuse (e.g. by condensation) or disposed of. Removal efficiency can also be improved by increasing the temperature or reducing the pressure (IPPC BREF, 2017b).

- ***Optimum catalyst selection to increase resource efficiency***

  In the selection of catalysts, the optimum balance between the following factors should be considered to increase resource efficiency and wastewater recovery potential:

  - Catalyst activity
  - Selectivity of the catalyst
  - Life of the catalyst
  - Use of less toxic metals

  The potential for wastewater recovery increases with the use of less toxic metals.

- ***Recovery and reuse of organic solvents to improve resource efficiency***

  In the production of all organic basic chemicals, recovery of organic solvents used in the processes is ensured by using appropriate techniques such as distillation, liquid phase separation. When necessary for recovery, purification is carried out using distillation, adsorption, stripping or filtration processes and the organic solvent is returned to the process (IPPC BREF, 2017b).

- ***Oxidation of sulphides in the scrubber liquor (scrubber liquid) to sulphates***

  The process of oxidising sulphur using high pressure and high temperature (wet air oxidation) or oxidising agents such as hydrogen peroxide to reduce the sulphur content in spent scrubber liquor (scrubber fluid) discharged to the wastewater treatment system (IPPC BREF, 2017b).

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; TOB, 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 (TOB, 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).

Industrial Wastewater Treatment Plant

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

- ***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 (TOB, 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; TOB, 2021).

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

There is resource utilisation in industrial facilities and inefficiency and environmental problems arising from resource utilisation may arise from input-output flows. For this reason, Water and wastewater used in production processes and auxiliary processes should be monitored in terms of quantity and quality (TUBITAK MAM, 2016; TOB, 2021). Process-based quantity and quality monitoring together with other good management practices (personnel training, establishment of an environmental management system, etc.) can reduce energy consumption by 6-10%, it can provide a reduction of up to 25% for water consumption and wastewater quantities (Öztürk, 2014).

The main stages for monitoring water and wastewater in terms of quantity and quality are as follows

- Use of monitoring equipment (such as counters) to monitor water, energy, etc. consumption on a process basis,
- Establishment of monitoring procedures,
- Determining the use/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).

- ***Providing technical***

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

  In industrial production processes, planning by using the least process in the process until a raw material turns into a product is an effective practice to reduce labour costs, resource use costs and environmental impacts and to ensure efficiency (TUBITAK MAM, 2016; TOB, 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 (TOB, 2021).

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

  Preparation of 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 is important in terms of water efficiency. At this point, determination of water needs throughout the facility and in production processes, water quality requirements at the points of use, wastewater generation points and wastewater characterisation should be carried out (MoAF, 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 (TOB, 2021).

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

  The first step in achieving water efficiency in industrial facilities is to set targets (TOB, 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 extremely important to determine the water saving potential and water efficiency targets for each production process and the plant as a whole (TOB, 2021).

- ***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 throughout the plant and on the basis of production processes facilitates the identification of unnecessary water use points and high water use points, evaluation of water recovery opportunities, process modifications and determination of water losses (TOB, 2021).

2.1.3 General Water Efficiency BATs

- ***Determination and minimisation of water losses***

  Water losses occur in equipment, pumps and pipelines in industrial production processes. First of all, water losses should be identified and equipment, pumps and pipelines should be regularly maintained and kept in good condition to prevent leakages (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 (TOB, 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).

- ***Use of pressure washing systems for equipment cleaning, general cleaning, etc.***

  Water nozzles are widely used in equipment plant cleaning. Effective results can be achieved by using correctly placed, appropriate nozzles to reduce water consumption and wastewater pollution loads. The use of active sensors and nozzles at points where high water consumption occurs and where possible is very important in terms of efficient use of water. It is possible to achieve significant water savings by replacing mechanical equipment with pressurised nozzles (TUBITAK MAM, 2016). Reducing water consumption, wastewater generation and wastewater pollution load through the use of water pressure optimised nozzles in technically appropriate processes are the main environmental benefits of the application.

