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GUIDE

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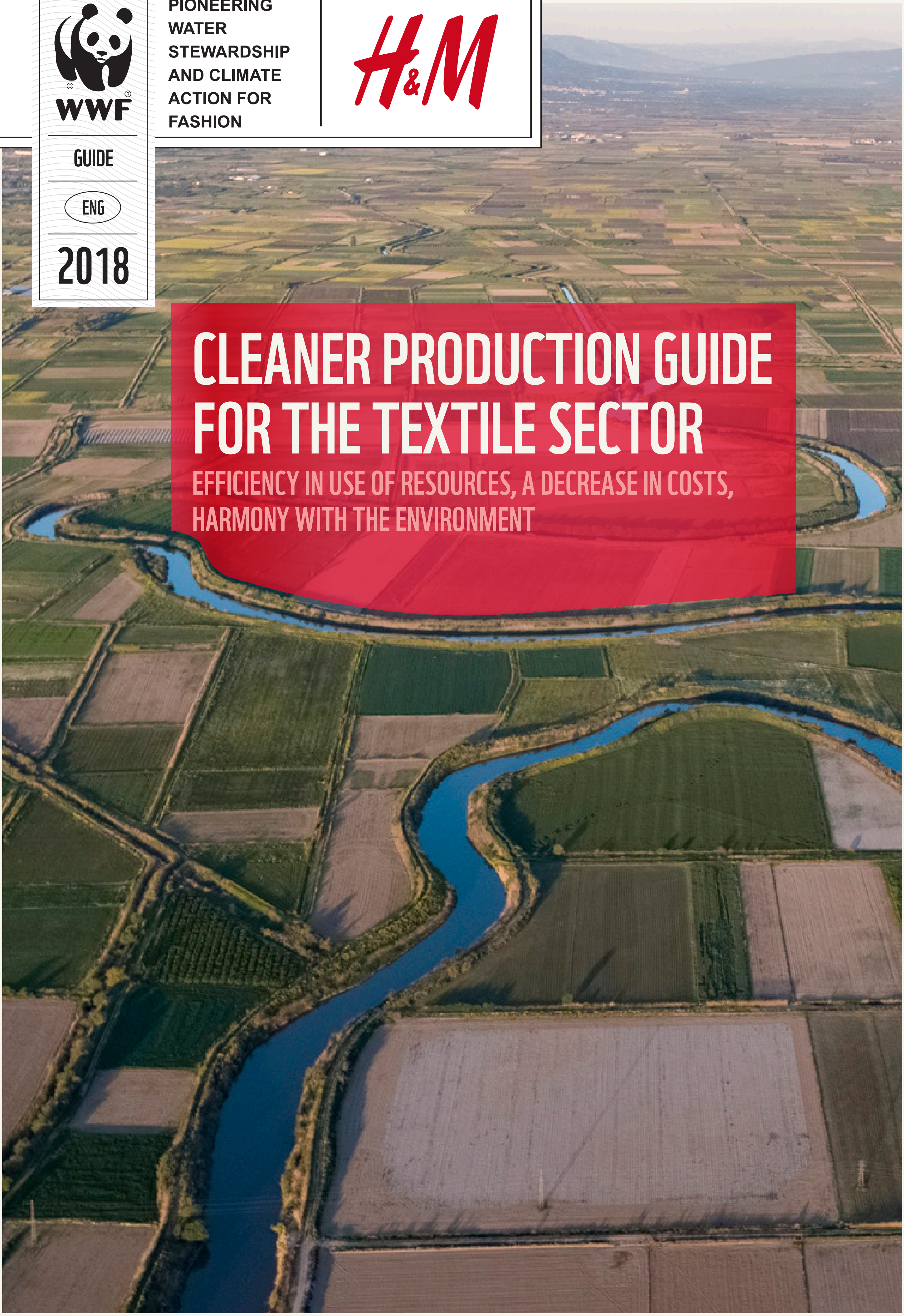
2018

PIONEERING WATER STEWARDSHIP AND CLIMATE ACTION FOR FASHION

H&M

CLEANER PRODUCTION GUIDE FOR THE TEXTILE SECTOR

EFFICIENCY IN USE OF RESOURCES, A DECREASE IN COSTS, HARMONY WITH THE ENVIRONMENT



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PREFACE:
WATER STEWARDSHIP IN THE BÜYÜK MENDERES BASIN

The Büyük Menderes basin, one of Turkey's 25 river basins, is one of the priority areas for WWF-Turkey. WWF-Turkey has been working in the basin for 20 years, focusing on the promotion of integrated basin management and the efficient use of water resources in agriculture.

Aslı Pasinli
CEO
WWF-Turkey

The Büyük Menderes River, its branches and its associated groundwater, is the basin's main water source. The river is 584 kilometers long and has a high socio-economic importance for agriculture and industry. However, water in the basin is under pressure. While the main problem is water quality, it is predicted that climate change and development plans will reduce the amount of available seasonal water in the near future. In this context, measures to mitigate water risks must be taken to ensure environmental and socio-economic sustainability in the basin.

The textile sector is a leading sector in the Büyük Menderes basin, significantly contributing to the regional economy. Textile enterprises are mainly concentrated in the provinces of Denizli, Uşak and Aydın. The textile sector is most important to Denizli province, accounting for 30% of its employment and 50% of its exports. The textile sector faces water risks due to the high amount of water used in dyeing and finishing processes and can have a large negative impact on the quality of the available water due to the high volume of chemicals used in these processes. With less water in the basin, the increase in demand for water is likely to cause competition between textile companies and with other sectors. In addition, resource efficiency in the supply chain has become a priority for many international customers and buyers. Taking into account these considerations, strategies specific for the sector need to be developed to ensure sustainable water use.

In our strategy, "Water Stewardship in the Büyük Menderes Basin", we target textile companies operating in Denizli and Aydın provinces. In partnership with H&M, we are launching a movement for the transition to cleaner production processes in the textile industry. Building from the results of this partnership, WWF-Turkey will develop technical and financial cooperation mechanisms so that cleaner production investments can be realized. Together H&M and WWF-Turkey will engage key stakeholders from the private sector, the government and civil society to work towards our shared vision of water stewardship in the basin.

This model – which includes using less water energy and fewer chemicals in production, and reducing the amount of solid wastes – reduces production costs while also reducing the impact of production processes on water resources. In many applications, investment costs are recuperated in under a year.

Through this "Cleaner Production Guide in the Textile Sector", we hope to contribute to the initiation of cleaner production practices and sustainability in the textile sector. In addition to ensuring resource efficiency in textile production, we hope that the guide will light the way for textile producers to take action against sectoral water risks.

PREFACE:
PIONEERING WATER STEWARDSHIP AND CLIMATE ACTION FOR FASHION

Julia Bakutis
Regional Sustainability Manager, Europe Region
H&M

Our planet provides us with an abundance of natural resources. However global demands are rapidly outstripping supply. Put simply, the fashion industry is running out of the natural resources it uses to make products and we cannot continue to operate in the same way.

At H&M group, we believe that an industry-wide shift from a linear to a circular business model is the only solution. As a global, influential company, we also believe that we play an important role in conserving water ecosystems and increasing access to safe drinking water and sanitation for the people around us.

We have worked on water issues for over a decade and built up a water strategy with the aim to be an industry leader in water stewardship. United in a common vision for better availability and quality of freshwater, H&M group began a long-term partnership with WWF in 2011.

We work with our business partners to help fabric producers reduce their ecological footprints and collect water management and impact assessment data. Our work with resource efficiency and cleaner production programs has continued to help our supply chain business partners reduce their water consumption. In 2017, our efforts reduced water consumption by 7.82 million m^3 globally. Our cleaner production program trained 2,636 workers in 270 production units across Bangladesh, China, Indonesia, India and Turkey.

In Turkey and in the Büyük Menderes basin, we have the opportunity to encourage our partners to take an active role in our water stewardship strategy. Through our partnership with WWF we believe that we can show a path for real change. We hope that this guideline offers practical, useful information for textile companies looking to make the change with us. We welcome all of you to our water stewardship journey.

INTRODUCTION

While the concept of cleaner production is of great importance for Turkey, its application to date has been limited. A significant part of the activities in this area have been carried out by universities or in small pilot projects. Implementation of cleaner production practices applied in cooperation with state institutions and organizations need to be increased and brought to scale.

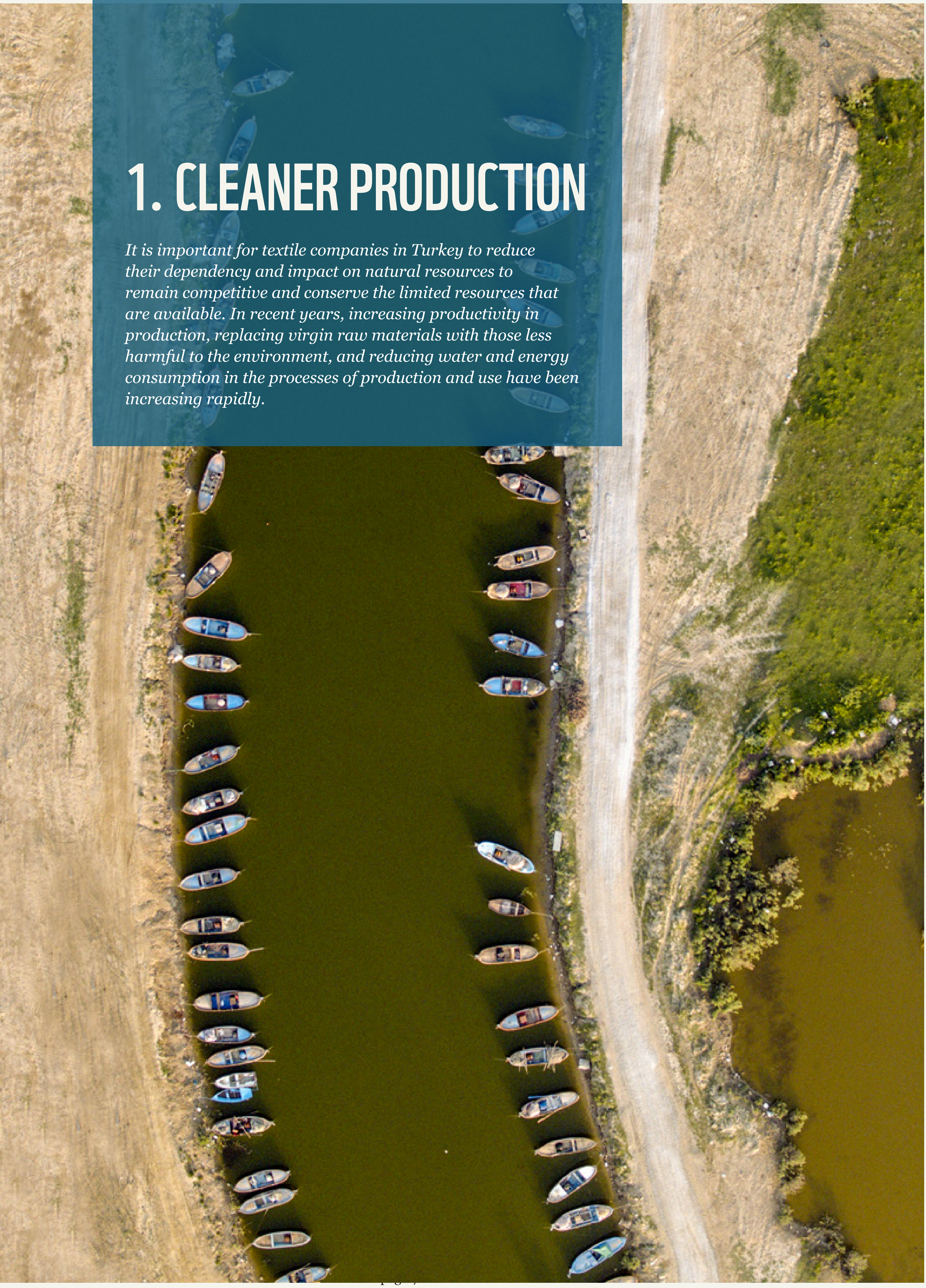
In this context, and in order for cleaner production practices to spread and be adopted at large, we need to develop the relevant technical capacity of Turkey's industry and increase awareness of the approach and its benefits. This guideline contributes to these two goals and as a result makes for a more sustainable textile industry in Turkey.

Textile companies that adopt cleaner production processes see an increase in competitiveness due to:

- Efficiency in resource utilization,
- Decrease in production and waste management costs,
- Compliance with environmental laws, regulations and relevant national strategies, reducing the risk of fines,
- Meeting the relevant expectations of international brands,
- Increasing brand value,
- Ability to benefit from the financial opportunities of national and international financial institutions.

1. CLEANER PRODUCTION

It is important for textile companies in Turkey to reduce their dependency and impact on natural resources to remain competitive and conserve the limited resources that are available. In recent years, increasing productivity in production, replacing virgin raw materials with those less harmful to the environment, and reducing water and energy consumption in the processes of production and use have been increasing rapidly.



Why Cleaner Production?

According to the cleaner production approach, pollution and waste are largely a result of the insufficiency and inefficiency of resource use and production processes. Cleaner production aims to solve these problems; therefore, it not only reduces waste generation, but also provides economic benefits (Demirer G. N., 2003).

In addition to the economic benefits of cleaner production, increased environmental awareness has led consumers in developed countries to prefer products produced with less harm to the environment. There is also a growing global awareness of the impact of climate change and its impact on the availability of water. This has led relevant institutions and sectors to seek different ways of doing business.

Treating polluting wastewater and correctly disposing it afterwards is the first measure often taken to reduce textile industry's negative impact on the environment. This approach, which is known as "pollution control", requires large investments, often at the industrial park or municipal level in addition to plant level.

Waste reduction and decreasing the amount of raw materials required for core textile processes is another way to mitigate impact on the environment that is less expensive than pollution control.

Benefits of Cleaner Production for Businesses

Understanding and implementing cleaner production interventions is beneficial for a private enterprise in many ways. These benefits can be summarized as follows:

- **Economic Benefits:**
  1. **Increase in production efficiency:** As a result of the efficient use of resources, more raw material becomes a commercially-viable product. Reducing the use of energy, natural resources and raw materials provides savings for the enterprise. Thus, production costs are reduced and more production is possible with fewer raw materials. More efficient resource use can increase production speed and competitiveness.
  2. **Reduction of waste treatment and disposal costs:** Cleaner production practices reduce the amount of waste generated during the production process. As a result, energy and chemical use, man power allocation, space requirements and disposal costs are reduced.
- **Environmental Benefits:**
  1. **Reduction of environmental impacts:** Cleaner production practices provide efficient use of natural resources; minimization of solid waste, wastewater and emissions; and reduction of toxic contents. Thus, the negative impacts of the production processes on humans and nature are reduced. It also contributes positively to the performance of the waste management infrastructure.

2. **Support for compliance with legislation today and preparation for the future:** Cleaner production practices are advantageous in terms of compliance with applicable laws and regulations. It is the general trend that environmental legislation is becoming more demanding and is more often enforced; this trend is very relevant in the case of China. If legislation changes, it may be expensive to adapt and impossible to comply, which may lead to more costs. But, cleaner production prepares enterprises for future regulations.

- **Social Benefits:**

1. **Safeguarding and building reputation:** Cleaner production practices can help manage and develop the image and reputation of a business whereas poor management of water resources, waste and wastewater can threaten the reputation of the business. Consumers increasingly demand that production does not harm the environment or detrimentally affect local people. A company that is sensitive to the environment acquires the support of society and consumers and increases its competitive advantage and market share. The implementation of cleaner production interventions can be a signal to international partners of the forward-thinking mindset of the company, its willingness to invest in its future and its knowledge of forefront technology and practices.
2. **Support for occupational safety and worker health:** It is possible to prevent potential accidents by improving and developing working conditions. At the same time, employees are protected from pollutants and dangerous substances (Demirer G.N. & Mirata M., 1999; UNEP, 2002).

Prospects for the Future in Turkey

- International brands expect their business partners to comply with environmental legislation as well as produce with high social and environmental standards.
- Laws now require producers to reduce and prevent environmental impact.
- Cleaner Production is becoming one of Turkey's national strategies.
- Global competition forces businesses to be as efficient as possible.
- National and international financial institutions' interest in cleaner production is growing; appropriate conditional financing opportunities are developing.
- Cleaner production is now an important tool to increase brand value.

Benefits of Cleaner Production

- Less water and fewer chemicals use in production,
- More product with fewer resources,
- Energy saving,
- Less solid waste and wastewater,
- Decrease in costs,
- Compliance with the environmental legislation and readiness for any future regulations.

Cleaner Production in Turkey

The cleaner production concept was first introduced in Turkey in 1999 by TÜBİTAK and TTGV (Technology Development Foundation of Turkey) with the "Industry Sector Report from the Science-Technology-Industry Discussion Platform, Cleaner Production-Cleaner Products Eco-Friendly Technology". It was recognized on the national scale, between 2008 and 2011, via the United Nations Joint Program "Enhancing the Capacity of Turkey to Adapt to Climate Change". These initiatives and many others have raised awareness, increased knowledge and available information, created capacity, and led to impactful partnerships.

