

Istanbul Chamber of Industry Sectoral Committees in Global Competition, Sector Strategies Project

TURKISH HEAT TREATMENT INDUSTRY







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s Istanbul Chamber of Industry, we have been trying to support our country's search for sectoral strategy and policy by publishing comprehensive reports for different sectors for the purpose of increasing the competitiveness of our industry for more than 20 years. In our reports prepared with the contributions of our industry representatives, especially our members of the Sectoral Committees, we seek an answer to the question of how our country can better fulfill its potential in the light of the changing global conditions and market dynamics.

It is undoubtedly very important to catch the most up-to-date in order to answer such questions correctly. Sometimes, it is also important to re-address and renew what was written and said in the past in line with the needs of the present. As a matter of fact, in recent years, our world and our country have witnessed developments that almost no part of the industry can escape from adapting. Many changes, from digitalization to global climate change, from the COVID-19 pandemic to the multilateral world trade system, are turning the priorities of business life upside down.

The work in your hand now is the updated version of our Heat Treatment Industry sectoral report published in 2017. The heat treatment industry, which has made a significant progress in terms of both quality and production capacity with the breakthroughs it has made in the 2000s, provides vital intermediate goods to industries such as automotive, machinery and white goods, the leading industries in production and export of Türkiye.

With a world market of nearly \$100 billion in 2018, the industry projects a certain recovery in the coming years despite the lost momentum due to the negative developments in global trade and the pandemic in recent years. Our country, on the other hand, has the potential to become a strong alternative to Asian countries with its experience and knowledge in the industry in the process of accelerated restructuring in global supply chains after the pandemic.

At this point, we must emphasize that the sector needs a serious investment. The recently increased production costs have made it necessary to focus on technology, efficiency, and human capital. The trends in automation, digitalization, and transition to smart production systems, which are gaining momentum in the industry, will deeply affect both the heat processor companies and the industries they serve in terms of competitiveness.

Due to the high energy consumption and carbon emissions in the industry, compliance with new global sustainability standards is becoming increasingly urgent. In this direction, heat processors are faced with a radical transformation process in areas such as the use of renewable energy, updating the machinery and reorganizing the production processes.

Due to its forward-looking connections, the heat treatment industry sector needs to be considered together with the industry in general. Therefore, this report includes not only the figures and development dynamics of the sector itself, but also the projections regarding the sectors it serves. Similarly, expectations for market developments and the possible effects of the EU Green Deal on the industry are also analyzed. In the conclusion part, the main problems of the industry are discussed under fourteen headings, and its solution proposals and demands are listed.

We believe that this work will further increase the contribution of our sector to the competitiveness of our industry. For this valuable work, we would like to thank our consultant Dr. Can Fuat Gürlesel, to our members of the 45th Sectoral Committee for Metal Forming, Heat Treatment and Coating Industry and the Metal Heat Treaters' Society (MISAD) for their contribution to the report with their feedback, and to the employees of our Chamber's Economic Research and Corporate Finance Branch.

Erdal BAHÇIVAN

Istanbul Chamber of Industry Chairman of the Board of Directors

EXECUTIVE SUMMARY

HEAT TREATMENT INDUSTRY

The Heat Treatment Industry falls within the scope of and is defined under Division 25 of NACE Rev. 2 industry classifications, "Manufacture of Fabricated Metal Products". Heat treatment is defined as the set of treatments applied specifically to metallic materials to improve their mechanic properties such as rigidity and durability following certain temperature change methods, thereby increasing the material's value. In technical terms, heat treatment is carried out to improve all properties of the material, including rigidity, toughness, durability, corrosion and wear resistance, etc. Heat treatment is also defined as controlled heating and cooling processes to give the required properties to solid metals or alloys. Heat treatment is carried out in vacuum, controlled atmosphere furnaces, induction/flame surfacehardening machines, fluidized beds and salt baths. Considering the industries that need and receive its services, heat treatment is of strategic importance to the economy. The competitiveness of other industries directly depends on an advanced heat treatment industry. Development of the heat treatment industry paves the way for technologyintensive industries. A well-developed heat treatment industry is necessary for the development of machinery, automotive, defense, aviation-space, base metal, and metal goods industries, all of which vital for economy and industrialization. Heat treatment multiplies the value-added of these industries. Metal pieces that have not undergone heat treatment are not used in the products or manufacturing processes of these industries. Heat treatment industry is the steppingstone for other industries to achieve international standards in their products. A well-developed heat treatment

industry also generates considerable foreign exchange revenue.