- ***Determination of wastewater streams that can be reused with or without treatment by characterising wastewater quantities and qualities at all wastewater generation points***
Determination and characterisation of wastewater generation points in industrial plants enables the reuse of various wastewater streams with or without treatment (Öztürk, 2014; TUBİTAK MAM, 2016; TOB, 2021). In this context, filter backwash waters, TO concentrates, blowdown waters, condensate waters, relatively clean washing and rinsing waters can be reused without treatment in the same/different processes and in areas that do not require high water quality (such as facility and equipment cleaning). In addition, wastewater streams that cannot be directly reused can be reused in production processes after treatment using appropriate treatment technologies.

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

- ***Where technically feasible, treatment of suitable wastewater and use as steam boiler feed water***
Although it is difficult to apply in industrial plants, it is possible to treat suitable wastewater to process water quality and reuse it in production processes, including steam boilers. In this way, savings ranging from 20-50% in total water consumption and wastewater generation can be achieved (Öztürk, 2014; TUBİTAK MAM, 2016). The initial investment cost required for the application is the treatment system to be used. Considering the amount of water to be recovered, the amount of economic savings, unit water-wastewater costs applied, treatment system operation-maintenance costs, payback periods vary (TOB, 2021). A combination of membrane systems (ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO) systems can be used for recovery. For example, in some industrial plants, cooling system blowdown water can be treated and reused as process water (TOB, 2021).

- ***Use of cooling water as process water in other processes***
Water cooling systems are widely used in processes where thermal energy is used intensively and cooling is required. It is possible to recover heat by using heat exchangers in cooling water return, prevent contamination of cooling water, and save water and energy by increasing cooling water return rates (TUBITAK MAM, 2016; TOB, 2021). In addition, in case of separate collection of cooling water, it is generally possible to use the collected water for cooling purposes or to reuse it in appropriate processes (EC, 2009). Reuse of cooling water can save 2-9% of total water consumption (Greer et al., 2013). Energy consumption can be saved up to 10% (Öztürk, 2014; TOB, 2021).

- ***Use of automatic control-close valves to optimise water use***
Monitoring and controlling water consumption using flow control devices, meters and computer-aided monitoring systems provide significant technical, environmental and economic advantages (Öztürk, 2014). Monitoring the amount of water consumed in the plant and in various processes prevents water losses (TUBITAK MAM, 2016). It is necessary to use flow meters and counters in the plant in general and in production processes in particular, to use automatic shut-off valves and valves in continuously operating machines, and to develop monitoring-control mechanisms according to water consumption and some determined quality parameters by using computer-aided systems (TUBITAK MAM, 2016). With this application, it is possible to save up to 20-30% of water consumption on process basis (DEPA, 2002; LCPC, 2010; IPPC BREF, 2003). By monitoring and controlling water consumption on a process basis, 3-5% savings can be achieved in process water consumption (Öztürk, 2014).

- ***Avoiding the use of drinking water in production lines***

In different sub-sectors of the manufacturing industry, waters with different water quality can be used for production purposes. In industrial plants, raw water supplied from groundwater sources is generally used in production processes after treatment. However, in some cases, although it is costly in production processes, drinking water can be used directly or raw water is disinfected with chlorinated compounds and then used in production processes. These waters containing residual chlorine can react with organic compounds (natural organic substances (DOM)) in water in production processes and form disinfectant by-products harmful to living metabolisms (Özdemir & Toröz, 2010; Oğur et al.) The use of drinking water containing residual chlorine compounds or raw water disinfected with chlorinated compounds should be avoided as much as possible. Highly oxidising disinfection methods such as ultraviolet (UV), ultrasound (US) or ozone can be used instead of chlorine disinfection for disinfection of raw water. In order to increase the technical, economic and environmental benefits of the application, the determination and use of the water quality parameters required in each production process helps to reduce unnecessary water supply and treatment costs. With this application, it is possible to reduce water, energy and chemical costs (TUBITAK MAM, 2016).

- ***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 is 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 for production processes, garden irrigation, tank and equipment cleaning, surface cleaning, etc. if it meets the required quality requirements (Tanık et al., 2015).