Several laws support the concept of cleaner production. Legislation identifies the need for the development of cleaner production technologies and often refers to cleaner production concepts. However, apart from the "Notification on Integrated Pollution Prevention and Control in the Textile Sector", legislation and action plans that directly incentivize cleaner production do not exist in Turkey. Luckily, the 2009 legislation the "Identification of the Framework Conditions and Research & Development Needs for the Promotion of Cleaner Production Applications in Turkey Project" brings cleaner production into the legislative framework. The General Directorate of Efficiency within the Ministry of Science, Industry and Technology published an assessment report of this legislation.

Legislative regulations related to cleaner production:

1. Integrated Pollution Prevention and Control Communication in the Textile Sector (Ministry of Environment and Urban Planning, 14 December 2011)

    a. The aim of the Communiqué is to encourage the most effective and efficient use of raw materials, energy and cleaner production technologies. It also aims to control all kinds of emissions, discharges and wastes discharged to the water, air and soil during production.

    b. Textile facilities with a capacity exceeding 10 ton/day, which engage in weaving, washing, desizing, mercerizing, bleaching, dyeing-printing, finishing and other finishing operations are subject to the provisions of this Communiqué.

    c. Manufacturers are obliged to submit Cleaner Production Plans (CPP) containing the Best Available Techniques (BATs) to the Ministry every five years and implement these plans.

2. Draft Regulation on Integrated Pollution Prevention and Control (IPPC) (Ministry of Environment and Urban Planning, 2017)

    a. With this Regulation, it is obligatory to obtain an IPPC certificate in order to construct, install, change, operate or relocate facilities which carry out certain resource-intensive activities (see Annex-I List).

    b. In this context, pretreatment (washing, bleaching, polishing, etc.) or dyeing of fabric fibers or fabrics of a quantity greater than 10 tons per day is subject to this directive.

c. It is essential that all measures are taken to prevent waste, to prevent or reduce any environmental impact, and to make efficient use of energy, water, raw materials and other resources. This includes the implementation of all the necessary preventive measures to prevent and reduce pollution, especially by applying the Best Available Techniques (BAT), to prevent, to minimize waste or to prepare waste for reuse, recycling, recovery processes in case of waste, when it is not economically feasible.

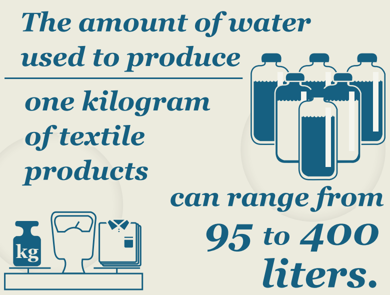
The current legislation that supports the concept of cleaner production is as follows:

- Environmental Law
- Regulation on Water Pollution Control
- Regulation on Control of Pollution Caused by Dangerous Substances in and around Water
- Regulation on the General Principles of Waste Management
- Regulation on Solid Waste Control
- Regulation on the Control of Hazardous Wastes
- Regulation on Waste Oils Control
- Regulation on the Control of Vegetable Waste Oils
- Regulation on Control of Waste Batteries and Accumulators
- Regulation on Packaging Waste Control
- Regulation on Hazardous Chemicals
- Regulation on Restrictions on the Production, Market Supply and Use of Certain Hazardous Materials, Preparations and Products
- Regulation on the Inventory and Control of Chemicals
- Regulation on the Restriction of the Use of Certain Hazardous Materials in Electrical and Electronic Goods
- Regulation on the Control of End-of-Life Vehicles
- Regulation on the Reduction of Ozone Depleting Substances
- Regulation on the Reduction of Sulfur Ratio in Some Fuel Types
- Regulation on the Control of Industrial Air Pollution
- Regulation on Environmental Inspection
- Notification on Integrated Pollution Prevention and Control in the Textile Sector

2. RESOURCE USE AND ENVIRONMENTAL IMPACTS IN THE TEXTILE SECTOR

Due to the large amount water used in the dyeing and finishing processes the textile industry is among the largest consumers of water in the fashion industry. The textile industry also draws attention with its high chemical consumption and high energy use in the dyeing and finishing processes.

Overview



Water Consumption

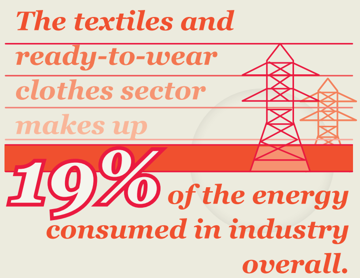
The textile industry uses a vast amount of water throughout the dyeing and finishing processes and is among the largest consumers of water among all industries. The amount of water used to produce one kilogram of textile product can range from 95 to 400 liters. A study conducted for the Turkish textile industry has shown that between 20 and 230 m³ of water is used for 1 ton of textile fabrics. (Öztürk et al., 2009).

Chemical Consumption

The textile industry also draws attention with its high consumption of chemical substances. The high chemical load in textile factories due to pre-finishing, dyeing, finishing, sizing and other processes varies according to the processes used. The total amount of chemical used in textile can vary between 10% and 100% by weight of the textile product (Öztürk et al., 2009).

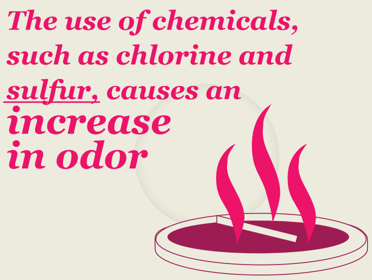
Wastewater Generation

Depending on the wet textile process in the facility, the wastewater can vary. For example, wastewater resulting from desizing and finishing process can contain high BOD (Biochemical Oxygen Demand), wastewater from bleaching can contain AOX (Absorbable Organic Halogen) and wastewater following painting processes can contain BOD, COD (Chemical Oxygen Demand) and heavy metals. Concentrations of volatile organic compounds (VOC) are also high in the, printing, and finishing processes.



Energy Consumption

Energy use is high in dyeing and finishing processes, thread production, and weaving, constituting 19% of the total energy expenditure in industry (Halkbank, 2010). In the textile sector, LPG and fuel-oil are mostly used as fuel. For this reason, CO, SO_2, NO_x, aldehydes and dust are present in the textile industry flue gas emissions.



Odour

Odour is one of the important environmental problems created by the textile sector. The main sources of odour problems are the drying, dyeing and printing processes and wastewater treatment plants. The use of chemicals, such as chlorine and sulfur, causes an increase in odor (BUTEKOM, 2014).

Environmental Impacts Specific to Textile Production Processes

In this section, the major textile production processes and their environmental impacts (waste, wastewater, emissions, etc.) are summarized. (Halkbank, 2010; Ministry of Environment and Urban Planning, 2012)

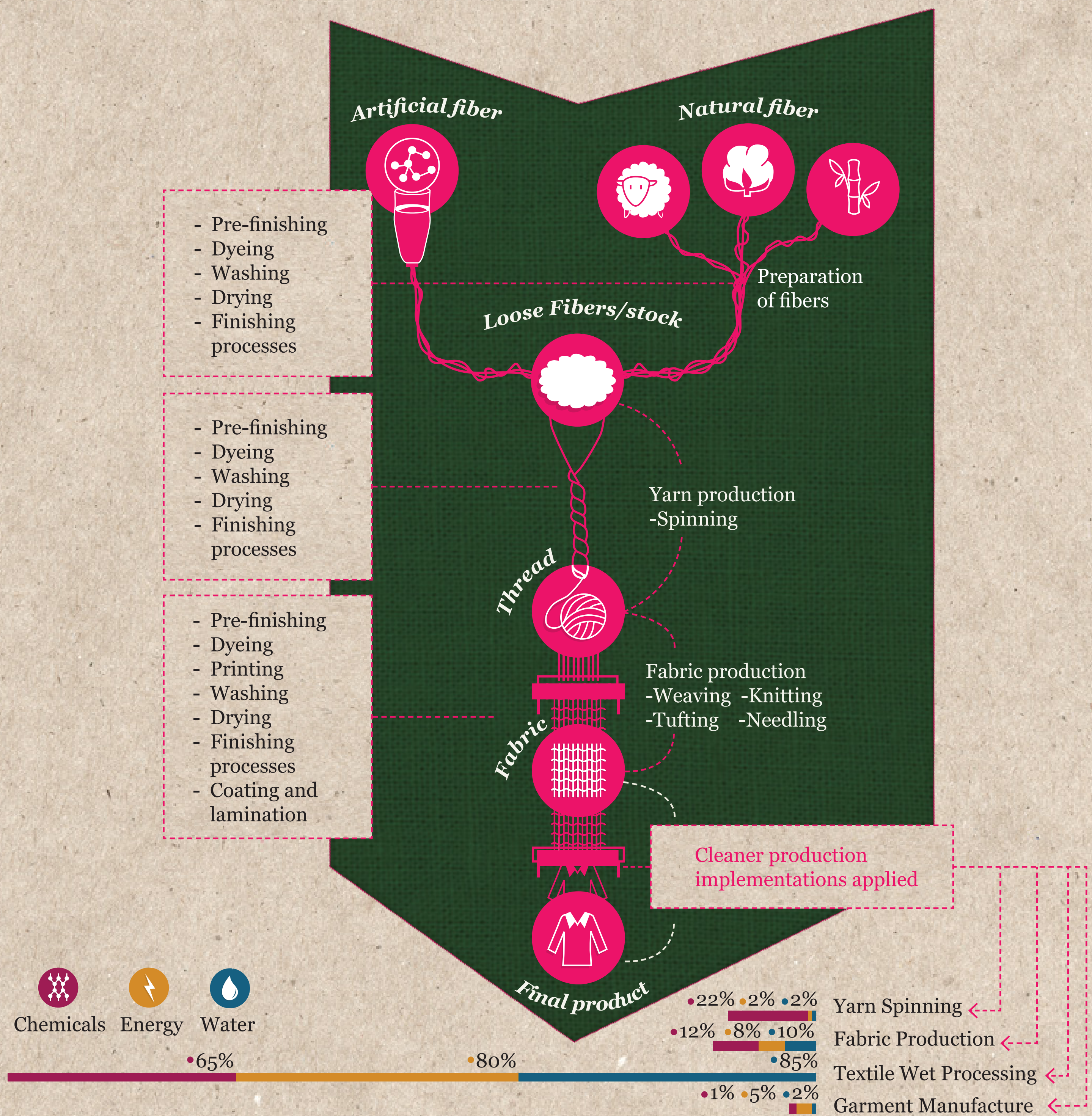


Figure 1. Main textile production processes (Ministry of Environment and Urban Planning, 2012) and Distrubition of water, energy and chemicals in textile processing (% of total) (PaCT Manual (Unpublished)/IFC)

Manufacturing Process	Environmental Impacts
1. Fiber Production A textile is a flexible material consisting of a network of natural or artificial fibers (yarn or thread).	
a. Natural Fibers	
Cotton Risks: Cotton production uses large quantities of insecticides, fertilizers and water for irrigation. The use of aerial spraying spreads chemicals widely into the environment.	**Wastewater** The most significant natural fiber used in textile is cotton and to size it starch and derivatives are often utilized. Starch effluent increases the wastewater BOD values. Wastewater from cotton fiber production can be heavily polluted due to inherent and added substances on the textile fibers such as oil, waxes, and lubricants, which are expelled through scouring to refine the fibers and make them hydrophilic.
Wool Risks: Wool production often involves use of pesticides and fertilizers.	**Wastewater** A wastewater high in organic matter and other pollutants is generated during wool fiber production. Trichloroethylene, which is used with a solvent to wash oily wool, can cause soil and groundwater contamination if sufficient treatment is not applied. For a safe discharge to the environment, detergent, surfactants, pesticides, and other contaminants in the wastewater must be treated. **Emissions** No important air pollution; however, depending on the sludge treatment system, dust and odor may be generated. **Solid Waste** There are two basic outputs of wool washing processes: waste oil and sludge. Commonly used methods for the treatment of sludge are incineration (with heat reclamation); pyrolysis/transformation to gas, brick production, fertilizer production either with or without other organic materials, and disposal in a land fill. It is possible to reclaim between 20 - 40% of the oil originally used at the beginning of the wool washing process.
b. Synthetic Fibers	
Acrylic Risks: Non-renewable resource and has a long process. Non-degradable. No recycling infrastructure.	**Wastewater** Carcinogenic chemicals such as vinyl acetate (on priority lists for EPA) , acrylamide (unknown carcinogen), N-dimethyl-formamide (classified as dangerous to the environment) and acrylonitrile (also known as vinyl cyanide) are produced.
Vinyl (polyvinylchloride PVC) Risks: Non-renewable resource and has a long- process. Vinyl is produced by wet or dry spinning, which is more polluting than wet spinning.	**Wastewater** Carcinogenic chemicals such as phthalates are added. Phthalates are known as endocrine disrupters. PVC production generates dioxins, highly toxic substances that are linked with cancer. Dioxins are a global health threat because they persist in the environment and in mammals and do not degrade. PVC also contaminates the environment during its disposal.
Polyester (PET) Risks: Non-renewable resource and has a long process. Non-degradable. No recycling infrastructure. Energy and water intensive.	**Wastewater** Often involves use of carcinogenic chemicals such as benzene, toluene, arsenic, and heavy metals including antimony. Allergy-provoking dyes and carriers are added.

Manufacturing Process	Environmental Impacts
2.Yarn manufacturing	
Yarn is produced by spinning raw fibers of wool, flax, cotton, hemp, or other materials to produce long strands. During the spinning process the ring, open-end, friction and/or air jet methods are used. Today, the most common methods are ring and open-end spinning. Properties of the fiber used in the spinning process, such as its consistency, strength, flexibility, hardness and stiffness allow for the use of this thread in different cloth.	**Wastewater** The preparations agents (conditioning agents and spinning lubricants) applied to the fiber during the spinning process have significant environmental implications for the subsequent finishing steps of the textile chain. Since these auxiliaries need to be completely removed before dyeing, they are found either in the exhaust air from the high-temperature processes or in the water from wet treatments. In the second case they increase the organic load of the final effluent. **Emissions** Spinning lubricants may be responsible for the emission not only of hard-to-biodegrade organic substances such as mineral oils, but also of hazardous compounds such as polyaromatic hydrocarbons, APEO and biocides. When found in the exhaust air they contribute to air pollution. **Solid Waste** There is no significant solid waste generation at this stage.

3.Fabric Production	
Textiles are formed by weaving, knitting, crocheting, knotting, or felting. When a woven fabric is created, two yarn groups, called warp and weft, are passed horizontally and vertically under and over each other. Knitted fabric is stitched together with one (weft knitted) or multiple (warp knitted) yarns arranged in the same direction. In addition to knitting and weaving, non-woven surfaces (tufting surfaces, glued surfaces, and non-woven surfaces) can be created by various methods. Some technical textiles and the use of textiles for flooring coverings (wall to wall carpeting, etc.) are now a developing branch of the textile industry.	**Wastewater** Among the significant environmental impacts resulting from textile manufacturing are the chemical substances that are used in the sizing process, and then removed in a process known as desizing. This process causes a high pollution load. For knitting, mostly mineral oils and wax are used. The washing process of the final fabric contributes significantly to the total pollution produced by the respective factory. **Emissions** The only significant environmental impact that occurs from non-woven textile products arises from the gases released during the thermal and chemical bonding process. **Solid Waste** There is no significant solid waste generation at this stage.

Manufacturing Process	Environmental Impacts
4.Pre-finishing Processes	
Raw textile surfaces are subjected to finishing processes such as bleaching, mercerizing, dyeing, printing and finishing. According to fashion or where they will be used they are subjected to treatments to add inlays, color, gloss, and/or properties such as moisture wicking, anti-wrinkling, anti-bacterial, anti-static, and stain resistance. Pre-finishing is an important production step that adds added value to the fabric.	**Wastewater** Finishing operations are predominantly chemical and therefore can create adverse environmental impacts. The major environmental problems associated with pre-finishing of natural fibers originate from emissions to the water. Desizing is the largest emission source in the overall process. Removing natural sizing agents has the biggest impact; water that has not been demineralized can represent 70% of the total COD in the wastewater. Mercerization leads to strong alkalinity in wastewater and must be neutralized or recovered Bleaching may result in various pollutant discharges to the wastewater, depending on the chemical substance used. The breakdown of hydrogen peroxide during bleaching causes only water and oxygen formation. However, the use of sodium hypochlorite and sodium chloride can lead to secondary reactions that form organohalogen compounds. Pre-finishing of natural fibers predominantly results in water emissions. Some of the contaminants that can be found in its wastewater are from the impurities on the fibers when the fibers enter the process chain like pesticides, blending oils, knitwear oils and other preparation chemicals, and some from the chemical and auxiliary substances used in the process like detergents, wetting agents, and reduction chemistries. The most important environmental impact from synthetic fibers is the potentially harmful impurities and additives in the fibers that may be passed into the water during the finishing process. These impurities include unreacted monomers, oligomers with low molecular weight and catalyst remnants, some of which are created during the production of the fiber. These also pass into the air during heating processes. **Emissions** Drying and curing textiles generate air emissions due to the volatility of the active substances used in these processes. By-products and their decomposition that are created during the process, like monomers, oligomers, and impurities lead to pollution. Furthermore, residual substances from upstream processes can cause air emissions and sometimes odors. For example, polychlorinated dioxins/furans may arise from the thermal treatment of textiles that have been previously treated with chlorinated carriers or perchlorethylene. Directly heated (methane, propane, butane) stenters may produce emissions (non-combusted organic compounds, CO, NOx, formaldehyde). **Solid waste** There is no significant solid waste generation at this stage.