Heat treatment industry is related to all industries that use heat-treated metal as input. Industries with the highest level of heat treatment processes, hence closest to heat treatment industry, are as follows: automotive and automotive supply, rail systems, defense, aerospace, machinery, medical devices, base metals, metal goods, energy, and construction materials. Heat treatment is used in practically every area of the abovementioned industries.

There are two types of heat treatment operations. The first is commercial heat treatment carried out by companies operating in the heat treatment industry. The second is inhouse captive heat treatment carried out in other industries that require heat treatment in their business and utilize heat treatment within their capacity in their manufacturing processes. A certain number of these businesses, although having established heat-treatment facilities to meet their own needs, are able to provide commercial heat treatment services to other companies as well.

GLOBAL HEAT TREATMENT INDUSTRY

In industrialized countries, many metal, composites and ceramics used in industries such as automotive, aerospace, defense, machinery, construction and infrastructure materials, major appliances and consumer electronics undergo heat treatment. The input of these industries is exclusively heat-treated. Therefore, the existence, development and competitiveness of other industries depend on the presence of the heat treatment industry. Heat treatment industry is a capital-intensive industry. It uses industrial and large-scale furnaces and equipment. The heat treatment industry is also an energy-intensive industry with high operating costs. As a result, heat treatment industry is a deciding factor in the cost effectiveness and competitive strength of many other industries.

The USA, Germany, Japan, South Korea, China, India, the Central European Countries, Canada, Mexico, and Russia are the leading countries in the heat treatment industry. In 2016, the global heat treatment market size was USD 90.7 billion. Market growth continued in 2017 and 2018. In 2018, the market reached its historically largest turnover with USD 98.8 billion. In 2019, however, the market shrunk by 2.7 percent to USD 96.1 billion. In 2020, the pandemic had a drastic impact on the market. The market shrunk 12.0 percent in 2020, down to USD 84.5 billion.

The shares of industries utilizing heat treatment industry output in 2020 were as follows; Automotive dropped to

98.8 USD Billion

In 2018, the market reached its historically largest turnover with USD 98.8 billion.

30 percent. Machinery climbed from 15 to 16 percent. Infrastructure and construction materials rose to 14 percent. Fasteners and hand tools and aerospace and defense industries remained the same. Metal goods industry declined 1 percent. Rail systems increased 1 percent.

Asia continues to increase its share in the global heat treatment market. In 2020, the share of Asia in global heat treatment market climbed to 42 percent. Europe's share dropped to 30 percent. North America's share fell to 23 percent. The market shrinkage in 2020 brought about by the pandemic is the reason behind the loss of Europe and North America's market shares. Meanwhile, Central and South America and Middle East and Africa maintained their market share.

Regarding the heat treatment furnace market, the growth in the heat treatment market in 2017 and 2018 brought more furnace investments, increasing the heat treatment market size to USD 11.2 billion in 2018. Heat treatment furnace investments stagnated once again in 2019 and stood at USD 11.35 billion. In 2020, as a result of the pandemic, the market shrank by 6.0 to USD 10.67 billion.

Heat treatment furnace control systems have changed dramatically over the years. Heat treatment processes and furnaces and manufacturing process flows are integrated to increase efficiency. In the near future, automatic and continuous integration with fully intelligent furnaces and equipment will enable errors and interruptions to be reported ahead of time. Due to global warming trends and high carbon emissions generated by heat treatment furnaces, there is a rapid change in the design and technology of the furnaces as well as investment decisions involving this machinery. The goal is to reduce heat treatment process temperatures, eliminate heat losses and reduce the duration of the heat treatment process. Different phases of the treatment are combined to shorten and simplify heat treatment. The COVID-19 pandemic has brought about new conditions in economic activity. These are expected to influence the heat treatment industry, same with every other industry.