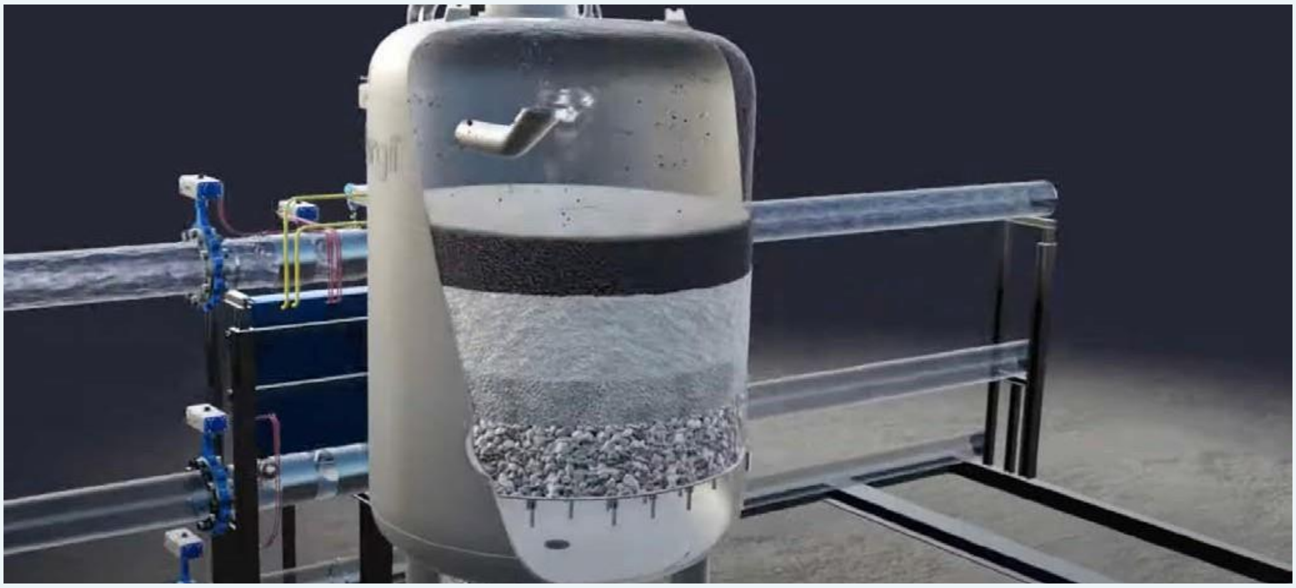
In various examples, roof rainwater collected in industrial facilities was stored and used inside the building and in landscape areas, resulting in 50% water saving in landscape irrigation (Yaman, 2009). Perforated stones and green areas can be preferred in order to increase the permeability of the ground and to allow rainwater to pass and absorb into the soil on the site (Yaman, 2009). Rainwater collected on building roofs can be used for car washing and garden irrigation. It is possible to recover and reuse 95% of the collected water by biological treatment after use (Şahin, 2010).

- ***Optimising the frequency and duration of regeneration (including rinses) in water softening systems***

Cationic ion exchange resins, which are one of the most frequently used methods for softening raw water in industrial plants, are routinely regenerated. In regeneration, pre-washing of the resin using raw water, regeneration with salt water and final rinsing processes are carried out respectively. Regeneration periods are determined depending on the hardness of the water. If the hardness is high, regeneration should be performed more frequently in water softening systems.

In regeneration processes, washing, regeneration and rinsing wastewaters are generally removed directly. However, if the washing and final rinsing waters are of raw water quality, they can be sent to raw water storage or reused in processes that do not require high water quality such as facility cleaning and green area irrigation (TOB, 2021).

It is very important to determine the optimum regeneration frequency in regeneration systems. Although regeneration in water softening systems is adjusted according to the frequencies recommended by the supplier or depending on the flow rate and time entering the softening system, this frequency also varies depending on the calcium concentration in the raw water. For this reason, online hardness measurement is applied while determining the regeneration frequency. Thus, regeneration frequencies can be optimised and excessive washing rinsing or backwashing with salt water can be prevented by using online hardness sensors.



Water Softening Systems

https://www.youtube.com/watch?v=Deazp2Ukgio

- ***Reuse of pressurised filtration backwash water prior to water softening at appropriate points***

Softened water with low calcium and magnesium concentrations is required for many industrial processes. With water softening systems, calcium, magnesium and some other metal cations in hard water are removed from the water and soft water is obtained.

Savings are achieved by reusing pressurised filtration backwash water at appropriate points before water softening. This measure is similar in content with practices such as "Reuse of filter backwash water in filtration processes, reuse of relatively clean water in production processes, reduction of water consumption by using on-site cleaning systems".