<table>
<tr><th>Manufacturing Process</th><th>Environmental Impacts</th></tr>
<tr><td colspan="2">5.Dyeing</td></tr>
<tr><td>
Dyeing is a coloring method in which a substance is applied to provide a smooth appearance and to ensure proper performance and durability.
Different dyeing techniques are available:

Mass dyeing/gel dyeing is an additive used in synthetic fiber manufacturing. This technique is the most common application method for polypropylene (PP) fibers and is also applied in acrylic (PAC) fibers.
Pigment dyeing is a water-insoluble substance that is non-affinitive to fiber, forms a layer on the fiber surface and is fixed with a binder.
Soluble or partially-soluble dye gives color by diffusing into the fibers.

</td><td>
Wastewater
Textile dyeing requires the use of many different chemicals and auxiliary substances that support the dyeing process.
Dyes: In oxidative conditions, biodegradation is absent or very low, so it must be removed from the wastewater. Dyes that pass through wastewater treatment plants may inhibit photosynthesis by changing the color of the water. In addition, AOX emissions (absorbable organic halogens) and heavy metal emissions which originate from dyes, can lead to serious toxicity problems.
Auxiliary chemical substances in dye formulations: As they are not absorbed by the fibers, they are completely discharged into the waste water. These additives are not toxic to aquatic organisms; however they do not biodegrade easily.
Sulfur-containing reducing agents, which are used in the dyeing processes: These are poisonous for aquatic organisms and they increase the COD load. Furthermore, sulfur anions convert into hydrogen sulfuric acid under acidic conditions, resulting in odor and corrosive qualities.
Sodium hydrosulfite (sodium dithionite): Used in sulfur, cube as and polyester (PES) fiber dyeing. It transforms into sulfide during the dyeing process and is poisonous for species of fish and bacteria.
Oxidizing substances: Dichromate is still widely used for fixation of chrome dyes in wool dyeing. While Cr (III) exhibits low toxicity, Cr (VI) is very toxic and carcinogenic to animals. Bromate, iodate, chlorite and hypochlorite usage can cause AOX (Adsorptive Organic Halogen) emissions.
Salt: Large amounts of salt are used with reactive dyes, especially in cotton dyeing processes. Salt cannot be removed in conventional wastewater treatment systems, so is discharged into the environment. Although the toxicity of commonly used salts in the aquatic environment is very low, the use of large-scale salt in arid or semi-arid regions can cause concentrations above the toxicity limit values and increase the salinity of groundwater.
Carriers: Many contain different organic compounds that are volatile by steam, are difficult to biodegrade and are poisonous to aquatic life and to humans. However, carriers are usually 75 – 90% absorbed by fibers due to their high affinity for the fibers, and only hydrophilic carriers are found in wastewater.
Other auxiliary chemical substances: Leveling agents, retarders, auxiliary products to improve speed, dispersants, and complex agent compounds are water-soluble, hard to biodegrade and as a result pass through the wastewater treatment plants with little to no change. Some of these are toxic and/or lead to the creation of metabolites that can affect the reproduction of aquatic organisms.
Emissions
Due to the low vapor pressure of the substances in the dye bath, emissions to air are generally not significant. However, fugitive emissions from dosing/dispensing chemicals and dyeing processes in “open” machines can impact the workplace air quality. A few exceptions are the thermosol process, pigment dyeing and those dyeing processes where carriers are employed. In pigment dyeing the substrate is not washed after pigment application and therefore the pollutants are quantitatively released to air during drying. Emissions from carriers are emitted to air and water.
Solid Waste
There is no significant solid waste generation at this stage.
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Manufacturing Process	Environmental Impacts
6. Continous Printing	
Printing is the process of applying color to fabric. But instead of coloring the whole textile as in the dyeing process, only designated areas are colored to have a desired pattern. This requires different techniques and different machines depending on the dyeing, but the physical and chemical processes are similar. A typical printing process consists of preparing the paint film, printing, fixing and further processing.	**Wastewater** Typical emission sources for the printing process are printing paste residues, wastewater from washing and cleaning processes, and volatile organic compounds from drying and fixation. **Print paste residues** are produced throughout the printing process, and the amount can reach significant levels depending on the situation if there are incorrect measurements or extra paste is applied to secure quality of the printing. **Wastewater from washing and cleaning processes** The wastewater resulting from the cleaning processes constitutes a larger proportion of the total pollution load compared to that resulting from the washing operations. **Emissions** **Volatile organic compounds arising from drying and fixation** The following pollutants can be found in air emissions from printing: • Aliphatic hydrocarbons (C10 - C20) from binders • Monomers such as acrylates, vinyl acetates, styrene, acrylonitrile, acrylamide, butadiene • Methanol from the fixation material • Other alcohols, esters and polyglycols from emulsifying agents • Formaldehyde from fixation materials • Ammonia (from disruption of urea and, for example, ammonia in pigment printing pastes) • N-methylpyrrolidone from the emulsifying agents • Phosphoric acid esters • Phenylcyclohexene from thickeners and binders **Solid waste** There is no significant solid waste generation at this stage.

Manufacturing Process	Environmental Impacts
7. Finishing Processes	
Includes all the processes applied to textile materials to ensure the desired end use properties. These properties involve appearance, feel, waterproofing, insect resistance, and anti-bacterial, flame retardancy, among others.	**Wastewater** Though the amount of wastewater generated during finishing process is considerably low compared to the total amount of wastewater generated in a textile plant, its pollutant concentration level is very high with 10-200 g/l COD and 5-25% of the active ingredient contents. Most of these substances have low or no biodegradability and some are toxic. **Emissions** During drying and condensation processes air emissions occur due to the volatility of the active substances and their constituents. The emission loads depend on drying or condensation temperature, amount of volatile substances in the finishing bath, type of fibers and potential reactants in the formulation. **Solid waste** There is no significant solid waste generation at this stage.
8. Coating and Lamination	
Generally, coated and laminated textiles are a combination of a woven, knitted or nonwoven fabric and a thin and flexible film made from natural or synthetic polymeric materials.	**Wastewater** There is no significant wastewater generation at this stage. **Emissions** Air emissions arising from solvents in the formulations of coating compounds, additives and by-products are its main environmental issue. Significant pollutants that emerge during this process are: Polyamide 6 and its copolymers, fatty amines derived from surfactants, fatty alcohols, fatty acids, glycols from emulsifiers, alkylphenols from dispersants, glycols from hydrotropes, aliphatic hydrocarbons, N-methylpyrrolidone, formaldehyde from melamine resins and methanol. **Solid waste** There is no significant solid waste generation at this stage

3. CLEANER PRODUCTION METHODS IN THE TEXTILE SECTOR

Cleaner production interventions for the textile sector include general applications and special applications for different manufacturing processes.

Cleaner production practices, which are summarized in this chapter, are based on the "Best Available Techniques for the Textile Industry (BAT)" published by the Ministry of Environment and Urban Planning in 2012.

General Practices

Facility Management	• Establishment of an Environmental Management System. • Implementation of environmental education programs. • Preparation of annual waste inventory reports based on mass balances, showing all substance inputs and outputs. • Monitoring the quantity and quality of all inputs and outputs related to the production process (raw materials, chemicals, energy, water, products, wastewaters, air emissions, sludge, solid wastes, hazardous wastes and byproducts). • Adoption of better practices in maintenance and cleaning activities. • Optimization of the formulas applied during production by taking into consideration the environmental impacts. • Taking precautions to reduce the vibration of the equipment and installation of sound insulation on the walls. • Storage of all chemical substances according to the instructions given on the Safety Data Sheets. • Prevention of chemical spills, and in the event of a spill, the control and clean-up of the area, preventing chemical spills from interfering with the environment or the sewage system.
General Measures	• Automatic dosage and dispensing systems for the dosage of chemicals. • When possible, manufacturing without chemical use. • Where chemical use is essential, use of the chemical posing the least risk. • Instead of alkylphenol, ethoxylates and other dangerous substances, use of easily biologically-degraded surfactant agents. • Preventing or reducing the use of complex agents in pre-finishing and dyeing processes. • The application of hydrogen peroxide under optimum conditions. • Use of complex agents that can be easily biodegraded. • Prevention or reduction in the use of antifoaming substances.
Raw Material Selection	Consideration of the upstream environmental impacts of fibers and selection of the raw material with the least impact. Man-made fibers: select material treated with low-emission and biodegradable/ bioeliminable preparation agents. Cotton: select material sized with low add-on techniques (pre-wetting of the warp yarn) and high-efficiency bioeliminable sizing agents; use the available information to avoid processing fiber material contaminated with the most hazardous chemicals such as PCP. Wool: use the available information to avoid processing fiber material contaminated with the most hazardous chemicals such as pesticide residues; minimize at source any legally-used sheep ectoparasiticides. This can be done by encouraging the development of low pesticide residue wool, by continuing dialogue with competent bodies responsible for wool production, and marketing in all producing countries; and select wool yarn spun with biodegradable spinning agents instead of formulations based on mineral oils.

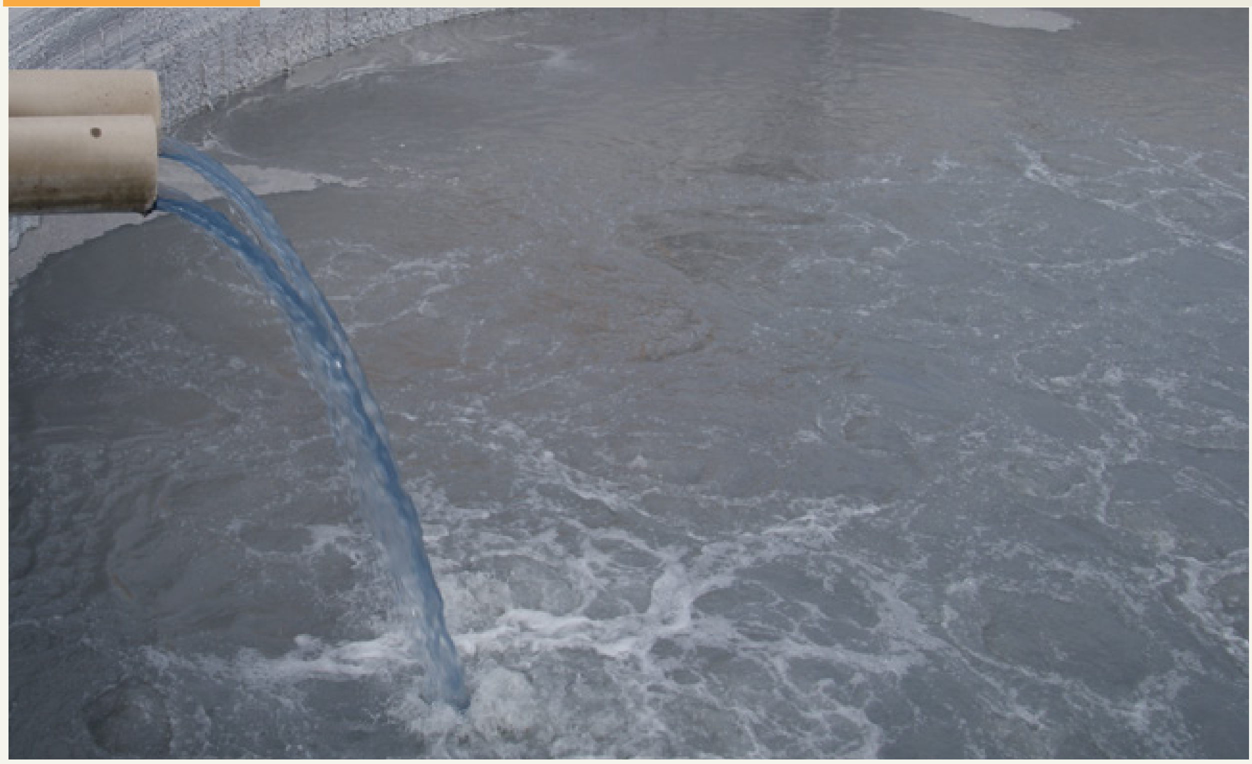
Water and Energy Management	• Control and record keeping of water and energy consumption. • The use of flow control devices and automatic shut-off valves in continuously running machines. • Using automatic equipment to check the volume and temperature of the baths in intermittent working machines. • To prevent waste of water and energy, documentation of the production procedures should be available and it should be used by employees. • Implementation of time optimization in production, regulation of all processes to ensure they are completed in the shortest time possible. • Investigating the possibilities of combining different operations in one step. • Use of low and very low float rate machines in intermittent processes. • Use of perpetual low input processes. • Improvement in washing efficiency. • Reuse of cooling water as process water (at the same time providing heat recovery). • Characterization of discrete wastewater streams and assessment of water/ material recovery and assessment of reuse possibilities. • Installation of steam insulation to prevent loss. • Insulation of pipes, valves, tanks and machinery to minimize energy losses. • Optimization of boiler rooms with applications such as the reuse of steam condensates. • Recovery of waste heat from waste gas and wastewater. • Use of frequency-controlled electric motors.

Practices for Various Textile Production Processes

Pre-Finishing	In the removal of knitting lubricants from fabric: • Instead of using mineral oil-based lubricants for processing, selection of knitted fabrics produced by using biodegradable and water-based lubricants. • Implementing the thermo-fixing process before washing, collection of oils, and air emissions from the stenter separately and treatment with dry electro-filtration systems which allow energy recovery. • Removal of water-insoluble oils by organic solvents. • Degradation of persistent pollutants during operation (e.g. by advanced oxidation processes).
Desizing	• Selection of raw sizing materials with high biodegradability, produced by efficient washing systems that employ fewer input techniques. • Application of desizing with oxidation when the source of raw material cannot be controlled. • Combination of desizing / washing and bleaching in a single step. • Recycling and reuse of sizing materials by proper methods.
Bleaching	• Application of hydrogen peroxide bleaching with techniques that minimize the use of hydrogen peroxide stabilizers or techniques with high biodegradability complexing agents. • The use of sodium chloride in the bleaching of flax and bast fibers which are not bleachable by hydrogen peroxide alone; selection of two-step hydrogen peroxide-chlorine dioxide bleaching, for instance the use of elemental chlorine-free chlorine dioxide. • Limiting the use of sodium hypochlorite to only those situations where high whiteness is desired and to fragile and depolymerized fabrics. • Use of innovative chemicals where possible in bleaching processes (such as bleaching with enzymes, bleaching with ozone), which have lower environmental impacts.