The main reason for the restructuring of global supply chains is to reduce the dependence on Asia. This trend is expected to lead to new heat treatment production hubs and capacities in regions outside of Asia. Compliance with climate change and sustainability rules is set to affect the metal industry more so than others. Regulations call for the reduction of emissions, higher energy efficiency, and use of renewable energy. The heat treatment industry is set to make investments in modernization to comply with this transformation. Automation and smart systems will be integrated into production and other business processes in general. Furthermore, there will be stronger connections between commercial heat treatment industry players and their customers. Automation and smart systems are projected to enhance productivity. Heat treatment industry companies will move all their business processes to the digital platforms in line with the trend of digitization. Investments will be made in digital infrastructure. Digitization will also increase the need for competent human resources.

EU's carbon border adjustment mechanism, which will commence in 2023, will also play a significant role. In its transitional phase, the carbon border adjustment mechanism applies to iron-steel industry and aluminum industry, which account for the majority of the heat treatment industry's turnover. Producers and exporters of heat-treated products will favor heat treatment industry companies with emissions within EU's reference values in order to eliminate or reduce their carbon tax liability.

Global heat treatment industry turnover is expected to grow by 1.5 percent in 2021. One of the key reasons behind this limited growth is the slow recovery in automotive and aviation. The projected turnover growth for 2022 is 2 percent. The growth is expected to reach 3 percent in 2023, 2024 and 2025. In line with these forecasts, the global heat treatment industry turnover is expected to reach USD 96 billion in 2025, up from USD 84.5 billion in 2020. The projected five-year average growth is 2.5 percent.

The heat treatment industry will have to increase efficiency by becoming leaner, faster, and more productive in the face of increasing costs. The heat treatment industry is transitioning from a bulk processing model to an individual processing model. As component sizes decrease with the developments



in material technologies, each individual component has to go heat treatment separately. As a result, orders are expected to be smaller, but more diverse. Special alloys and composite materials will acquire a larger share in heat treatment. Small and medium-sized companies in the heat treatment industry will begin to specialize due to the diversification in tasks, materials, and processes. These companies will focus on tailored work. Larger scale companies will continue to transform into integrated firms in line with the trend of specialization.

Technology and innovation partnerships will intensify between furnace manufacturers and heat treatment companies, and heat treatment companies and their customers. Qualifications for heat treatment industry workforce will change, along with a growing demand for qualified human resources. Vacuum technology and lowertemperature processes are becoming increasingly prominent in the heat treatment industry equipment. Vacuum furnaces with greater capacity and function are standing out from other alternatives.

Temperatures used in industrial heat treatment are expected to go down even further. Likewise, heat treatment durations will be shorter. This makes nanotechnology and thermo/ chemical surface treatment, precision technologies and MIM processes much more important in heat treatment operations. Heat treatment furnaces are being modernized in terms of energy usage. Energy sources such as microwave, laser and infrared are being evaluated as alternatives to enhance energy efficiency and reduce energy consumption. Heat treatment companies are expected to focus on aftersales services, build their metallurgy, engineering, and technical expertise, develop practical skills and train their existing workforce to enhance their competitiveness.

TURKISH HEAT TREATMENT INDUSTRY

The main customers of Turkish heat treatment industry are automotive, machinery, metal goods, fasteners, building materials, and major appliances. Businesses in the aforementioned industries either procure the services of commercial heat treatment companies or carry out their inhouse heat treatment operations.

The total size of the heat treatment market is calculated and presented as the sum of the works performed by the companies that provide heat treatment services or carry out such operations in-house. Total market size is an indicator of the volume of heat treatment of manufactured products. In 2015, Turkish heat treatment industry's market size was calculated as TRY 3.05 billion, or USD 1.12 billion. Heat treatment industry's production volume fluctuated upward The production technology utilized in the heat treatment industry in Türkiye has developed over the years, with the most advanced technologies being readily available today.

in following years before shrinking 3 percent in 2020 due to the pandemic. Between 2015 and 2020, total production grew 25 percent. Likewise, heat treatment industry manufacturer prices showed a fluctuating upwards trend over the years. Between 2015 and 2020, manufacturer prices in the heat treatment industry climbed 126.8 percent. Based on these data, the nominal size of the heat treatment industry can be seen to have grown from TRY 3.05 billion in 2015 to TRY 8.63 billion in 2020. In nominal terms, the market grew 183 percent between 2015 and 2020. Market size rose from USD 1.12 billion in 2015 to USD 1.34 billion in 2018. However, due to the slowdown and subsequent decline in production in 2019 and 2020, combined with the depreciation in Turkish lira, reduced total market size in USD terms. In 2020, total market size was USD 1.225 billion.