- ***Reuse of nanofiltration (NF) or reverse osmosis (RO) concentrates with or without treatment depending on their characterisation***

Depending on the wastewater characterisation and the appropriate point of use, the reuse potential of other wastewater from membrane processes (backwashing without or with chemicals, CIP cleaning, module cleaning, cleaning of chemical tanks, etc.) should be assessed.

Nanofiltration is a membrane-based liquid separation technique with low energy consumption and low operating pressures suitable for the treatment of well water and surface water. Reverse osmosis is also a membrane-based liquid separation technique and can separate smaller substances than nanofiltration (Akgül, 2016).

Savings are achieved by reusing nanofiltration or reverse osmosis concentrates with or without treatment depending on their characterisation. Measures should be taken to reduce water consumption by reusing clean water in the production processes of filter backwash water in filtration processes and using cleaning systems (TOB, 2021).

Reverse Osmosis System

https://genesiswatertech.com/wp-content/uploads/2019/08/RO-waste-water-

- ***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.

- ***Storage and storage of substances (such as oils, emulsions, binders) that pose a risk to the aquatic environment and prevention of their mixing with wastewater as much as possible after use*** Dry cleaning techniques in industrial plants to prevent the mixing of chemicals that pose a risk to the aquatic environment such as oils, emulsions and binders into wastewater streams

can be used and leaks can be prevented. In this way, water resources can be protected (TUBITAK MAM, 2016).

- ***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.

- ***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. nSavings between 1-5% can be achieved.

- ***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).

Computer Aided Control System

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

- ***Reducing water consumption by reusing filter wash water in filtration processes, reusing relatively clean cleaning water in production processes and using clean-in-place systems (CIP)***

  The wastewater from backwashing of activated carbon filters and softeners usually contains only a high content of suspended solids (TSS). Backwash water, which is one of the easiest types of wastewater to recover, can be recovered by filtration with ultrafiltration plants. In this way, water savings of up to 15% can be achieved (URL - 1, 2021).

  Regeneration wastewater generated after the regeneration process are soft waters with high salt content and constitute approximately 5-10% of total water consumption. Regeneration wastewater is collected in a separate tank and utilised in processes with high salt requirements, plant cleaning and domestic use. For this purpose, a reserve tank, water installation and pump are required. By reusing regeneration wastewater, water consumption, energy consumption, wastewater amounts and salt content of wastewater are reduced by approximately 5-10% (Öztürk, 2014). The payback period varies depending on whether the regeneration wastewater is consumed in production processes, plant cleaning and domestic use. The potential payback period is estimated to be less than one year if regeneration waters are reused in production processes that require high salt (since both water and salt will be recovered). For facility and equipment cleaning and domestic use, the payback period is estimated to be over one year (MoAF, 2021).

  In our country, reverse osmosis (RO) concentrates are combined with other wastewater streams and discharged to the wastewater treatment plant channel. The concentrates formed in TO systems used for additional hardness removal can be used in garden irrigation, in-plant and tank-equipment cleaning (TUBITAK MAM, 2016; TOB, 2021). In addition, with the structuring of monitoring for raw water quality, it is possible to feed TO concentrates back to raw water reservoirs and re-evaluate them by mixing (TOB, 2021).

- ***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; TOB, 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; TOB, 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).

- ***Documented production procedures are kept and used by employees to prevent water and energy wastage***

  In order to ensure efficient production in an enterprise, effective procedures should be implemented to identify and evaluate potential problems and resources and to control production stages (Ayan, 2010). Determining and implementing appropriate procedures in production processes ensures more efficient use of resources (such as raw materials, water, energy, chemicals, personnel and time) and ensures reliability and quality in production processes (Ayan, 2010). The existence of documented production procedures in production processes contributes to the evaluation of business performance and the development of the ability to develop immediate reflexes to solve problems (TUBITAK MAM, 2016; TOB, 2021). Effective implementation and monitoring of the procedures created specifically for production processes is one of the most effective ways to ensure product quality, receive feedback and develop solutions (Ayan, 2010). Documentation, effective implementation and monitoring of production procedures is a good management practice and an effective tool in structuring and ensuring the continuity of the cleaner production approach and environmental management system. In addition to the potential benefits, the cost and economic gains of the application may vary from sector to sector or depending on the facility structure (TUBITAK MAM, 2016; TOB, 2021). Although establishing and monitoring production procedures is not costly, the payback period may be short considering the savings and benefits it will provide (TUBITAK MAM, 2016; TOB, 2021).