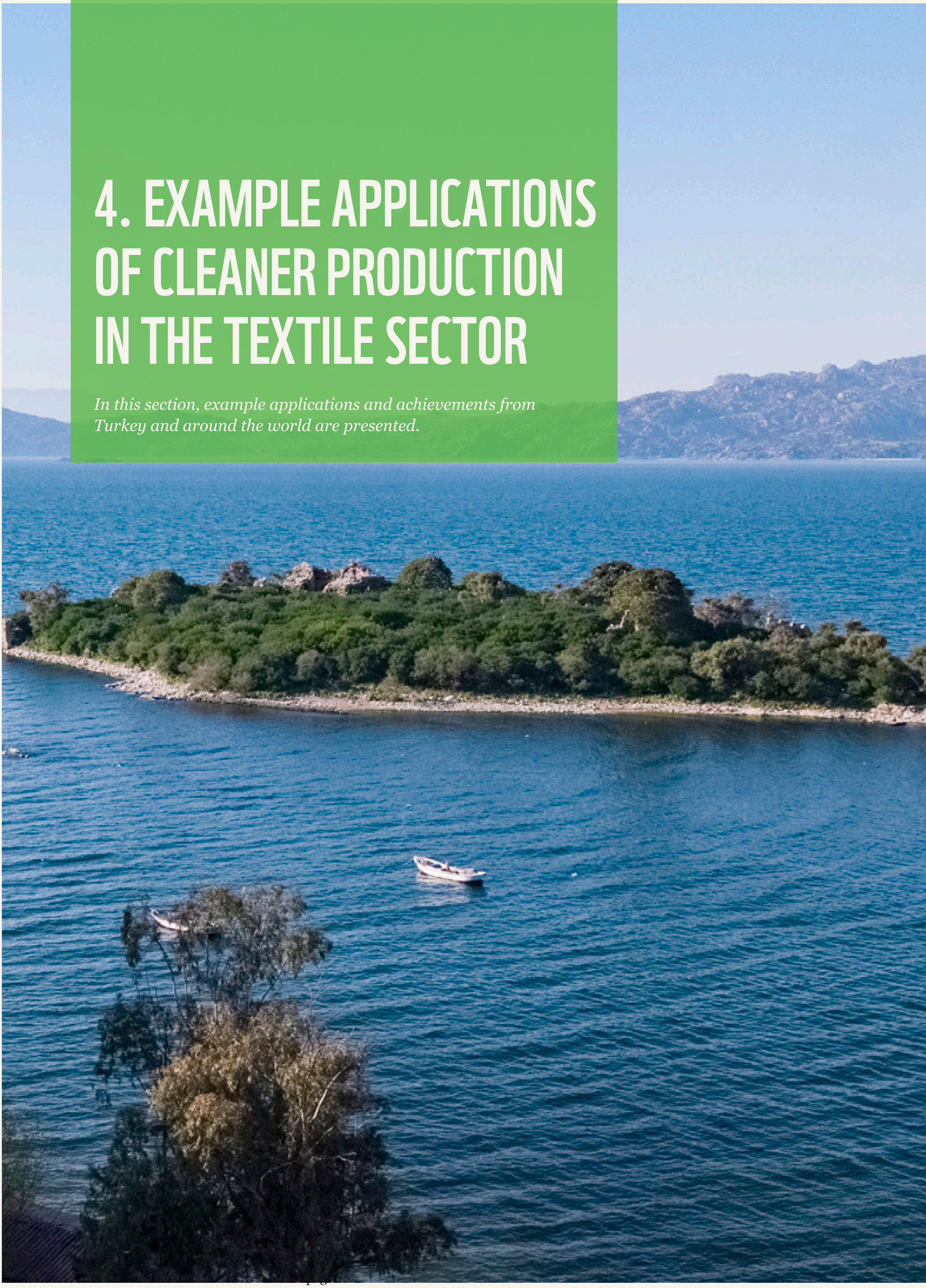
Mercerization	• Recovery and reuse of alkaline in the mercerization rinse water. • Reuse of alkaline wastewater in other pre-treatments.
Dyeing	**General** • Use of dyes that are highly absorbed in/adsorbed on the fiber. • Use of auxiliary chemicals that will not prevent the dyes from being highly absorbed in/adsorbed on the fiber. • Reducing the number of dyes in the dosing and dispensing of paint formulations (e.g. by using trichromatic systems) and the use of automatic dosing and dispensing systems (manual systems can only be used for rarely used dyes). **Intermittent Painting** • The use of automatic control mechanism equipment and a good insulation system to minimize steam losses. • Selection of the most suitable machines for the lot sizes that will be treated. • Low or very low float ratio in selection of new machines; disposal of operation floats and washing floats; the ability to separate the floating material from goods during processing. • Instead of oversized washing method, application of filling and unloading systems. • Reuse of rinsing water in the next dyeing batch. • Reuse of the dye bath when technically feasible. **Continuous Painting** Reduction of concentrate float losses as listed below: • The use of less input processes and the minimization of the volume of the impregnation vat when impregnation and dyeing techniques are used. • Adoption of distribution systems, where the chemicals are distributed on-line in separate lines and mixed just before application. • The use of advanced systems for dosing of impregnation floats. • The use of reverse flow washing. • Dirty residual water in the fiber should be removed before the next washing step via fiber wringing rollers and similar equipment. **Disperse Dyeing** • Avoidance of the use of dangerous carriers. • Avoiding the use of sodium dithionite by using disperse dyes which can be removed by hydrolytic solubilization in an alkaline medium instead of by reduction; or instead of sodium dithionite, use of sulfinic acid derivative based reducing materials. • Use of optimized dye formulations with high biodegradability, including dispersants. **Sulphurous Dyes** • The use of pre-reduced liquid dye formulations having sulfur content of less than 1% or stabilized pre-reduced sulfur-free dyes instead of conventional powder and liquid sulfur paints. • The use of sulfur-free reducing materials or sodium dithionite, rather than sodium sulphide. • Taking precautions to ensure that the reducing agent is only used at the required level for the reduction of the dye (for example, using nitrogen to flush out the machine and remove oxygen from the air). • Hydrogen peroxide is preferred as the oxidant. **Reactive Dyes** • Use of reactive dyes, which are highly absorbed in/adsorbed on fiber and those that require less salt. • Avoiding the use of surfactants and complexing agents in rinsing and neutralization steps after painting by applying hot rinsing and energy recovery.

Printing-Painting	• In rotary screen printing, reduction of losses in print paste. • Reduction of water consumption in cleaning processes. • The use of digital ink-jet printing machines for short production (less than 100 meters) of flat fabrics. • The use of digital printing machines for the printing of carpets and bulky fabrics. • The use of single-step printing or two-step printing with controlled moisture addition instead of urea in reactive prints. • The use, in pigment prints, of printing pastes with low volatile organic carbon emissions (emission value <0.4 g Org.-C/kg textile), that are alkyl phenol (APEO) ethoxylate-free and that are highly biodegradable or have reduced ammonia content (Emission value: 0.6 g NH3/kg of textile).
Finishing	• Minimizing wastewater formation with technique applications such as foam and spraying. • Reduction of the energy consumed in the stenter by methods such as insulation, energy recovery, and use of mechanical pre-drying devices. • The use of formulas optimized for low air emissions. • The use of formaldehyde-free crosslinking agents in the production of carpets for easy maintenance operations. • Ensuring that chemicals are retained by fiber with 98% efficiency, by using the appropriate material preparation procedures for mothproof processes. If the chemical used is applied in a dye bath, provide the pH <4.5 at the end of the process and prevent overflow spillage. Selection of auxiliary agents that do not delay or interfere with the retainment of chemicals by the fiber. • Instead of applying the softeners in intermittent dyeing machines, apply softeners in foulards spraying or foam systems in softening treatment processes.
Washing	• Instead of transferring to washing/rinsing processes, employ the use of single tank wash or smart rinse techniques. • Reduction of water and energy consumption by using high-efficiency washing machines and energy recovery equipment in a continuous process. • The use of completely closed circuited equipment when the use of halogenated organic solvents cannot be avoided. • Assessment of the cleanliness of the wastewater from relatively cleaner washing rinsing sources.



4. EXAMPLE APPLICATIONS OF CLEANER PRODUCTION IN THE TEXTILE SECTOR

In this section, example applications and achievements from Turkey and around the world are presented.



H&M Cases from Turkey

H&M works with their business partners to help fabric producers improve their environmental footprint and collect water management/impact assessment data. In 2017, H&M connected fabric mills involved in making 60% of their products (2016: 56%, 2015: 50%, 2014: 35%) to H&M's supplier assessment systems. H&M's work with resource efficiency and cleaner production programs has continued to help the supply chain business partners to reduce their water consumption. This program aims to reduce environmental impacts associated with textile wet processing, particularly groundwater extraction and surface water pollution. Below are cases that show the impact of H&M's cleaner production programs in Turkey.

Case 1

Factory A

This facility produces 90% knit fabric. Production capacity is 20 ton/day. The raw materials being used are cotton, viscose, synthetic and blended fabrics. Production stages and processes are dyeing, printing, cold pad-batch and mercerized production.

Improvement Area	Improvement Method	Project Description
Electricity & Natural Gas	Technical Update	Renovation of dryer
Electricity	Changing Equipment	Use of LED lighting system applications at apparel department
	Install a new system	Installation of servo system in fabric cutting edge process. Servo systems are closed-loop systems which have some benefits over open-loop systems, including the fact that they improve transient response times, reduce steady state errors and reduce system sensitivity to load parameters.
Electricity & Water	Technical Update	Installation of new foulard machine and new technology for dyeing process
Management	Install a new system	Use of 5S methodology in chemical warehouse and feeding area. 5S methodology is to sort, set in order, straighten, shine and sustain to have a good warehouse management

Number of projects implemented	7	
Actual savings realized	Water (Kilo-liters)	-
	Electricity (KWh)	81,500
	Chemical (kg)	-
	Coal (kg)	-
	Natural gas (m^3)	78,000
Financial actual savings realized (TRY)		301,788

Case 2
Factory B

The facility is a knit dye-house with a 30 ton/day capacity: 10 ton of printing (there are 3 rotary screen printing machines) and 20 ton of dyeing. Operating activities are high temperature dyeing, rotary screen printing and finishing.

Improvement Area	Improvement Method	Project Description
Electricity	Management	Energy efficiency increasing in pumps
	Changing Equipment	Replacement of inefficient and the environment lamps with LED lighting
Water	New Technology	Use of Reverse Osmosis systems in boiler feedwater
Energy	Install a new system	Installation of compressed air leakage maintenance program to reduce the energy use
		Installation of steam trap maintenance program to avoid from steam and heat loses and also increase equipment lifetime
Natural Gas & Coal	Renovation to the equipment	Effective insulation on steam and how water pipes

Number of projects implemented	6	
Actual savings realized	Water (Kilo-liters)	-
	Electricity (KWh)	316 ,187
	Chemical (kg)	-
	Coal (kg)	494,250
	Natural gas (m^3)	27,200
Financial actual savings realized (TRY)		187,683

Case 3
Factory C

Factory produces denim. Cutting, knitting, ironing, packaging and washing are the main processes. There is also printing, piece-dyeing, and laser processes in the factory.

Improvement Area	Improvement Method	Project Description
Water	Management	Control of the cogeneration boiler's water amount, blowdown and conductivity
Electricity & Natural Gas	Renovation to the equipment	Effective insulation for cogeneration waste heat recovery and steam boilers
		Effective insulation on steam and hot water pipes
	Management	Control of steam trap to avoid from heat loss
Electricity	Changing Equipment	Replacement of inefficient halogen lamps with LED lighting
Wastewater	Management	Reduction of wastewater pollution load and improvement of treatment pool usage

Number of projects implemented	8	
Actual savings realized	Water (Kilo-liters)	16,367
	Electricity (KWh)	53,020
	Chemical (kg)	316,197
	Natural gas (m^3)	14,711
Financial actual savings realized (TRY)		29,732

Case 4
Factory D

This factory produces denim and cutting, knitting, ironing, packaging and washing are the main processes. There are printing, piece dyeing, and laser processes in the factory.

Improvement Area	Improvement Method	Project Description
Electricity & Water & Chemical	Technical Update	Installation of new machinery for using laser method in denim bleaching process
Chemical	Install a new system	Installation of chemical dosing system
Natural Gas	Management	Removal of the all air leakages in the facility
Management	Management	Monitoring of the water consumption in the sub processes
		Monitoring of the wastewater consumption by installing a flow meter at the effluent point of the wastewater treatment plant
Electricity	Changing Equipment	Replacement of fluorescent lamps with LED lightings at the washing department.
	Management	Illumination of working area by LED lighting in the sewing machines
	Technical Update	Installation of new burners for the dryer machine

Number of projects implemented		6
Actual savings realized	Water (Kilo-litres)	-
	Electricity (KWh)	213,677
	Chemicals (kg)	-
	Natural Gas (m^3)	210,000
Actual financial savings realized (TRY)		577,593,7

Case 5
Factory E

This factory produces thread by using ring technology. In the weaving production unit, polyviscose woven fabric is produced. In the dyeing and dressing production units, batch and/or thread dye fabrics are produced.

Improvement Area	Improvement Method	Project Description
Natural Gas & Electricity	Renovation to the equipment	Effective insulation on steam and hot water pipes
Electricity	Management	Separation of compressor room from each cogeneration apartment (atmospheric fresh air intake of the compressor) to make compressor work efficiently
	Renovation to the equipment	Installation of functional lamp and automation of the lighting
	Management	Maximization of daylight use
Natural Gas & Electricity	Management	Adjust temperature of boiler room to a specific degree to make boiler work efficiently
		Control of compressed air leakage
	Renovation to the equipment	Installation of the air tank traps to avoid loses

Number of projects implemented		7
Actual savings realized	Water (Kilo-liters)	-
	Electricity (KWh)	201,586
	Chemicals (kg)	-
	Natural Gas (m^3)	876,28
Financial actual savings realized (TRY)		107,768

Total investments and savings in 5 factories A, B, C, D and E.

Factory		E	D	C	B	A
Investment (thousand TRY)		136	2,843	143	260	3,160
Electricity	**Consumption in 2015 (MWh)**	50,066	2,511	4,545	10,765	7,472
	Annualized saving (MWh)	256	267	66	316	82
	Savings (%)	0,50%	10,60%	1,50%	2,90%	1,10%
Water	**Consumption in 2015 (1000 m^3)**	1.963	761	364	1.171	464
	Annualized savings (1000 m^3)	0	36	16	0	0
	Savings (%)	0,00%	4,80%	4,50%	0,00%	0,00%
Natural gas	**Consumption in 2015 (1000 m^3)**	14,277	2,791	1,134	2,570	722
	Annualized savings (1000 $m^{3)}$	110	252	18	27	78
	Savings (%)	0,80%	9,00%	1,60%	1,10%	10,80%
Chemicals	**Consumption in 2015 (ton)**	NA	889	96	3,376	2,198
	Annualized savings (ton)	0	62	0	0	0
	Savings (%)	NA	6,90%	0,00%	0,00%	0,00%
Coal	**Consumption in 2015 (ton)**	NA	0	0	13.207	NA
	Annualized savings (ton)	NA	0	0	494	NA
	Savings (%)	NA	NA	NA	3,70%	NA
Financial Savings (thousand TRY)		129	602	34,2	179	288

Case 6
Feasibility Studies

H&M continues its cleaner production program, covering 20% of applicable units in 2018. To support a science-based and solution-oriented conversation about resource use in the Büyük Menderes Basin, feasibility studies were implemented in collaboration with WWF-Turkey.

Within the study, management approaches in use of raw materials, chemicals, water, energy, waste and wastewater were assessed in four facilities in the basin and opportunities to implement cleaner production was assessed in facilities in Aydın and Denizli.

Assessment of Cleaner Production Implementation Potential in 4 Facilities in the Büyük Menderes Basin

Factory	Investment Range* (TRY)	Water Saving (%)	Energy Saving (%)	Other Savings (%)	Payback period (year)
Factory F Initially started with towel dyeing; there are three production units namely knitting, dye-house and digital printing.	500,000 – 1,900,000	30-65%	10-30%	Salt: 15-20% Labor: 5%	1-3 year
Factory G The production processes of the company are about 90% knitting and about 10% weaving. Main machines in the machine track are weaving, dyeing, printing, washing, drying, finishing and quality control machines.	1,200,000 – 3,500,000	30-55%	15-25%	Dye/chemical: 15-20% Process time: 40-60%	2-3 year
Factory H An integrated enterprise that produces towels, bathrobes, home textiles and bed clothes, cotton woven fabric and consists of yarn, weaving, dyeing/finishing, digital printing, apparel and embroidery units.	500,000 – 2,400,000	25-45%	10-30%	Salt: 5-10% Labor: 10-15 %	1-3 year
Factory I The main activity is design and production of cotton and cotton blended fabrics. This brand is known for shirting fabrics and has been exporting. The company also produces jacket and trousers fabric.	900,000 – 3,400,000	25-60%	5-20%	Dye/chemical: Up to 10% Labor: Up to 30%	2-3 year

* Amount includes the cost of implementing all proposed measures from the feasibility study. These amounts will be lower if only some of the measures are taken.

Factory F

Cleaner Production Application Potential	Investment Range (TRY)	Average Water Saving (%)	Average Energy Saving (%)	Other Savings (%)	Payback period (year)
Recycling and Reuse of Process-based Wastewater	50,000-250,000	10-20%	1-5%	-	1-3
Performing Water Recycling Optimization by Water Pinch Analysis	50,000-100,000	Up to 5%	Up to 1%		Up to 1 year
Using a Fill-and-Draw System Instead of Over-flow Washing	Less than 50,000 TRY	5%	-	-	Up to 1 year
Recycling of Wastewater Generated in Balloon Squeezing Process	5000-10,000	1-2%			Up to 1 year
Increasing the Efficiency of the Reverse Osmosis (RO) Unit	30,000-200,000	1-2%	Up to 1%	-	1-2
Reuse of Final Rinsing Water of Continuous Washing Machine	50,000-100,000	Up to 5%	Up to 1%	-	1-2
Sand Filter Integration and System Optimization in Water Softening System	20,000-50,000	10-15%	1-2%	Salt:15-20% Labor: 5%	Up to 1 year
Harvesting and Use of Rainwater in Production Process	100,000-200,000	Up to 1%	Up to 1%	-	7-8
Recycling of Cooling Waters	50,000-100,000	Up to 5%	1-2%	-	1-2
Monitoring of Steam Leaks and Prevention of Losses	1500-112,500	2-3%	2-4%		1–2
Caustic Recovery	*	-	-	Caustic: 50-60 %	1-3
Waste Heat Recovery in Stenter	100,000-500,000	-	4-5%	-	2-4
Wastewater Heat Recovery in Continuous Washing Machine	50,000-150,000	-	Up to 2%	-	1-2
Supply of Hot Water by Recovering the Waste Heat from Compressed Air Systems	5000-20,000	-	1-2%	-	Up to 1 year
Total	**Around 0,5-1,9 Million TRY**	**30-65%**	**10-30%**	**Various**	**1-3 year**

* It would be more accurate to determine it by technical staff and authorized persons in the company as a result of a more detailed analysis, test and trial production.