The number of enterprises operating in the commercial heat treatment industry in Türkiye increased to 220 in 2020, up from approximately 200 in 2015. And close to 70 percent of these are medium-sized high-tech enterprises. The production capacity of commercial heat treatment industry enterprises climbed to 325,000 tons in 2020, cf. 280,000 tons in 2015. While its share in the total heat treatment industry production capacity had been 19.6 percent, it dropped to 18.8 percent in 2020. Compared to the 4,000 people employed in the commercial heat treatment industry in 2015, it is estimated that this number was around 5,000 in 2020.

The turnover size of the commercial heat treatment industry

was USD 225 million in 2020, up from USD 220 million in 2015. Its share in the total heat treatment industry decreased to 18.4 percent.

The production technology utilized in the heat treatment industry in Türkiye has developed over the years, with the most advanced technologies being readily available today. Commercial enterprises in the heat treatment industry are completing their maturation period. These enterprises are generally small and medium-sized and now meet international standards, especially those of technology and quality. Commercial heat treatment industry enterprises work more efficiently with higher capacity utilization rates. They are always engaged in efforts to boost improvement and efficiency with a view to bearing the high investment and operating costs. Another advantage the commercial heat treatment enterprises have is that they constantly keep themselves up-to-date in line with the new production technology trends.

Moreover, prestigious local and foreign enterprises in many industrial branches in Türkiye have in-house heat treatment capacity. There are many reasons for enterprises to integrate heat treating into their own production processes. The key reasons may be listed as speeding up the process, eliminating bottlenecks, achieving sustainability in quality, meeting the standards, and scalability and cost advantages. Enterprises utilize in-house heat treatment on critical parts, parts that are important for safety and durability, and precision work. Although the commercial heat treatment industry employs an increasing number of qualified engineers and technical personnel, it continues to be a labor-intensive industry. The commercial heat treatment industry is not only capitaland labor intensive but also an energy-intensive industry. The main input of the heat treatment industry is energy. Energy accounts for a sizable portion of production costs. The commercial heat treatment industry has a high level of environmental impact, accordingly, requiring a high level of environmental sensitivity. The industry's environmental impact may be categorized under the headings of water and energy consumption, use of chemicals and waste output. It is for this reason that the heat treatment industry is positioned to be subject to the regulations set forth by the EU Green Deal. The heat treatment industry also makes significant indirect contributions to exports with its direct activities which may be considered as exports.

The share of the commercial heat treatment cost in the total production cost of a heat-treated product still sits somewhere between 1 and 2 percent. In international operations, this rate is 3-5 percent. The reason behind the relatively low level for this share in Türkiye is the low price point of commercial heat treatments. Price competition within the commercial heat treatment industry also contributes to this trend. While the automotive industry had accounted for 60 percent of commercial heat treatments in Türkiye in 2015, it is estimated that this rate decreased to 55 percent in 2020. It is estimated that the share of the machinery industry increased from 10 percent to 11 percent, the share of fasteners from 7 percent to 9 percent, and the share of the metal goods industry from 3 percent to 4 percent. The share of the infrastructure and construction materials industry was 5 percent, the white goods industry 5 percent, the rail systems 2 percent and the shares of the aviation, space and defense industries 1 percent each.

The commercial heat treatment industry owes its strength to the advanced manufacturing technologies used, efforts to follow and adopt the developments in manufacturing technologies, the cumulative sectoral know-how, and the logistics infrastructure deployed for domestic and international purposes.