- ***Implementation of time optimisation in production and arrangement of all processes to be completed as soon as possible***

  In industrial production processes, planning the process from raw material to product by using the minimum number of processes is an effective practice for reducing labour costs, resource use costs and environmental impacts and ensuring efficiency. In this context, it may be necessary to revise the production processes so that the minimum number of process steps is used (TUBITAK MAM, 2016). In cases where the desired product quality cannot be achieved due to some inefficiencies, inefficiency and design errors in basic production processes, production processes may need to be renewed. Therefore, in this case, the resource utilisation and the amount of waste, emission and solid waste generated in the production of unit amount of product increases. Time optimisation in production processes is an effective application (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.

- ***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.

2.1.4 Precautions for Auxiliary Processes

BATs for steam generation

- ***Ensuring water saving by insulating 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***

Steam losses may occur if the steam lines are not designed properly, routine maintenance and repairs of the steam lines are not carried out, mechanical problems occurring in the lines and the lines are not operated properly, steam lines and hot surfaces are not fully insulated. This situation affects both water consumption and energy consumption of the plant. It is necessary to use control systems with automatic control mechanisms in order to make steam isolation and continuous monitoring of 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, the amount of regeneration water, the amount of salt used in regeneration and reverse osmosis concentrates are also reduced. Full steam isolation application and automatic control mechanisms to minimise steam losses are used in many plants with high steam consumption. With the configuration of the application, fuel savings of 2-4% are 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.), routine inspection and cleaning of heat treatment units (including chimneys) in specified periods, effective maintenance-repair, cleaning and loss control practices can save 1-6% in water consumption (Hasanbeigi, 2010; Öztürk, 2014; TOB, 2021).

Industrial Steam Boilers

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 application in terms of reducing water consumption (IPPC BREF, 2009). An average of 5% reduction in water consumption can be achieved by recovering condensate (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***

Steam boiler condensate is generally discharged from the system at atmospheric pressure from equipment outlets and steam traps. As the pressure decreases in condensate systems, some of the condensate re-evaporates and cools to the boiling point of water at atmospheric pressure. The re-evaporated condensate, called flash steam, is lost by being thrown into the atmosphere. In condensate return lines, which are usually quite long, cooling and therefore evaporation is inevitable. In order to prevent re-evaporation of condensate, savings can be achieved by keeping it in a flash tank under pressure until it returns to the boiler feed tank. As the pressure decreases in the condensate taken into the tank, the vapour formed is collected on the tank and feeds the low pressure steam system from here. The remaining hot condensate is taken from the bottom of the tank to the boiler.

- ***Re-use of the 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; TOB, 2021).

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.

BATs for cooling systems

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

Closed loop cooling systems significantly reduce water consumption compared to open loop systems with more intensive water use. In closed loop systems, while the same water is recirculated within the system, it is usually necessary to add cooling water equal to the amount of water evaporated. By optimising cooling systems, evaporation losses can also be reduced.

- ***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 can be reduced and water saving can be achieved. In addition, good conditioning of the cooling make-up water can also increase the number of cycles (TOB, 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 is possible to save water by cooling with dry air.

- ***Water recovery with tower cooling application in systems without closed loop***

  Cooling towers are divided into two as counter-flow and cross-flow according to their working principles. In counter-flow cooling towers, the air flow moves upwards while the water flows downwards, and in cross-flow cooling towers, the air flow moves horizontally while the water flows downwards.

  The water exposed to fresh air cools down until it reaches the cold water pool, where it is collected and sent to the plant. During these processes, some of the water evaporates. The air, whose humidity increases as a result of the evaporation of the water, is discharged to the atmosphere from the fan chimney at the top of the tower. Evaporation losses in cooling towers must be managed effectively.

  Various chemicals are used in cooling towers to prevent the formation of bacteria and parasites and to control lime deposits. These chemicals condense with the evaporation of water and cause unwanted deposits and deposits in the tower. Blowdown system is used to keep this condensation at a certain level. Blowdown water can be treated and recovered by membrane filtration systems or by using ion exchange resins. Recovery of blowdown wastewater is important for water efficiency.