Factory G

Cleaner Production Application Potential	Investment Range(TRY)	Average Water Saving (%)	Average Energy Saving (%)	Other Savings (%)	Payback period (year)
Recycling and Reuse of Process-based Wastewater	50,000-250,000	10-20%	1-5%	-	1-3
Performing Water Recycling Optimization by Water Pinch Analysis	50,000-100,000	Up to 5%	Up to 1%	-	Up to 1 year
Employing Air-flow (Air Jet) Dyeing Machines	400,000-1,200,000	15-20%	Up to 5%	Paint & Chemical: 15-20% Process time: 40-60%	2-3
Increasing the Efficiency of the Reverse Osmosis (RO) Unit	30,000-200,000	1-5%	Up to 1%	-	1-2
Replacing Steam traps in Dyeing Machines	40,000- 80,000	1-2%	Up to 1%	-	1-2
Harvesting and Use of Rainwater in Production Process	100,000-200,000	Up to 2%	Up to 1%	-	5-7
Caustic Recovery	*	-	-	Caustic: 50-60%	1-3
Waste Heat Recovery in Stenter	300,000-1,000,000	-	4-5%	-	2-4
Recovering the Waste Heat from Compressed Air Systems	5,000-20,000	-	1-2%	-	Up to 1 year
Heat Recovery from Wastewater	100,000-300,000	-	Up to 5%	-	1-2
Waste Water Heat Recovery from All Continuous Washing Machines	50,000-150,000	-	Up to 2%	-	1-2
Steam Recovery in Sanforizing Process	50,000-100,000	1-2%	Up to 1%	-	1-2
Total	**Around 1,2-3,5 Million TRY**	**30-55%**	**15-25%**	**Various**	**2-3 year**

* It would be more accurate to determine it by technical staff and authorized persons in the company as a result of a more detailed analysis, test and trial production.

Factory H

Cleaner Production Application Potential	Investment Range (TRY)	Average Water Saving (%)	Average Energy Saving (%)	Other Savings (%)	Payback period (year)
Recycling and Reuse of Process-based Wastewater	50,000-250,000	10-20%	1-5%	-	1-3
Performing Water Recycling Optimization by Water Pinch Analysis	50,000-100,000	Up to 5%	Up to 1%		Up to 1 year
Increasing the Efficiency of the Reverse Osmosis (RO) Unit	30,000-200,000	%1-2	Up to 1%	-	1-2
Using a Fill-and-Draw System Instead of Over-flow Washing	Less than 50,000 TRY	5%	-	-	Up to 1 year
Replacing Manual Backwash Water Softening System by Automated Water Softening System	50,000-200,000	5%	Up to 1%	Salt: 5-10% Labor: 10-15%	1-2
Harvesting and Use of Rainwater in Production Process	150,000-300,000	Up to 4%	Up to 1%	-	5-6
Caustic Recovery	*	-	-	Caustic: 50-60%	1-3
Waste Heat Recovery in Stenter	100,000-500,000	-	4-5%	-	2-4
Heat Recovery from Wastewater	100,000-300,000	-	Up to 5%	-	1-2
Waste Water Heat Recovery from All Continuous Washing Machines	50,000-150,000	-	Up to 2%	-	1-2
Monitoring of Steam Leaks and Prevention of Losses	1500-112,500	2-3%	2-4%	-	1-2
Burning Efficiency Analyses and Optimization in Steam Boilers	<20.000	-	Up to 5%	-	Less than 1 year
Relocating the Compressed Air Systems for Improved Efficiency	5000-100,000 TRY	-	Up to 1%	-	Less than 1 year
Supply of Hot Water by Recovering the Waste Heat from Compressed Air Systems	5000-20,000	-	1-2%	-	Less than 1 year
Total	**Around 0,5 – 2,4 Million TRY**	**25-45%**	**10-30%**	**Various**	**1-3 year**

* It would be more accurate to determine it by technical staff and authorized persons in the company as a result of a more detailed analysis, test and trial production.

Factory I

Cleaner Production Application Potential	Investment Range (TRY)	Average Water Saving (%)	Average Energy Saving (%)	Other Savings (%)	Payback period (year)
Recycling and Reuse of Process-based Wastewater	50,000-250,000	10-20%	1-5%	-	1-3
Performing Water Recycling Optimization by Water Pinch Analysis	50,000-100,000	Up to 5%	Up to 1%	-	Up to 1 year
Reuse of Final Rinsing Water of Continuous Washing Machine	50,000-100000	Up to 5%	Up to 1%	-	1-2
Recycling of Final Rinsing Waters of Post-processes for Light Color Fabrics	50,000-150,000	2-3%	Up to 1%	-	2-3
Employing Automated Dye Preparation/Dosing Technologies	100,000-1,000,000	-	-	Paint/chemical: Up to 10% Labor: Up to 30%	Up to 2 years
Replacing Manual Backwash Water Softening System by Automated Water Softening System	50,000-200,000	Up to 5%	-	Salt: 5-10% Labor: 10-15%	2-3
Increasing the Efficiency of the Reverse Osmosis (RO) Unit	30,000-200,000	1-2%	Up to 1%	-	1-2
Adaptation of Jet Fabric Dyeing Principles to Yarn Dyeing Process	*	*	*	*	*
Implementing Ozone Bleaching	*	*	*	*	*
Prevention of Cooling Water Discharge in Yarn Dyeing Process	50,000-100,000	Up to 5%	Up to 1%	-	2-3
Comparative Evaluation of PVA and Starch Based Sizing	*	*	*	*	*
Caustic Recovery	*	-	-	Caustic: 50-60%	1-3
Harvesting and Use of Rainwater in Production Process	150,000-300,000	10%	Up to 1%	-	4-5
Waste Heat Recovery in Stenter	100,000-500,000	-	4-5%	-	2-4
Waste Heat Recovery in Heat Transfer Oil System	200,000-400,000	-	Up to 3%	-	1-3
Steam Recovery in Sanforizing Process	50.000-100.000	1-2%	Up to 1%	-	1-2
Better Monitoring of Compressed Air Leaks	5.000- 25.000	Up to 2%	-	-	Less than 1 year
Total	**Around 0,9-3,4 Million TRY**	**25-60%**	**5-20%**	**Various**	**2-3 years**

* It would be more accurate to determine it by technical staff and authorized persons of the company as a result of a more detailed analysis, test and trial production.

Other Cases from Turkey and Around the World

More examples of and impact from cleaner production implementations in textile sector are provided in this section.

Case 1

Country: Turkey

Textile production includes dyeing and finishing for a women's outerwear group in Bursa. An environmental performance evaluation was carried out primarily within a cleaner production project implemented by TTGV within the UNIDO Eco-efficiency Program.

Improvement Areas:

- Better control of water consumption values for each process and determination of optimum water consumption values in these processes;
- Reduction of washing duration, closing the overflow washing valves in the overflow wash;
- Renewal of the in and out valves of cooling water sections of the painting machines;
- Collection of the cooling water by the drying machine to send it to the soft water pool for reuse;
- Determination of the optimal flow of water used in the fabric finishing machine;
- Fabric feather incinerator (gaze) to send cooling water to the soft water pool for reuse; and
- Transition to automation in water softening system (Alkaya & Demirer, 2014).

Environmental Performance After Implementation	
Resources/Wastes	**Decrease Percentage %**
Water consumption	-40,2
Energy consumption (kWh/ton cloth)	-17,1
Total salt consumption (kg/ton cloth)	-46,0
Organic load (COD) of wastewater	-25,4
CO_2 Emissions (kg/ton cloth)	**-13,5**

Case 2

Country: Turkey

This textile company performs knitting, dyeing and finishing fabric. Research was carried out by TTGV within the scope of İzmir Eco-efficiency (Cleaner Production) Program.

Improvement Areas:

- Recovery of cogeneration plant waste heat,
- Collection of rain water and process wastewaters and reusing them in the production process (TTGV and İZKA, 2015).

Achievements		
Business Expense Items	**Amount (per year)**	**Cost (TRY)**
Labor Force	918 hour/year	17,100
Maintenance and other expenses	175 l oil/year	3,000
Energy use	90,000 kWh/year	19,800
Total		39,900
Business Income Items	**Amount (per year)**	**Cost (TRY)**
Water Savings	38,500 m^3/year (6,7%)	4,000
Reduction of Treatment Facility Sludge	221 ton/year (14%)	15,994
Total Energy Savings (Natural Gas, Coal, Electricity)	601 TEP (Tons Equivalent Petroleum)/year	987,965
Initial Investment Cost		429,038
Total Annual Savings		1,007,959
Operating expenses		39,900
Net income		**968,059**
Refund Time = 5.1 months		

Case 3

Country: Turkey

This textile factory produces denim fabric.

Improvement Area:

- Replacement of chemical substances that are used in production that have caused undesirable results in product quality and environment

Project	
	On the basis of consumption quantities, formulas used, GBDs, etc., and problematic chemicals (toxic, low biodegradability, carcinogen, etc.)
Problematic chemicals identified	8 chemicals were identified as problematic. (2 ion retainers, 1 stabilizer, 3 sulfur dyes, 1 formaldehyde content resin and 1 disperser)
Achievements after chemical change (Öztürk et al., 2009)	
Biodegradability of the wastewater	Increased from 40% to 60% (by changing the ionic scavenging agent in the dyeing zone)
Treatment plant COD	Reduced to 3100 kg COD/month
The sulfur level in the dyeing process	Reduced by 70%

Case 4

Country: Tunisia

The optimization of SITEX production processes, which produce denim and indigo fabrics, aimed to reduce water use, the environmental impacts of the dyeing process, waste generation; all while lowering costs and increasing competitiveness.

Improvement Areas:

- Reduction of the water used in the rinsing phase at level of 6 m^3/hour by canceling the fifth rinse tank. (This reduction is achieved by monitoring and controlling the water used during the rinse phase.)
- Recycling of the cooling water used in the thread burning stage (Goller machine) and reuse in the Frigotol cooling pool resulted in soft water savings of 6 m^3/hour.
- Recycling of the cooling water used in the thread burning stage (Denimrange) and re-use in the Frigotol cooling pool resulted in soft water savings of 4 m^3/hr (Regional Activity Center for Cleaner Production (CP/RAC), 2008a).

	Cleaner Production Potentials			Project Totals
	1	2	3	
Wastewater volume reduction (m^3/year) Annual savings (USD/year)	18,000 29,000	10,000 16,000	12,000 19,000	 64,000
Reduction in energy use (thousand kilocalories/year) Annual savings (USD/year)	843,000 13,000			13,000
Reduction in refining chemical use (ton) Annual savings (USD/year)	32,8 11,000	18 6,000	22 7,000	 24,000
Save on machine parts Annual savings (USD/year)	 9,000			
Total savings (USD/year)	62,000	22,000	26,000	110,000
Investment (USD)	1,000	2,000	2,000	5,000
Refund period	Immediate	1 month	1 month	17 days

Case 5

Country: Egypt

Three textile companies (El Nasr Spinning and Weaving Co., Dakahleya Spinning and Weaving Co. and Amir Tex Co.) have identified cleaner production opportunities for their black sulfur dyeing process.

Improvement Areas:

- Removal of sodium sulfite and acid dichromate from use to make treating the wastewater from the facility easier and less costly,
- Replacement of sodium sulfite by a mixture of glucose and sodium hydroxide in all three facilities,
- Replacement of dichromate with sodium perborate at El Nasr Spinning and Weaving Co. and replacement of dichromate with hydrogen peroxide at Dakahleya Spinning and Weaving Co,
- In El Nasr Spinning and Weaving Co. desizing and cooking processes are combined to reduce the temperature of the impregnation bath.
- In Dakahleya Spinning and Weaving Co., switching to a cold wash between dyeing and oxidation processes,
- In Amir Tex Co. two cold washbasins have been canceled after overfilling.

Process optimization	
Combining desizing and cooking processes	
Process time	Reduced by 2 hours
Steam use	Reduced by 16%
Electricity use	Reduced by 22%
Switching to cold wash between dyeing and oxidation processes	
Process time	Reduced from 13 hours to 8 hours
Water, steam and electricity costs	Reduced by 38-39%
Cancellation of two cold washbasins after overfilling	
Water use	Reduced by 15%
Electricity use	Reduced by 18%
Steam use	Reduced by 21%

Case 6
Country: USA

In the textile factory:

- Existing but unused flow meters were activated in the dyeing tanks.
- With the help of differential pressure transmitters placed in the dyeing tanks, the amount of dyeing solution in the tanks was continuously measured.
- With the help of a computer program/automation system, the painting processes applied in the painting tanks were automatically monitored.
- The applied automation system made it possible to use as many paint/dyeing solutions as needed for dyeing fabrics of different qualities and quantities.

Achievements	
Water, heat and chemical use	Decrease between 6-16%
Water Savings	53,374 m^3/year
Chemical Savings	407,8 ton/year
Economic benefits	172,755 USD/year
Amortization period	4 months

5. HOW CAN CLEANER PRODUCTION PROJECTS BE IMPLEMENTED?

With Cleaner Production Assessment (CPA) it is possible to identify cleaner production possibilities in areas where resources are used inefficiently and where waste is not well managed. In Turkey, there are incentives to support cleaner production and loan opportunities from various institutions aimed directly at enabling cleaner production. Cleaner production practices can be realized through the aid of various exemptions, incentives and financial support.

Cleaner Production Assessment

While Cleaner Production can be applied with different tools, the most widely used tool is a Cleaner Production Assessment (or Audit). Cleaner Production Assessment (CPAs) is a method which is based on the systematic analysis of industrial processes and their environmental impacts. The aim is to identify areas where resources are not used efficiently and where waste is not managed well. (Figure 3). A CPA consists of five phases, identifies the points where resources are not used efficiently and where waste/emissions are heavily generated and takes into consideration technology, management processes, raw materials, processes, emissions, suppliers, products etc. of companies (Figure 2 and 4).

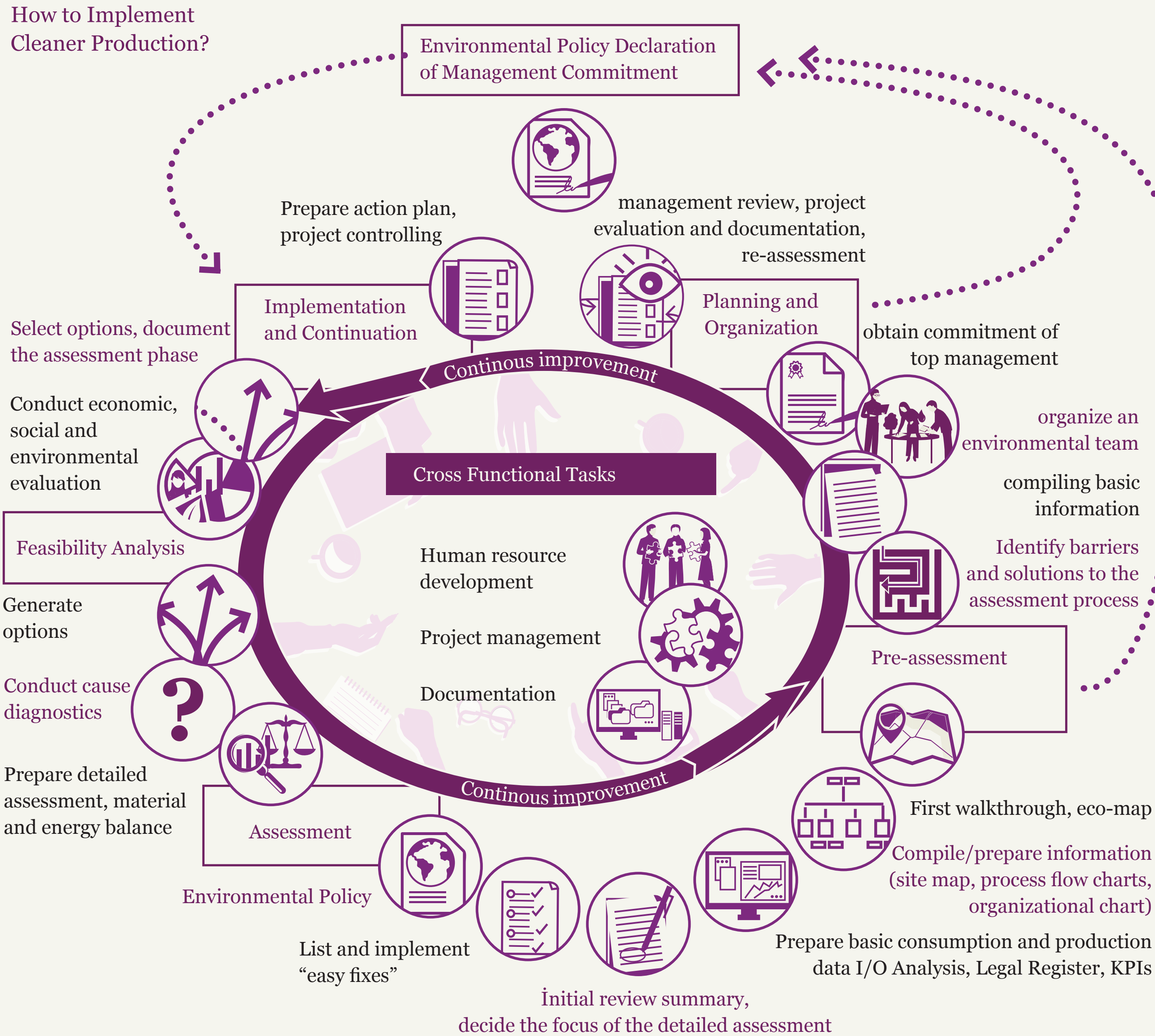


Figure 2. Cleaner Production Assessment (CPA) cycle (UNIDO (2011)