The major weakness of the commercial heat treatment industry is small scale operations. The industry has not yet achieved the scale that will enable optimum efficiency. The lack of skilled labor persists at all levels. Another weakness is price competition, which causes prices to drop or remain stagnant. Costs are high. Profit margins and profitability remain low.

With the changes in global supply chains, it is predicted that industries will be less dependent on Asia. This trend has already triggered a rise in demand for the capacity in Türkiye. The heat treatment industry will also be positively affected by this increase in demand. Similarly, the practice of nearshoring has also gained prominence. Türkiye offers a pivotal opportunity for buyers in its nearby markets. The heat treatment industry will also benefit from this trend. The continuation of the trend of utilizing in-house heat treatment capacity remains to be the most pressing threat to the commercial heat treatment industry. Many enterprises that outsource from commercial heat treatment enterprises still tend to switch to their in-house capacities when manufacturing needs reach a certain scale. While enterprises investing in their in-house operations qualify for incentives, commercial heat treatment industry enterprises cannot benefit from investment incentives.

While the automotive industry will support the heat treatment volume in the coming period, albeit to a limited extent, it will lead to an increased need for technology, material and process changes. The share of the automotive industry in the heat treatment market will have also recorded a limited decline by 2025. The machinery industry



will become the most important sector in terms of the additional demand it is expected to create. In this context, it is estimated that the share of the machinery industry in the heat treatment market will rise to 14 percent in 2025. The demand from the fasteners and hand tools industry for the heat treatment industry will be above the average. It is predicted that the share of the fasteners and hand tools industry in the heat treatment market will increase to 10 percent. The contribution of the infrastructure and building materials industry to the business volume of the heat treatment industry will be limited. Accordingly, it is estimated that the share of the infrastructure and building materials industry in the total business volume of the heat treatment industry will drop to 4 percent. The white goods industry will make a high-level contribution to the business volume of the heat treatment industry. Accordingly, it is estimated that the share of the white goods industry in the total business volume of the heat treatment industry will climb to 6 percent. The contribution of the metal goods industry to the business volume of the heat treatment industry will be similar to the averages in previous periods. Accordingly, it is estimated that the share of the metal goods industry in the total business volume of the heat treatment industry will remain the same as 3 percent. The aviation, space and defense industry will make a high-level contribution to the business volume of the heat treatment industry. Accordingly, it is estimated that its share in the total business volume of the heat treatment industry will rise to 3 percent. The rail systems industry will make a high-level contribution to the business volume of the heat treatment industry. Accordingly, it is estimated that its share in the total business volume of the heat treatment industry will rise to 3 percent.

In the heat treatment market, business volume forecasts are made for each year, concluding with the expectation for cumulative growth between the years 2015 and 2021. With the first three quarters of 2021 behind, the increase in production/business volume has started to take shape in real terms. 2021 sees surges in business volume. In 2022, business volume growth will slow down due to the base effect. In 2023, on the other hand, the business volume growth is expected to slow down due to the uncertainty created by the elections to be held. For 2024 and 2025, it is predicted that the business volume of the heat treatment industry will achieve a grow rate close to average. Based on this forecast, the total production or business volume of the heat treatment industry will grow by 30 percent between 2021 and 2015, and the production/ business volume of the commercial heat treatment industry will grow by 27 percent.

The total heat treatment market sees rapid expansion especially in 2021. However, in 2021, the Turkish lira will once again depreciate significantly, which will have a negative impact on market size in dollar terms. A slowdown is expected for the rising growth trend of the market after 2021. The size of the market, which stood at USD 1.225 billion in 2020, is predicted to grow by 33 percent until 2025 and reach USD 1.63 billion in 2025. The commercial heat treatment market will also follow a similar growth path for the years in question. The size of the market, which stood at USD 225 million in 2020, is predicted to grow by 30 percent until 2025 and reach USD 295 million in 2025.