Tower Type Cooling Systems

https://www.revueconflits.com/geopolitique-de-lenergie-francois-campagnola

- ***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; TOB, 2021). In these systems, more than 95% of the circulating water can be recovered (TUBITAK MAM, 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 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; TOB, 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).

- ***Avoiding unnecessary cooling processes by determining the processes that need wet cooling***

  The boundaries of the plant site affect the design parameters such as cooling tower height. In cases where it is necessary to reduce the tower height, hybrid cooling system can be applied. Hybrid cooling systems can be evaporative and non-evaporative (wet and dry) is a combination of 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).

- ***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).

- ***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).

- ***Use of air cooling systems instead of water cooling in cooling systems*** Industrial cooling systems are used for cooling heated products, processes and equipment. For this purpose, closed and open circuit cooling systems can be used, as well as industrial cooling systems using a fluid (gas or liquid) or dry air.
  (IPPC BREF, 2001b; TOB, 2021). Air cooling systems consist of finned pipe elements, condenser and air fans (IPPC BREF, 2001b; TOB, 2021). Air cooling systems can have different operating principles. In industrial air cooling systems, the heated water is cooled by air in closed circuit cooling condensers and heat exchangers (IPPC BREF, 2001b; TOB, 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, since some water is discharged as blowdown in cooling systems, water loss also occurs in this way (IPPC BREF, 2001b; TOB, 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; TOB, 2021).

BATs for cogeneration system

- ***Utilisation of hot water produced in the cogeneration system in processes for heating purposes***
  With the inclusion of cooling systems in cogeneration systems (trigeneration)
  It is possible to convert 10-30% of the efficiency losses into hot water, water vapour, cold air, hot air and water (absorption heat exchangers must be used for this). Thus, it is possible to meet a part of the energy required in processes such as cooling and drying in the plant from the waste heat in the cogeneration systems. Energy costs can be reduced by up to 40% in plants utilising cogeneration systems (TUBITAK MAM, 2016).

- ***Use of cold water produced in the cogeneration system in cooling processes*** It is possible to save water by utilising cold water produced in the cogeneration system in cooling processes (TUBITAK MAM, 2016).

Bibliography

- Abbassi, B., & Al Baz, I. (2008). Integrated Wastewater Management: A Review. https://doi.org/10.1007/978-3-540-74492-4_3.
- Adar, E., Delice, E., & Adar, T. (2021). Prioritising of industrial wastewater management processes using an integrated AHP-CoCoSo model: comparative and sensitivity analyses. International Journal of Environmental Science and Technology, 1-22.
- Akgül, D. (2016). Cost Analysis of Drinking and Potable Water Production with Reverse Osmosis and Nanofiltration Systems in Turkey. Istanbul Technical University Institute of Science and Technology.
- Ayan, B. (2010). International Certification Systems in Welded Manufacturing Enterprises. Izmir: Dokuz Eylül University, Institute of Social Sciences, Department of Business Administration, Master's Thesis.
- Christopher, S. (1998). ISO 14001 and Beyond Environmental Management Systems in the Real World.
- CPRAC. (2021). Med No:55. Retrieved from http://www.cprac.org/en/media/medclean
- MOEU. (2006). Refreance Document on Best Available Techniques for the Production of Polymers. Retrieved from http://webdosya.csb.gov.tr ' ippc ' icerikbelge1151
- MoEU. (2020e). Cleaner Production Practices in Certain Sectors Project. Republic of Turkey Ministry of Environment, Urbanisation and Climate Change General Directorate of Environmental Management.
- Delmas, M. (2009). Erratum to "Stakeholders and Competitive Advantage: The Case of ISO 14001. doi:10.1111/j.1937-5956.2004.tb00226.x.
- DEPA. (2002). Danish Environmental Protection Agency (DEPA). Danish Experience, Best Avaible Techniques-Bat in the Clothing and Textile Industry.
- EC. (2009). Source Document on Optimal Techniques for Energy Efficiency. European Commission.
- Greer, L., Keane, S., Lin, C., & James, M. (2013). Natural Resources Defence Council's 10 Best Practices for Textile Mills to Save Money and Reduce Pollution. Natural Resources Defence Council.
- Hasanbeigi, A. (2010). Energy-Efficiency improvement opportunities for the textile industry. China Energy Group Energy Analysis Department Environmental Energy Technologies Division, Ernest Orlando Lawrence Berkeley National Laboratory.
- Hutchens Jr., S. (2017). Using ISO 9001 or ISO 14001 to Gain a Competitive Advantage.
- IPPC BREF. (2001b). Reference Document on the application of Best Available Techniques to Industrial Cooling Systems. Integrated Pollution Prevention and Control (IPPC).
- IPPC BREF. (2003). Reference Document on Best Available Techniques for the Textiles Industry. Retrieved from https://eippcb.jrc.ec.europa.eu/reference
- IPPC BREF. (2006). European Commission (EC) Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Surface Treatment of Metals and Plastics.
- IPPC BREF. (2007f). Reference Document on Best Available Techniques in the Production of Polymers.
- IPPC BREF. (2009). Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques for Energy Efficiency. Retrieved from https://eippcb.jrc.ec.europa.eu/reference/BREF/ENE_ Adopted_02-2009.pdf)
- IPPC BREF. (2017b). European Commission (EC) Integrated Pollution Prevention and Control Reference Document on Best Available Techniques for the Production of Large Volume Organic Chemicals. Official Journal of the European Union.
- IPPC BREF. (2019). Best Available Techniques (BAT) Reference Document for the Food, Drink and Milk Industries. https://eippcb.jrc.ec.europa.eu/reference.
- ISO 14001 User Manual. (2015). Generic ISO 14001 EMS Templates User Manual.
- Kayabek, C. Y., Yildirim, A. S., & Ince, F. (2005). Maintenance and Disinfection in Open Cycle Cooling Systems (OCSCS). Journal of Tesisat Engineering, Issue: 88, pp. 35-39,.
- Kuprasertwong, N., Padungwatanaroj, O., Robin, A., Udomwong, K., Tula, A., Zhu, L., . . Gani, R. (2021). Computer-Aided Refrigerant Design: New Developments.
- LCPC. (2010). Lebanese Cleaner Production Centre . Cleaner Production Guide for Textile Industries.
- Naghedi, R., Moghaddam, M., & Piadeh, F. (2020). Creating functional group alternatives in integrated industrial wastewater recycling system: A case study of Toos Industrial Park (Iran). Journal of Cleaner Production. doi:https://doi.org/10.1016/j.jclepro.2020.120464.