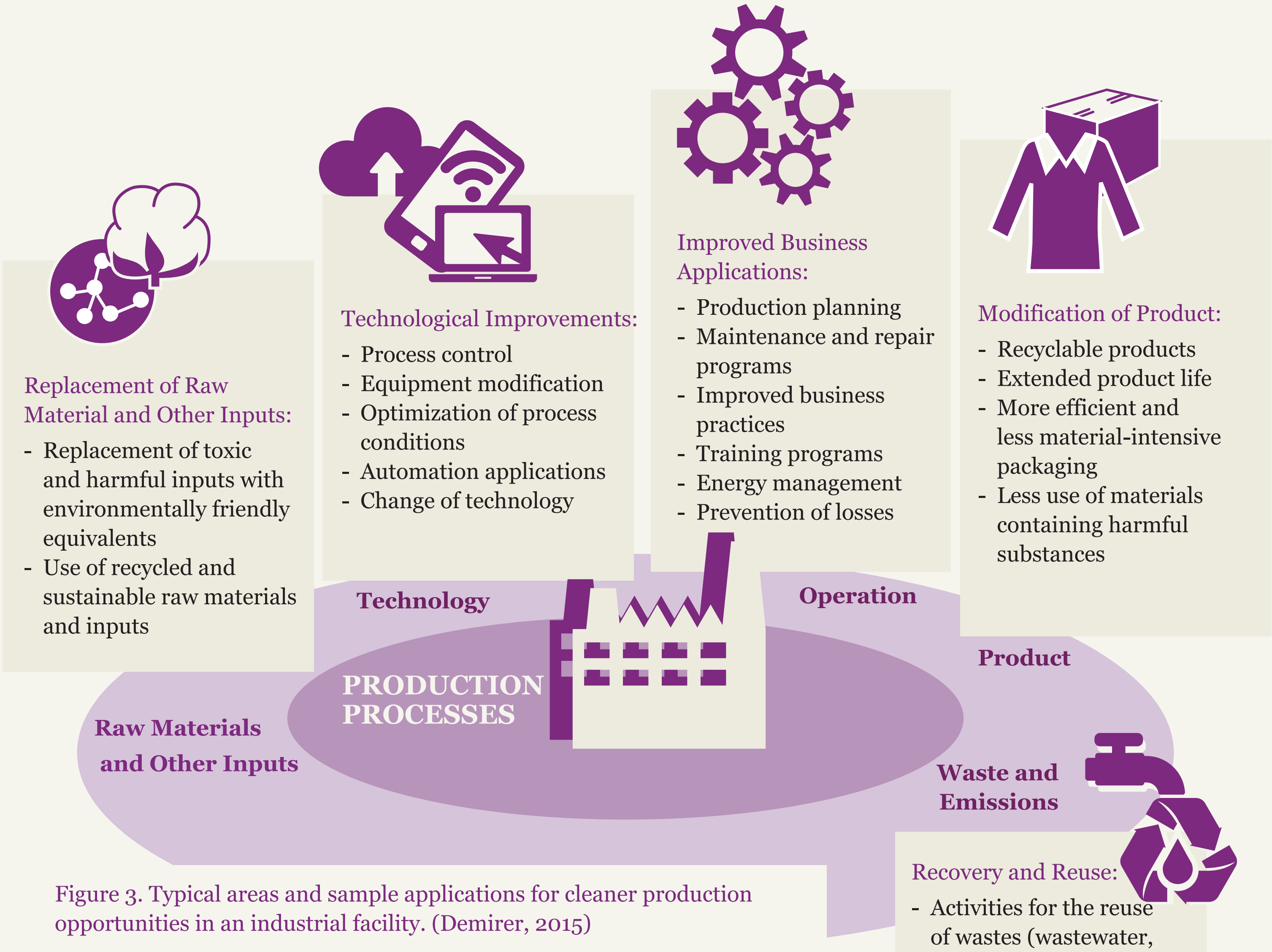


Figure 3. Typical areas and sample applications for cleaner production opportunities in an industrial facility. (Demirer, 2015)

5.1. Planning and Organizing Cleaner Production

5.1.1 Obtain Management Commitment

Experiences from many companies show that Cleaner Production initiatives result in both environmental improvements and better economic performance. However, this should be recognized by management of the company.
One of the most effective ways to make management see the benefits of implementation of Cleaner Production is to give examples from similar companies which have already implemented programs.

5.1.2. Establish a Project Team

The Cleaner Production project team undertakes the following tasks:

- Analysis and review of present practices,
- Development and evaluation of proposed Cleaner Production initiatives,
- Implementation and maintenance of agreed changes.

The project team should consist of people responsible for the business functions of the major facilities in the company, research & development staff and expert consultants. Members from outside the company can give an independent point of view to Cleaner Production activities.

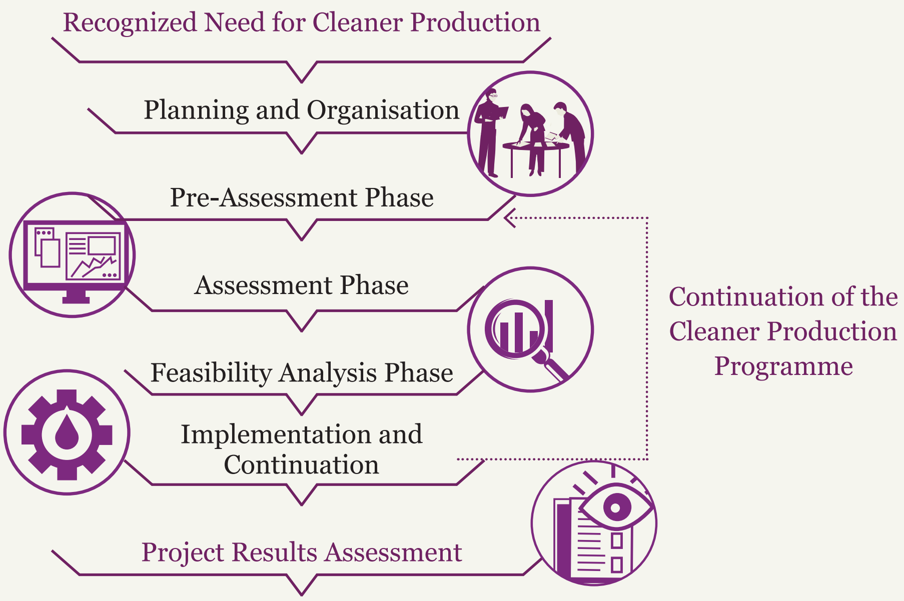


Figure 4. Overview of the Cleaner Production Assessment methodology

5.1.3. Develop Environmental Policy, Objectives and Targets

An environmental policy outlines the guiding principles for the assessment. The policy contains the company's mission and vision for continuous environmental improvement and compliance with legislation. The objectives describe how the company will do this. For example, the objectives could include the reduction of the consumption of materials, and the minimization of the generation of waste. Targets are used to monitor if the company is proceeding as planned. An example of a target might be a 20% reduction in electricity consumption within two years. In general, objectives and targets should be:

- Acceptable to those who work to achieve them,
- Flexible and adaptable to changing requirements,
- Measurable over time,
- Motivational,
- In line with the overall policy statement.

5.1.4. Plan the Cleaner Production Assessment

The project team should draw up a detailed work plan and a time schedule for activities within the Cleaner Production assessment. Responsibilities should be allocated for each task so that staff involved in the project understands clearly what they have to do.

5.2. Pre-assessment

The objective of the pre-assessment is to obtain an overview of the production and environmental aspects of a company. Production processes are best represented by a flow chart showing inputs, outputs and environmental problem areas.

5.2.1. Company Description and Flow Chart

A description of the company's processes should answer the following questions:

- What does the company produce?
- What is the history of the company?
- How is the company organized?
- What are the main processes?
- What are the most important inputs and outputs?

When looking for the answers to the questions the assessment team should first try to find already existing operational data such as production reports, audit reports and site plans. A checklist (Table 1) would make this step more comprehensive. Where information is not available the project team should make a plan how to obtain the missing data.

The process flow chart is meant to provide an overview and should thus be accompanied by individual input/output sheets for each unit operation or department in the company. Figure 5 provides an example of an input/output worksheet.

5.2.2. Walk-through Inspection

Much of the information needed to fill out the input/output sheets, described above, may be obtained during a walkthrough inspection of the company. The walk-through inspection should follow the process from start to finish, focusing on areas where products, wastes and emissions are generated.

Table 2 provides examples of the types of questions which the team may ask operators to facilitate the investigation. During the walk-through all obtained information should be listed, and if there are obvious solutions to the existing problems, they should be noted. Special attention should be paid to no cost and low-cost solutions. These should be implemented immediately, without waiting for a detailed feasibility analysis.

5.2.3. Establish a Focus

The last step of the pre-assessment phase is to establish a focus for further work. In an ideal case all processes and unit operations should be assessed. However, time and resource constraints may make it necessary to select the most important aspects or process areas. It is common for Cleaner Production assessments to focus on those processes that:

- Generate a large quantity of waste and emissions,
- Use or produce hazardous chemicals and materials,
- Entail a high financial loss,
- Have numerous obvious Cleaner Production benefits,
- Are considered to be a problem by everyone involved.

5.3. Assessment

The aim of the assessment phase is to collect data and evaluate the environmental performance and production efficiency of the company. Data collected about management activities can be used to monitor and control overall process efficiency, set targets and calculate monthly or yearly indicators. Data collected about operational activities can be used to evaluate the performance of a specific process.

Type of Information	Available	Not available	Requires updating	Not applicable
Process Information				
Process flow diagram				
Material balance data				
Energy balance data				
Site plans				
Drainage diagrams				
Operating procedures				
Equipment list & specifications				
Regulatory Information				
Waste license(s)				
Trade waste aggrement(s)				
Environmental monitoring records				
Environmental auidit reports				
Raw Material/Production Information				
Material safety data sheets				
Product & raw material inventories				
Production schedules				
Product composition & batch sheets				
Accounting Information				
Waste handling, treatment & disposal costs				
Water & sewer costs				
Product, energy & raw material costs				
Operating & maintanence cost				
Insurance costs				
Benchmarking data				

Table 1. Checklist for Background Information
(Please refer to the Annex for the printable version of Table 1)

Inputs	Process	Outputs
Raw materials:	Department:	Product:
Ancillary materials:	Process:	By-products:
Hazardous materials:		Air emissions:
Water:	Short Description:	Solid waste:
Energy:		Hazardous waste:
	Occupational health and safety:	Wastewater discharge:

Figure 5. Example of an input/output worksheet

Questions to be answered during a walk-through inspection:

Are there signs of poor housekeeping?

Are there noticeable spills or leaks? Is there any evidence of past spills, such as discoloration or corrosion on walls, work surfaces, ceilings or pipes?

Are water taps dripping or left running?

Are there any signs of smoke, dirt or fumes to indicate material losses?

Are there any strange odours or emissions that cause irritation to eyes, nose or throat?

Is the noise level high?

Are there open containers, stacked drums, or other indicators of poor storage procedures?

Are all containers labelled with their contents and hazards?

Have you noticed any waste and emissions being generated from process equipment (dripping water, steam, evaporation)?

Do employees have any comments about the sources of waste and emissions in the company?

Is emergency equipment (fire extinguishers etc.) available and visible to ensure rapid response to a fire, spill or other incident?

Table 2. Walk-through Inspection

5.3.1. Collection of Quantitative Data

It is important to collect data on the quantities of resources consumed and wastes and emissions generated. Data should be shown based on the scale of production. Collection and evaluation of data will most likely reveal losses. For instance, high electricity consumption outside production time may indicate leaking compressors or malfunctioning cooling systems.

Input/output worksheets are useful documents in determining what data to collect. Most data will already be available within the company's recording systems, e.g. stock records, accounts, purchase receipts, waste disposal receipts and production data.

5.3.2. Material Balance

The purpose of undertaking a material balance is to account for the consumption of raw materials and services that are consumed by the process, and the losses, wastes and emissions resulting from the process. A material balance is based on the principle of "what comes into a plant or process must equal what comes out". Ideally inputs should equal outputs, but in practice this is rarely the case, and some judgment is required to determine what level of accuracy is acceptable. Simply expressed, material or mass balance calculations are based on the following equation:

Total material in = material out (product) + material out (wastes) + material out (emissions) + material accumulated

A material balance makes it possible to identify and quantify previously unknown losses, wastes or emissions, and provide an indication of their sources and causes. Material balances are easier, more meaningful and more accurate when they are undertaken for individual unit operations. An overall company-wide material balance may then be constructed using these partial balances. The material balance sheets can also be used to identify the costs associated with inputs, outputs and identified losses. Presenting these costs to the management of the company often result in a speedy implementation of Cleaner Production options. The potential sources of material balance information can be:

- Samples, analyses, and flow measurements of feedstocks, products, and waste streams,
- Raw material purchase records,
- Material and emission inventories,
- Equipment cleaning and validation procedures,
- Batch make-up records,
- Product specifications and records,
- Design material balance,
- Operating logs and standard operating procedures and operating manuals,
- Waste manifests.

Environmental performance indicators for the process can be developed from the material balance data. This is achieved by dividing the quantity of a material input or waste stream by the production over the same period. Performance indicators may be used to identify over consumption of resources or excessive waste generation by comparing them with those of other companies or figures quoted in the literature. They also help the company track its performance towards its environmental targets.

5.3.3. Identify Cleaner Production Opportunities

The Cleaner Production assessment phase starts with making a “diagnosis” of the process to identify shortcomings and their causes, as well as to find options for how to improve it (Figure 6). The assessment team uses all means possible to identify Cleaner Production options. Ideas may come from:

- Literature,
- Personal knowledge,
- Discussions with suppliers,
- Examples in other companies,
- Specialised databases,
- Further research and development

It should be noted that during the assessment process, a number of obvious possibilities for immediate improvements may already have been identified. For example, one of the simplest and obvious measures is reduction in water use or energy use.

One way to produce ideas for Cleaner Production opportunities is to run a brainstorming session. Brainstorming sessions have proved to be most effective when managers, engineers, process operators and other employees as well as some outside consultants, work together without hierarchical constraints.

Many Cleaner Production solutions are arrived at by carefully analyzing the cause of a problem. Often the tendency is to jump from identifying where wastes and emissions are being generated directly to coming up with solutions how to prevent them. Five key areas of diagnosis of the causes are described in Figure 6.

Moreover, the team should focus on Cleaner Production prevention practices. Here it is important to keep in mind that there are five features which influence the process, and which can serve as focus points for generating options. They are input materials, technology, execution of the process, product and waste and emissions.

5.3.4. Record and Sort Options

- Once a number of Cleaner Production options have been suggested and recorded, they should be sorted into those that can be implemented directly and those that require further investigation. It is helpful to follow the steps: Organize the options according to unit operations or process areas, or according to inputs/outputs categories (e.g. problems that cause high water consumption).
- Any mutually interfering options should be identified, since implementation of one option may affect the other.
- Options that are cost free or low cost, that do not require an extensive feasibility study, or that are relatively easy to implement should be implemented immediately.
- Options that are obviously infeasible, or cannot be implemented should be eliminated from the list of options for further study.

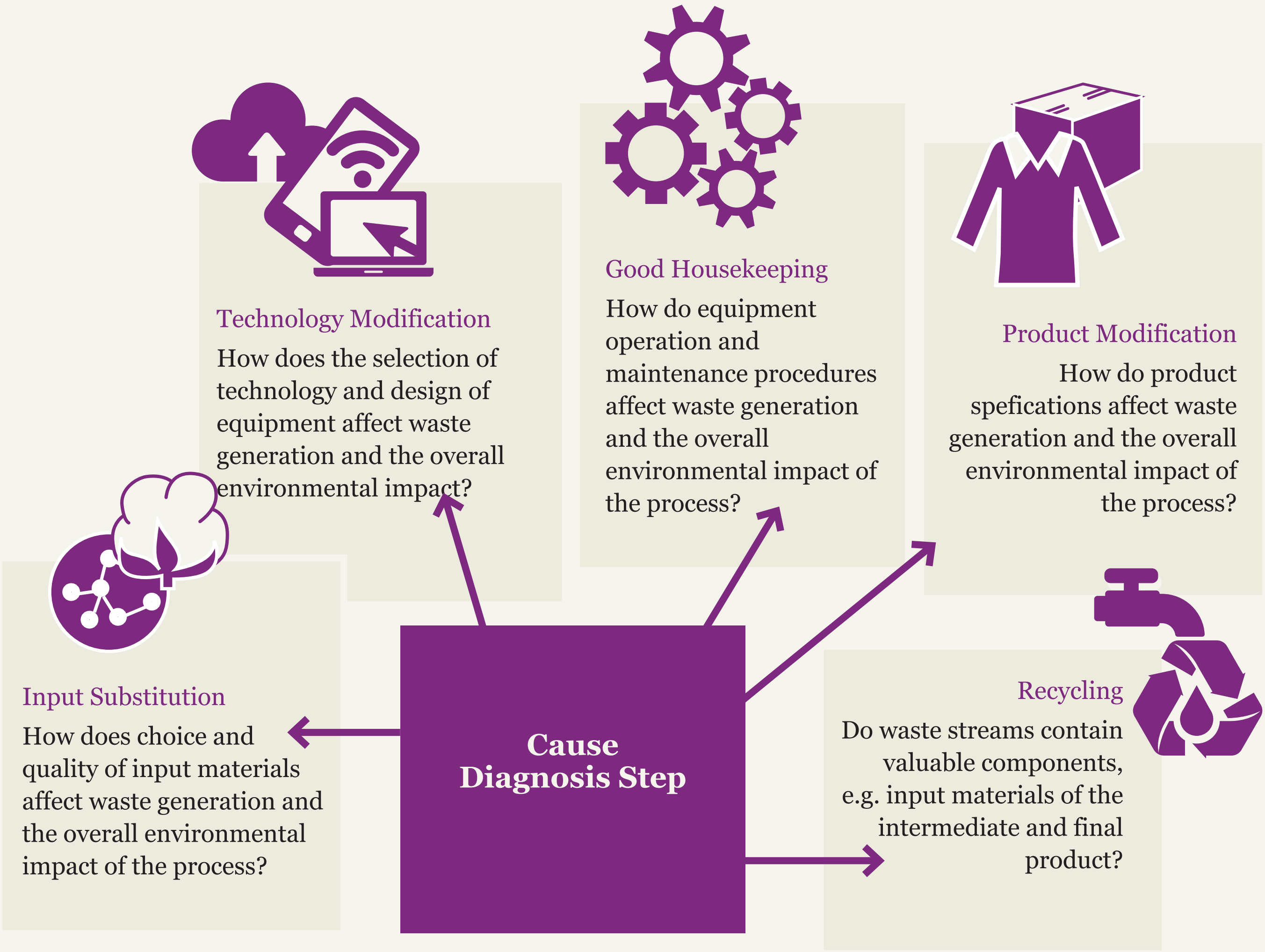


Figure 6. Cause diagnosis

5.4. Evaluation and Feasibility Study

The objective of the evaluation and feasibility study phase is to evaluate proposed Cleaner Production opportunities and to select those suitable for implementation. The opportunities selected during the assessment phase should all be evaluated according to their technical, economic and environmental merits. However, the depth of the study depends on the type of project. Complex projects naturally require more thought than simple projects.