RECOMMENDATIONS FOR THE HEAT TREATMENT INDUSTRY

Recommendations for the development of the heat treatment industry are as follows: The heat treatment industry should be considered an independent industrial branch. The classification of the heat treatment industry should be changed from "very dangerous" to "dangerous". The 7.5-hour limit on the industry's maximum working hours per day should be abolished. Environmental regulations governing the sector should be free of uncertainties. Sustainability investments should be supported. The SCT on oils used should be abolished. Enterprises in the industry should be enabled to utilize Eximbank loans. The heat treatment industry should be considered and promoted as a hightech industry. Adequate monitoring should be ensured for imports. Common minimum quality and business standards should be established within the industry. Investments for compliance with the EU Green Deal should be encouraged when necessary. Enterprises operating in the commercial heat treatment industry should have access to investment incentives. Cooperation models should be developed to provide a boost for the business volume of the commercial heat treatment industry. Energy costs should be dropped to reasonable levels by reducing taxes on the prices of electricity, renewable energy and natural gas used in industrial facilities.





HEAT TREATMENT INDUSTRY

Definition, scope, function of the heat treatment industry and its strategic importance for the economy are provided in the first part of the report. For this purpose, first, the place and definition of the heat treatment industry within the NACE industrial classification is given. Then, the functions, activities, production processes, strategic importance of the heat treatment industry and collaborated sectors are described.

1.1. Definition and Scope of the Heat Treatment Industry (with NACE Classification)

First, definition and scope of the heat treatment industry, an industrial branch constituting subject matter of this Report, are provided. The definition and scope provided in this part depend on NACE.2 industry codes.

"Metal Processing, Forming, Heat Treatment and Coating Industry" is provided under Title No. 25 Fabricated Metal Items Production in NACE.2 industry codes. Heat Treatment Industry is also addressed and defined under this headline.

25 Fabricated Metal Items Production

Fabricated metal items production usually involves manufacturing of "pure" metal products that are usually static and have a fixed function (parts, containers (barrel, casks, etc.), fittings or assembly pieces that are aimed at converting these products with moving parts that are not fully electrical, electronic, or optical into sophisticated units (sometimes with other metals).

Fabricated metal items production involves the following manufacturing processes; Heat treatment activities are provided under the headline 25.6.

25.1 Metal building materials production

25.11 Metal structure and structural elements production 25.12 Metal door and window production

25.2 Metal tank, reservoir and container production

25.21 Central heating radiators and hot water boilers production

25.29 Other metal tank, reservoir and container production 25.3 Steam generator production except for central heating hot water boilers

25.4 Weapon and ammunition production

25.5 Forging, pressing, punching, rolling of the metals; powder metallurgy

25.6 Metal processing and coating; machining 25.61 Metal processing and coating

25.62 Machine processing and forming of metals

25.7 Production of cutlery and other cutting tools and hand tools as well as general hardware
25.71 Cutlery set and other cutting tool production
25.72 Lock and hinge production
25.73 Hand tools, cutting tool tips, saw, etc. production
25.9 Production of other fabricated metal products
25.91 Production of steel barrels and similar containers
25.92 Production of light metal packaging materials
25.93 Production of wire products, chains and springs
25.94 Production of fittings and screw machine products
25.99 Production of other fabricated metal products that are not classified elsewhere

Heat Treatment Industry is classified under "25.6 Metal Processing and Coating, Machining" and it is grouped and described as provided below.

25.6 Metal processing and coating; machining

This group consists of general activities such as coating with minerals, priming, drilling, etching, polishing, welding that are carried out for processing metals based on an agreement or against fees.

25.61 Metal processing and coating

This category consists of:

- Coating, anodizing metals, etc.,
- Heat treatment of metals,
- Deburring, sandblasting, polishing through grinding, cleaning,
- Painting, etching metals,
- Coating metals with non-metal materials; + plastic

coating, enamel coating, varnishing, etc.

- Tempering metals, honing with soft things.
- 25.61.11 Metallic coating of metals
- 25.61.12 Non-metallic coating of metals services

25.61.21 Heat treatment processes for metals (except for metallic coating)

25.61.22 Other surface processing services for metals



25.62 Machine processing and forming of metals

This category consists of:

• Punching, grinding, milling, shaving, polishing, grooving, fixing, sawing, honing, sharpening, welding, connecting of metal parts, etc.,

• Laser cutting or engraving of metals.