- Oğur, R., Tekbaş, Ö. F., & Hasde, M. (2004). Chlorination Guide: Chlorination of Drinking and Potable Water. Ankara: Gülhane Military Medical Academy, Department of Public Health.
- Özdemir, K., & Toröz, İ. (2010). Monitoring of Chlorination By-Products in Drinking Water Sources by Differential UV Spectroscopy Method. ITU Journal.
- Öztürk, E. (2014). Integrated Pollution Prevention and Control and Cleaner Production Practices in Textile Sector. Isparta.
- Potoski, M., & Prakash, A. (2005). Green Clubs and Voluntary Governance: ISO 14001 and Firms' Regulatory Compliance. American Journal of Political Science, 235-248.
- Singh, M., Liang, L., Basu, A., Belsan, M., Hallsby, G., & Morris, W. (2014). 3D TRASAR™ Technologies for Reliable Wastewater Recycling and Reuse. doi:10.1016/B978-0-08-099968-5.00011-8.
- Sahin, N. I. (2010). Water Conservation in Buildings. Istanbul Technical University, Institute of Science and Technology, Master Thesis.
- Tanık, A., Öztürk, İ., & Cüceloğlu, G. (2015). Reuse of Treated Wastewater and Rainwater Harvesting Systems (Handbook). Ankara: Union of Municipalities of Turkey.
- TOB. (2021). Technical Assistance Project for Economic Analyses and Water Efficiency Studies within the Scope of River Basin Management Plans in 3 Pilot Basins. Republic of Turkey Ministry of Agriculture and Forestry.
- TUBİTAK MAM. (2016). Determination of Cleaner Production Opportunities and Applicability in Industry (SANVER) Project, Final Report. Scientific and Technological Research Council of Turkey Marmara Research Centre.
- URL - 1. (2021). Recovery of Filter Backwash Water. Retrieved from https://rielli.com/portfolio/filtre-ters- yikama-sularinin-geri-kazanimi/
- Yaman, C. (2009). Siemens Gebze Facilities Green Building. IX. National Installation Engineering Congress.

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

(0212) 276 65 48

www.iocevre.com