5.4.1. Preliminary Evaluation

The quickest and easiest method of evaluating the different options is to form a group, consisting of the project team and management personnel, and discuss the possible solutions one by one. This process should give a good indication of which projects are feasible and what further information is required.

5.4.2. Technical Evaluation

The potential impacts on products, production processes and safety concerns of the proposed changes need to be evaluated before complex and costly projects can be decided upon. In addition, laboratory testing or trial runs may be required when options significantly change existing practices. A technical evaluation will determine whether the option requires staff changes or additional training or maintenance.

5.4.3. Economic Evaluation

The objective of this step is to evaluate the cost effectiveness of the Cleaner Production opportunities. Economic viability is often the key parameter that determines whether or not an opportunity will be implemented (Table 3).

Preliminary Evaluation	Technical evaluation	Economic evaluation	Environmental evaluation
Is the Cleaner Production option available? Can a supplier be found to provide the necessary equipment or input material? Are consultants available to help develop an alternative? Has this Cleaner Production opportunity been applied elsewhere? If so, what have been the results and experience? Does the option fit in with the way the company is run?	Will the option compromise the company's product? What are the consequences for internal logistics, processing time and production planning? Will adjustments need to be made in other parts of the company? Does the change require additional training of staff and employees?	What are the expected costs and benefits? Can an estimate of required capital investment be made? Can an estimate of the financial savings be made, such as reductions in environmental costs, waste treatment costs, material costs or improvements to the quality of the product?	What is the expected environmental effect of the option? How significant is the estimated reduction in wastes or emissions? Will the option affect public or operator health (positive or negative)? If so, what is the magnitude?

Table 3. Aspects to be considered in the CP Evaluation

5.4.4. Environmental Evaluation

The objective of the environmental evaluation is to determine the positive and negative environmental impacts of the proposed Cleaner Production option. In many cases the environmental advantages are obvious: a net reduction in toxicity and/or quantity of wastes or emissions. In other cases, it may be necessary to evaluate whether an increase in electricity consumption, for instance, would outweigh the environmental advantages of reducing the consumption of materials.

For a good environmental evaluation, the following information is needed:

- Changes in amount and toxicity of wastes or emissions,
- Changes in energy consumption,
- Changes in material consumption,
- Changes in degradability of the wastes or emissions,
- Changes in the extent to which renewable raw materials are used,
- Changes in the reusability of waste streams and emissions,
- Changes in the environmental impacts of the product.

5.4.5. Select Viable Options

The most promising options must be selected in close collaboration with the management of the company. A comparative ranking analysis may be used to prioritize opportunities for implementation.

5.5. Implementation and Continuation

The objective of the last phase of the assessment is to ensure that the selected options are implemented, and that the resulting reductions in resource consumption and waste generation are monitored continuously.

5.5.1. Prepare an Implementation Plan

To ensure implementation of the selected options, an action plan should be developed, detailing:

- Activities to be carried out,
- The way in which the activities are to carried out,
- Resource requirements (finance and manpower),
- The persons responsible for undertaking those activities,
- A time frame for completion with intermediate milestones.

5.5.2. Implement Selected Options

As for other investment projects, the implementation of Cleaner Production options involves modifications to operating procedures and/or processes and may require new equipment. The company should, therefore, follow the same procedures as it uses for implementation of any other company projects. However, special attention should be paid to the need for training of the staff. The project could be a failure if it is not backed up by adequately trained employees. Training needs should have been identified during the technical evaluation.

5.5.3. Monitor Performance

It is very important to evaluate the effectiveness of the implemented Cleaner Production options. Typical indicators for improved performance are:

- Reductions in wastes and emissions per unit of production,
- Reductions in resource consumption (including energy) per unit of production,
- Improved profitability.

There should be periodic monitoring to determine whether positive changes are occurring and whether the company is progressing toward its targets.

5.5.4. Sustain Cleaner Production Activities

Sustained Cleaner Production is best achieved when it becomes part of the management through a formal company environmental management system or a total environmental quality management approach. An environmental management system provides a decision-making structure and action plan to support continuous environmental improvements, such as the implementation of Cleaner Production. If a company has already established an environmental management system, the Cleaner Production assessment can be an effective tool for focusing attention on specific environmental problems. If, on the other hand, the company establishes a Cleaner Production assessment first, this can provide the foundations of an environmental management system.

Financial Mechanisms

Albeit limited, incentive support and loans directly promoting cleaner production are provided by various institutions in Turkey. In addition, there are incentive mechanisms available for cleaner production studies and applications for investments, industrial zones, R&D and entrepreneurship. These can be in various forms such as exemptions, incentives and financial support.

International Finance Institutions

International finance institutions provide opportunities to support cleaner production investments through intermediaries. In addition, they invest in energy-saving technology products, improvement of production methods and quality, standardization in production increasing efficiency in the activities of enterprises, provision of credit support on issues such as heat insulation and waste management.

Institution	Instrument/Incentive	Relevant Link
The World Bank	Lending/financing instruments used by the World Bank for supporting the projects are: - Specific Investment Loan - Financial Intermediary Loan - Investment Project Financing The financing sources include IBRD, GEF (Global Environment Facility) and energy service companies. The World Bank provides credit lines through local financial intermediaries, including VakıfBank, Halk Bankası, Ziraat Bankası, İller Bankası, Türk Eximbank and the TSKB for lending to SMEs, large enterprises, municipalities and utilities.	World Bank: www.worldbank.org World Bank Lending Instruments: http://siteresources.worldbank.org/INTBULGARIA/Resources/Lending_Instr_Eng.pdf
International Finance Corporation (IFC)	IFC provides a senior loan up to $75 million to the Turkish Industrial Development Bank (TSKB) to fund pollution reduction and energy efficiency projects in Turkey.	Supporting Climate-Smart Investments: https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/climate+business/priorities/supporting+climate-smart+investments-update
	.	Pollution Abatement Loan: http://www.tskb.com.tr/web/307-1290-1-1/tskb-site-en/en-hakkimizda/tskbden-haberler-en/ifctskb-industrial-development-bank-of-turkey-partner-to-cut-pollution-abatement-and-boost-energy-efficiency
French Development Agency (AFD)	**SUNREF Turkey** It offers financial and technical assistance for companies and banks: - Assistance to identify green investment opportunities - Assistance to companies for the development of eligible, innovative and profitable green projects SUNREF Turkey operates in partnership with Halkbank and a credit line of 100 million EUR is provided.	SUNREF: https://www.sunref.org/en/projet/?secteur=&pays=turquie-en https://www.sunref.org/wp-content/uploads/2017/10/SUNREF-Turkey-brochure.pdf

Institution	Instrument/Incentive	Relevant Link
European Bank for Reconstruction and Development Bank (EBRD) Turkey Mid-size Sustainable Energy Financing Facility (MidSEFF)	MidSEFF was launched by the European Bank for Reconstruction and Development Bank (EBRD) with the support of the European Investment Bank (EIB) and the European Union (EU). It provides a total loan of EUR 1 billion through local Turkish banks for on-lending to private sector borrowers, for the financing of mid-sized (i.e. EUR 5-50 million) investments in: - Renewable energy - Waste-to-energy - Industrial energy efficiency	MidSEFF: http://midseff.com/tr/index.php,
European Bank for Reconstruction and Development Bank (EBRD) Turkey Sustainable Energy Financing Facility (TurSEFF)	The Turkey Sustainable Energy Financing Facility, TurSEFF, is a program developed by the European Bank for Reconstruction and Development Bank (EBRD) to provide financing for Sustainable Energy and Resource Efficiency (Energy Efficiency, Water Efficiency, Material Efficiency, Waste Management) investments in the public and private sectors. The total amount of the new phase of TurSEFF, launched in 2017, is €400 million, to which can be applied via Participating Financial Institutions, either commercial banks or leasing companies. A team of local and international experts provide support to help prospective borrowers identify and develop Sustainable Energy sub-projects and prepare successful loan or lease applications under TurSEFF. This technical assistance is provided free of charge to borrowers and is funded by the EU. - Industrial energy efficiency projects - Renewable energy investments - Small scale energy efficiency & renewable energy investments - Supplier, manufacturer and installer financing of eligible equipment - Vendor financing of eligible equipment	TurSEFF: http://www.turseff.org/
Other International Finance Organizations	Other international financial institutions/banks that provide loans via intermediate Turkish Banks to finance Turkish companies' projects in the fields of **renewable energy** and **energy efficiency** investments include: - The International Bank for Reconstruction and Development (IBRD) - European Investment Bank (EIB) - KfW Development Bank - Islamic Development Bank The loan structure can change according the source of the fund and financial strength of the applicant companies	IBRD: https://www.worldbank.org/en/who-we-are/ibrd EIB: www.eib.org KfW Development Bank: www.kfw-entwicklungsbank.de/International-financing/KfW-Development-Bank Islamic Development Bank: www.isdb.org

Banks		
Turkish banks provide support to the cleaner production investments acting as intermediary to the international finance institutions such as the IFC, AFD, kfW, EBRD etc. Turkish banks also have credit programs that address green investments. Local banks with different financial opportunities include:		
Türkiye Sınai Kalkınma Bankası (TSKB)	Akbank	Türkiye İş Bankası
Türkiye Kalkınma Bankası (TKB)	Garanti Bankası	Ziraat Bankası
Türkiye Halk Bankası	Türk Ekonomi Bankası (TEB)	İller Bankası
Vakıfbank	Deniz Bank	Türk Eximbank
Şeker Bank		

Institution	Instrument/Incentive	Relevant Link
Turkish Industrial Development Bank (TSKB)	TSKB provides financial support for sustainable investment projects in different sectors through its corporate lending and project finance services, under the following schemes: - Industrial Investments - Energy & Resource Efficiency - Environmental Protection Investments - Renewable Energy	http://www.tskb.com.tr/
Türkiye Kalkınma Bankası (TKB)	TKB provides financial supports to the projects related especially to industry, tourism, renewable energy and that are environmentally conscious	http://www.kalkinma.com.tr/dis_kaynakli_krediler.aspx
Türkiye Halk Bankası	Environmental Lending	https://www.halkbank.com.tr/5803-surdurulebilir_finans
Vakıfbank	Environmental Banking	www.vakifbank.com.tr/cevre-bankaciligi.aspx?pageID=460
Şeker Bank	Eco-loan	www.sekerbank.com.tr/esnaf-isletme/krediler/ekokrediticari
Akbank	Energy Efficiency Loans	www.akbank.com/tr-tr/urunler/Sayfalar/Enerji-Verimliligi-Kredileri.aspx
Garanti Bankası	**Büyük Menderes Cleaner Production Loan** The credit program is developed specifically for the textile sector in the Büyük Menderes basin to support cleaner production projects. The Bank also serves technical support to the projects.	
	Environmentalist SME	www.garanti.com.tr/tr/kobi/kobilere_ozel/destek_paketleri/cevreci_kobi_destek.page
Türk Ekonomi Bankası (TEB)	AFD Energy Loan	www.teb.com.tr/esnafim/AFD-kredileri/
Deniz Bank	Project Support Loans	www.denizbank.com/bankacilik/kobi-bankaciligi/kobi-kredileri/proje-destek-kredileri.aspx?menu
Türkiye İş Bankası	Project Financing	www.isbank.com.tr/TR/ticari/proje-finansmani-ve-yapilandirilmis-finansman/Sayfalar/proje-finansmani-ve-yapilandirilmis-finansman.aspx

Public Institutions

Public support is available to cleaner production investments at facilities in various ways including exemptions, incentives, direct financial support or by guarantee providing.

Institution	Instrument/Incentive	Relevant Link
Ministry of Economy	**Export Incentives** Although the Ministry of Economy has different support programs regarding export facilitation, “Supporting the Development of International Competitiveness” is the most related sub-program to Cleaner Production. The aim of this support is to increase the competitiveness and exports of the companies established in Turkey in the international arena.	Ministry of Economy (www.ekonomi.gov.tr) To ask questions directly, to ask for information and to follow your requests as regards the subjects that fall under the Ministry of Economy’s duties and authorities: (www.uzmanadanisin.ekonomi.gov.tr)
Ministry of Energy and Natural Resources	**Energy Efficiency Improvement Projects** The total investment cost excluding VAT is supported by 30%, with a maximum amount of 1,000,000 TRY and the maximum period of repayment is 5 years. Companies eligible for the support scheme: those with energy consumption > 1000 TPE.	http://odop.kalkinma.gov.tr/dokumanlar/14Enerji_Verimliliginin_Gelistirilmesi_Programi.pdf
	Voluntary Agreements Industrial entities make agreement with the General Directorate of Renewable Energy and commit to reduce their energy intensity by an average of at least 10% over three years following the agreement in accordance with the reference energy intensity of the past five years’ period. Companies eligible for the support scheme: those with energy consumption > 1000 TPE	www.yegm.gov.tr/verimlilik/d_gon_anlasmalar.aspx
	Renewable Energy Feed-in-Tariffs The recent feed-in tariffs rates for the renewable energy resources are as follows: Hydro Energy : 7,3 cent USD/kWh Wind Energy : 7,3 cent USD kWh Geothermal : 1,.5 cent USD /kWh Biomass : 13,3 cent USD kWh Solar Energy : 13,3 cent USD kWh These tariffs will be in place for 10 years. Companies that have required licenses can benefit from these tariffs.	
	Non-Tariff Incentives for Renewable Energy In order to reduce imports and increase domestic production, non-tariff incentives are provided. If the equipment that is utilized in renewable energy facilities is produced in Turkey, subsidies are granted to the producers.	

Institution	Instrument/Incentive	Relevant Link
Under Secretariat of the Treasury	Various incentives and tax/fee exemptions have been provided to companies to serve the objectives of the OIZ Law (numbered 4562). These incentives and exemptions are listed below: - Exemption from property taxes - Credit and loan interest support - Exemption from corporate taxes - Exemption from VAT - Exemption from the stamp tax - Discounts in Building Inspection Authority Fees - Benefits from incentives in one lower sub-region - Exemption from TRT Shares - Exemption from subdivision fees	https://www.hazine.gov.tr/
Regional Development Agencies	26 Development Agencies in Turkey offer financial support to the implementation of cleaner production investment in the context of their sectoral and target-oriented financial support programs. Financial support is provided for projects and actions of private sector entities, non-governmental organizations, public entities/organizations and all other real and legal persons that would help in the implementation of the Regional Plans and Programs. There are three types of financing mechanisms of Regional Development Agencies: - Direct financial support - Call for proposals - Guided project support	http://www.kalkinma.gov.tr/Pages/Tum-Kalkinma-Ajansi-Duyurulari.aspx
Credit Guarantee Fund (KGF)	KGF acts as a "joint guarantor" for SMEs that cannot get a loan due to insufficient collateral and supports them in access to financing. KGF Guarantee Products include the support programs listed below: - KOSGEB repayment support - TÜBİTAK transfer payments - Technological products investment support - Eximbank credits	http://www.kgf.com.tr/index.php/tr/

Institution	Instrument/Incentive	Relevant Link
Small and Medium Enterprises Development Organization (KOSGEB)	**SME Project Support Program** SMEs are supported through their projects related to production, management-organization, etc. Program duration: 3 years for operation Upper limit of non-refundable support: 150,000 TRY. Support rate of the program: 50% in Regions 1 and 2; and 60% in Regions 3, 4, 5, and 6.	http://www.kosgeb.gov.tr/site/tr/genel/detay/1226/kobi-proje-destek-programi
	KOBIGEL – SME Development Support Program A call-based support program for SMEs. Upper limit of the project support: 1,000,000 TRY; 300,000 TRY of which is non-refundable and 700,000 TRY is repayable. The Board decides on the amount of support.	http://www.kosgeb.gov.tr/site/tr/genel/detay/3288/kobigel-kobi-gelisim-destek-programi
	Cooperation Support Program Aims to support cooperation projects for joint production, joint design/ marketing/ laboratories/ manufacturing, provision of joint services in medium-high and high technology fields. Upper limit of the project support: 1,000,000 TRY (1,500,000 TRY for high technology areas), 300,000 TRY of which is non-refundable and 700,000 TRY is repayable.	http://www.kosgeb.gov.tr/site/tr/genel/detay/1228/isbirligi-gucbirligi-destek-programi
	R&D and Innovation Program The projects of small and medium sized enterprises fostering new ideas and inventions based on science and technology, developing entrepreneurs and new products/ processes, are supported.	R&D and Innovation Support: www.kosgeb.gov.tr/site/tr/genel/detay/1229/arge-ve-inovasyon-destek-programi
	Industrial Implementation Support Supports the projects for a new product/service to increase the quality of the products, to apply new and cost-reducing techniques and to commercialize the products or processes properly to the marketplace.	Industrial Implementation Support: www.kosgeb.gov.tr/site/tr/genel/detay/6521/endustriyel-uygulama-destek-programi

Institution	Instrument/Incentive	Relevant Link
Turkish Scientific and Technical Research Institute (TÜBİTAK)	**Industry R&D Start Program** R&D projects (including development of a new product, improvement of an existing product, improvement of product quality, or development of new techniques and new production technologies that reduce costs are supported.	https://www.tubitak.gov.tr/tr/destekler/sanayi/ulusal-destek-programlari/icerik-1501-tubitak-sanayi-ar-ge-projeleri-destekleme-programi
	SME R&D Start Program **Companies (SMEs)** SMEs are encouraged to develop new products, to improve an existing product, to improve product quality, or to develop new production technology. Budget of the project support: 500,000 TRY Project duration: 18months	https://www.tubitak.gov.tr/tr/destekler/sanayi/ulusal-destek-programlari/icerik-1507-tubitak-kobi-ar-ge-baslangic-destek-programi
	University-Industry Cooperation Support Program Aims to contribute to commercialization of knowledge & technology of universities/public research centers by developing products or processes that meet the needs of the institutions established in Turkey and to apply the project results nationwide. Upper limit of a project budget: 1,000,000 TRY Project duration: maximum 24 months.	https://www.tubitak.gov.tr/tr/destekler/sanayi/ulusal-destek-programlari/icerik-1505-universite-sanayi-isbirligi-destek-programi
	International Industrial R&D Projects Support Program Industrial companies can apply to this program with their R&D projects within a consortium including other international partners. No limitations exist on the support and project budgets.	https://www.tubitak.gov.tr/tr/destekler/sanayi/uluslararasi-ortakli-destek-programlari/icerik-1509-tubitak-uluslararasi-sanayi-ar-ge-projeleri-destekleme-programi

Stakeholders of Cleaner Production

Table 4. Institutions and organizations that stand out in the field of cleaner production in Turkey

Institution	Relevance to Cleaner Production Implementations	Useful Links
Ministry of Science, Industry and Technology General Directorate of Efficiency	The aim of the General Directorate is to develop resource efficiency policy and strategies, to increase efficiency in industry and to support cleaner production.	Policies, legislation, work related to resource efficiency and up-to-date developments in the textile sector can be followed: • DG Efficiency (www.vgm.sanayi.gov.tr) • Anahtar periodicals (http://anahtar.sanayi.gov.tr) • CP Information Platform (www.temizuretim.gov.tr)
Ministry of Environment and Urban Planning General Directorate of Environmental Management	To develop legislations, policy and strategies to prevent pollution and to support cleaner production implementations is among the mandates of the General Directorate of Environmental Management In 2011, the Directorate has released the "Integrated Pollution Prevention and Control Communication in the Textile Sector" that aims effective and efficient use of raw materials, energy and cleaner production technologies in textile sector.	Developments and up-to-date information on environmental legislation can be followed up on the General Directorate page (https://cygm.csb.gov.tr/)
Ministry of Energy and Natural Resources General Directorate of Renewable Energy	The projects prepared in accordance with principles published by the General Directorate of Renewable Energy are evaluated as Efficiency Improvement Project (VAP).	Information for support to VAP projects:http://www.enerji.gov.tr/tr-TR/Sayfalar/Enerji-Verimliligi-Destekleri
UNIDO	UNIDO's mandate is to establish public-private-sector-civil society-academia collaborations for the sustainable development of the industry; energy and environmental issues, as well as the implementation of technical cooperation projects.	Eco-efficiency (CP) Program http://www.ekoverimlilik.org/
Turkey Technological Development Foundation (TTGV)	TTGV implements activities related to Eco-efficiency and Industrial Symbiosis	TTGV web page: https://www.ttgv.org.tr/tr Eco-efficiency and Industrial Symbiosis: www.endustriyelsimbiyoz.org

Institution	Relevance to Cleaner Production Implementations	Useful Links
TÜBİTAK Marmara Research Center (MAM) Environment and Cleaner Production Institute	The institute functions as the National Cleaner Production Center; organizes sector specific trainings and coordination programs for capacity building including textile sector	http://www.temizuretimmerkezi.com/
Development Agencies	It is possible to get support for feasibility studies and implementation in cleaner production within the framework of periodic “financial support programs”. Investment Support offices also provide consultancy to the investors.	
Regional Environmental Center (REC)	REC aims to strengthen environmental capacity in Turkey. REC has produced a series of guidelines within their project titled “Resource Efficiency Guides” which are: • Cleaner Production Guide • Guide to Life Cycle Analysis • Eco-label guide	https://rec.org.tr/category/yayinlar/rehberler/
Business World and Sustainable Development Association (SKD)	SKD carries out various studies within the framework of the UN Sustainable Development Goals in order to increase the awareness and influence of the business world on sustainable development.	http://www.skdturkiye.org/
Boğaziçi University Sustainable Development and Cleaner Production Center	Among the aims of the center is to supply technology support for eco-efficiency – to increase manufacturing efficiency; reduce resource and chemical consumption, waste generation and more significantly, reduce risks to the environment –both in production and service industries.	http://www.sdcpc.boun.edu.tr/
Middle East Technical University (METU) İstanbul Technical University (ITU)	METU and ITU has activities that support cleaner production implementation via education, Research and Development, capacity building and consulting. The topics include: • Cleaner and Sustainable Production • Industrial Symbiosis • Environmental Performance Assessment • Waste Valorization • Recycling and Reuses	Environmental Engineering Department

CONCLUSION

The increase in costs of raw materials, energy, and water and pollution fees in Turkey and around the world is a reality for the textile industry. Water has significant economic importance as a natural resource in production processes as it is the core element of many business activities. On the other hand, water-related risks to business are becoming increasingly urgent. In the recent World Economic Forum Global Risks 2018 report, water-related issues are listed among one of the top five global risks to business.

Turkey is not a water-rich country. It is in the category of "country facing water shortage problems" with the 1.519 m^3 of water per capita. Turkey Statistical Institute (TUIK) foresees that Turkey's population will be 100 million by 2030. In this case, the amount of water per person is expected to be 1,120 m^3 / year. In other words, with its increasing population and growing economy and cities, Turkey is on the way to become a "water-poor" country.

Water quality has become a major issue to tackle, especially in the industrialized basins in Turkey such as the Ergene and Büyük Menderes basins. In addition, it is projected that climate change and development plans in these basins will decrease seasonal water availability in the near future.

The textile sector is particularly vulnerable to water risks as it uses high amount of water in dyeing and finishing processes. Water consumption may lead to competition for water resources considering the anticipated future increase in demand. In addition, resource efficiency in the supply chain is now one of the priority issues for many international buyers. Considering all of this, there is a need to develop sector-wide strategies for water sustainability in textile sector in Turkey.

There are also opportunities connected to water management, such as in the case of cleaner production implementations. Cleaner production is an innovative instrument in addressing water risks related to the water supply and costs of effluent disposal. It decreases the costs of production, thus supporting the increase in competitiveness and providing opportunities to access global markets.

This Guideline that is prepared with support from the WWF-H&M partnership on Water Stewardship and Cleaner Production, during 2017-2018 aims to assist the implementation of cleaner production in the textile sector. It has drawn upon lessons learned in cleaner production awareness-raising and implementation programs in Turkey and from around the world. This Guideline highlights actions that have been taken by specific textile companies to reduce water, effluent and chemical costs and the results of savings. Although these will not be applicable to all situations, the management approach outlined in this guide can be used by any organization, regardless of its size, process or location.

We are hoping this guideline will contribute to a sustainable textile sector in Turkey as well as to good water- and resource governance for the future of our river basins, the ecosystems, people and industry.

Annex
Checklist for Background Information

Type of Information	Available	Not available	Requires updating	Not applicable
Process Information				
Process flow diagram				
Material balance data				
Energy balance data				
Site plans				
Drainage diagrams				
Operating procedures				
Equipment list & specifications				
Regulatory Information				
Waste license(s)				
Trade waste aggrement(s)				
Environmental monitoring records				
Environmental auidit reports				
Raw Material/Production Information				
Material safety data sheets				
Product & raw material inventories				
Production schedules				
Product composition & batch sheets				
Accounting Information				
Waste handling, treatment & disposal costs				
Water & sewer costs				
Product, energy & raw material costs				
Operating & maintanence cost				
Insurance costs				
Benchmarking data				

References

Alkaya E. & Demirer G.N., 2014. *Sustainable Textile Production: A Case Study from a Woven Fabric Manufacturing Mill in Turkey*, Journal of Cleaner Production, Vol. 65, No. 4, p. 595-603.

BUTEKOM, 2014. *Tekstilde* Çevre. Bursa Tekstil & Konfeksiyon Ar-Ge Merkezi.

Cleaner Production Law of Peoples Republic of China. November, 2 2017 from http://www.npc.gov.cn/englishnpc/Special/CombatingClimateChange/2009-08/25/content_1515203.htm

Çevre ve Şehircilik Bakanlığı, 2012. *Tekstil Sanayi* İçin *MET* Kılavuzu, *Eşleştirme Projesi, IPPC – Entegre Kirlilik* Önleme *ve Kontrol*, Editors: J. Gontek, I. Montes, A. Nadolski, K. Wojcik, C. Seoánez, A.E. Öztürk, K. Yılmaz, I. Aktaş, M. Demir, E. Tok, Ş. Savaş, Ö. Gülay, Ö. Gürpınar, P. Başarısoy.

Demirer G.N., 2015. *Temiz* Üretim *Uygulamaları, 2023'e Doğru Atık Yönetimi Sempozyumu*, Türkiye Çevre Koruma Vakfı, January 25-29, 2015, Antalya.

Demirer G. N., 2003. *Kirlilik* Önleme *Yaklaşımlarının Temel Prensipleri*, Çevre ve Mühendis- TMMOB, No. 25, p. 13-20.

Demirer G.N. & Mirata M., 1999. *Endüstriyel Kirlilik* Önleme *ya da Temiz* Üretim-*I, Endüstri & Otomasyon*, No: 31, October, p. 110-113.

Halkbank, 2010. *Halkbank Kurumsal Sosyal Sorumluluk Projesi – Tekstil ve Hazır Giyim Sektör Raporu*, RİSK Mühendislik Eğitim Danışmanlık Hizmetleri Sanayi ve Ticaret A.Ş., December..

Nilsson L., Persson P.O., Rydén L., Darozhka S., Zaliauskiene A., 2007. *Cleaner Production – Technologies and Tools for Resource Efficient Production*, Baltic University Press.

Öztürk, E., Yetiş, Ü., Dilek, F. B. & Demirer, G. N., 2009. A *Chemical Substitution Study for a Wet Processing Textile Mill in Turkey*, Journal of Cleaner Production, 17, 2, p. 239-247.

PaCT Manual (Unpublished)/IFC.

Regional Activity Centre for Cleaner Production (CP/RAC), 2008a. *GRECO Med Cleaner Report Overview*. No. 10.

Regional Activity Centre for Cleaner Production (CP/RAC), 2008b. *GRECO Med Cleaner Report Overview*. No. 20.

REC Türkiye (Bölgesel Çevre Merkezi). *Sürdürülebilir* Üretim *ve Tüketim Yayınları – II*, Temiz Üretim.

Sanayi Genel Müdürlüğü, 2015. *Türkiye Tekstil, Hazırgiyim ve Deri* Ürünleri *Sektörleri Strateji Belgesi ve Eylem Planı*, BTSB, 2015-2018.

Toprak, T, Anis, P., 2017. *Textile industry's environmental effects and approaching cleaner production and sustainability, an overview*. Journal of

Textile Engineering & Fashion Technology 2(4):429□442

TTGV & İZKA, 2015. İzmir *Eko-verimlilik (Temiz* Üretim*) Programı*, Türkiye Teknoloji Geliştirme Vakfı (TTGV), İzmir Kalkınma Ajansı (İZKA).

United Nations Industrial Development Organization (UNIDO), 2011. Responsible Entrepreneurs Achievement Programme, Environmental Management Guide

United Nations Environment Programme (UNEP), 1996. *Guidance Materials for the UNIDO/UNEP National Cleaner Production Centres*. UNEP Industry and Environment, Paris.

WWF, 2015. *From Risk to Resilience: Does Your Business Know Water Risk?* Report

WWF-Türkiye, 2014. Türkiye'nin Su Riskleri Raporu.

http://www.ekoverimlilik.org/wp-content/uploads/yayinlar/MDGF_Bulten/MDG-F_Temmuz-Agustos_2010_Bulten.pdf. Retrieved February 4, 2018.

http://www.ekoverimlilik.org.

http://www.ttgv.org.tr/tr/projeler/izmir-de-eko-verimlilik-temiz-uretim-uygulamalarinin-yayginlastirilmasi-projesi.

http://users.metu.edu.tr/goksel/resource-efficiency/pdf/291.pdf.

https://tr.linkedin.com/pulse/uygulamal%C4%B1-kaynak-verimlili%C4%9Fi-e%C4%9Fitimi-istanbulda-g%C3%B6ksel-demirer.

http://anahtar.sanayi.gov.tr/tr/news/turkiyede-temiz-uretim-eko-verimlilik-alaninda-mevcut-durum/111.

http://ctue.mam.tubitak.gov.tr/tr/haber/temiz-uretim-egitimi-duzenlendi.

http://www.oka.org.tr/haber-detay.aspx?Id=1648.

http://www.gtecarbon.com/turkiye-icin-yesil-osb-cercevesinin-gelistirilmesi-projesi-teknik-olanaklar-ve-mevzuatfinansman-mekanizmalari-calistayi-ankarada-gerceklestirildi.

http://users.metu.edu.tr/goksel/resource-efficiency/pdf/269.pdf.

http://www.gtecarbon.com/buyuk-menderes-havzasinda-temiz-uretime-gecis-bilgilendirme-toplantisi-gerceklestirildi.

http://users.metu.edu.tr/goksel/resource-efficiency/pdf/292.pdf.

http://www.turkchemonline.com/Haber/Kurumsal-Surdurulebilirlik-ve-Cevresel Performans. html. Retrieved November 2, 2017.

http://www.ekoverimlilik.org/?page_id=569.Retrieved November 3, 2017.

http://www.ttgv.org.tr/content/docs/izmir-eko-verimlilik-stratejisi.pdf. Retrieved November 3, 2017.

http://www.resmigazete.gov.tr/eskiler/2015/03/20150310-5.htm. Retrieved November 2, 2017.

http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52008DC0397:EN:NOT. Retrieved November 2, 2017.

http://www.ekoverimlilik.org/?page_id=569. Retrieved November 2, 2017.

http://www.temizuretim.gov.tr/Files/TEM%C4%B0Z%20%C3%9CRET%C4%B0M%20MEVZUAT%20ENVANTER%C4%B0%20RAPORU.pdf. Retrieved November 2, 2017.

http://www.targetprj.org/wpcontent/uploads/2016/02/Temiz_%C3%9Cretim_ve_G%C4%B1da_Sanayi_EVREN_BAKAN.pdf. Retrieved November 2, 2017.

http://www.ekoverimlilik.org/?page_id=569.Retrieved November 3, 2017.

http://www.ttgv.org.tr/content/docs/izmir-eko-verimlilik-stratejisi.pdf. Retrieved November 3, 2017.

http://www.temizuretim.gov.tr/tesviklerdestekler.aspx. Retrieved November 3, 2017.

http://anahtar.sanayi.gov.tr/tr/news/turkiyede-temiz-uretim-eko-verimlilik-alaninda-mevcut-durum/111. Retrieved November 3, 2017.

http://www.cprac.org/en/media/medcleaner?page=13. Retrieved October 31, 2017.

http://www.cprac.org/en/media/medcleaner?page=14. Retrieved October 31, 2017.

http://infohouse.p2ric.org/ref/20/19041.pdf. Retrieved November 1, 2017.

http://www.instyle.com.au/environment/impact-of-materials.

Textile in Numbers

80%
Energy use in textile wet processing

85%
Water use in textile wet processing

19%
Textile constitutes 19% of the total energy expenditure in industry in Turkey

65%
Chemicals use in textile wet processing

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