25.62.01 Punching, grinding, milling, shaving, polishing, grooving, fixing, sawing, honing, sharpening, welding, connecting of metal parts, etc., 25.62.02 Laser cutting or engraving of metals

Heat treatment processes are classified in group 25 in NACE classification. In addition, companies operating in other industrial branches also have heat treatment capacity and operations. Companies in sectors such as base metal industry, defense industry, machinery industry, automotive industry carry out internal heat treatment processes. Heat treatment capacity of these sectors can be greater than the commercial heat treatment capacities of commercial heat treatment companies classified under group 25.

1.2. Heat Treatment Industry and Activities

1.2.1. Definition of Heat Treatment

Heat treatment is defined as the set of treatments applied to specifically metallic materials to improve their mechanic properties such as rigidity (hardness) and durability following certain temperature change methods, thereby increasing the material's value.

In technical terms, heat treatment is carried out to improve all properties of the material, including rigidity (hardness), toughness, durability, corrosion and wear resistance, etc. Heat treatment is also defined as controlled heating and cooling processes to build necessary properties into solid metals or alloys.

Heat treatment is carried out in vacuum, controlled atmosphere furnaces, induction/flame surface-hardening machines, fluidized beds and salt baths.

1.2.2. Heat Treatment Activities

Heat treatment is a process that is applied to the inputs required and used by almost every sector. However, the heat treatment is carried out for two main purposes in terms of application areas; the first purpose according to the area of use is forming. The second purpose is to add proper mechanical properties to the work piece. Heat treatments are mostly applied to metals. Metals such as iron, steel, stainless steel, structural steels, aluminum and copper are the most frequently used metals for the heat treatment. Approximately 80 percent of the heat treatment processes are applied on steel products.

1.2.2.1. Heat Treatment Processes for Product Forming

Heat treatment to shape the product involves normalizing (air cooling and tempering) processes which remove the residual stress from the previous processes (e.g., cold forming) and / or metallurgical improvement and soften the material.

Annealing Process: It is the process that involves heating the metals to the temperature below the solidification curve, keeping them at that temperature and cooling back. In other words, the material is always solid. Annealing processes:

a. Soft annealing: It is mostly applied for reducing the hardness of steel, improving the machining properties, or reducing the internal stresses of cast and forged parts.
b. Coarse-grain annealing: It is mostly applied for improving the machining properties of low-chrome metals/ steels.
c. Diffusion annealing: It is applied for the homogeneous diffusion of soluble components in the internal structure.
d. Normalization: It is applied for reducing the grain size, obtaining a homogeneous structure, improving mechanical properties, and scatting the carbide network that is in the grain boundary in metals/ steels above the eutectic point. After the normalization process, the forged, rolled, coarse structures are corrected and the material can be restored to properties that can be gained any time (such as pulling strength, ductility).

e. Stress relief annealing: It is applied to cast, forged, welded parts and cold formed materials. It is aimed at reducing the internal stresses of the material that are created during production.

f. Recrystallization: It is applied for the purpose of restoring the crystal structure of the forged and rolled materials to preprocessing conditions.

1.2.2.2. Heat Treatment Processes Adding Appropriate Properties to Metal Parts

Heat treatment processes aimed at adding appropriate properties to metal parts are carried out to achieve the desired properties with metal parts under working conditions when the heat treatment is completed or nearly completed. The heat treatment processes applied in accordance with the purpose of use vary depending on technical methods.

a. Hardening: This process is applied for the purpose of improving mechanical properties, increasing the hardness, and improving the wearing resistance.

b. Tempering (Annealing): This process is applied for eliminating high stresses and brittleness and adding a solid structure to the material.

c. Martempering: This is the intermittent tempering process that is performed slightly above the martensite formation point for the purpose of reducing the cracking and dimension change risks that may arise during hardening (quenching).
d. Austempering: This is the intermittent tempering process that is performed above the martensite formation point for the purpose of obtaining bainitic phase in the micro-structure

to increase ductility. **e. Surface hardening:** This is the process of hardening a certain zone or layer from the surface to the core that is applied when solid structure is needed against impacts and a solid hard surface against wearing of components. For this purpose, many different processes are applied. These processes are classified in two main groups:

e.1. Thermochemical process: It is applied to almost all steel groups particularly including low carbon steels. Steel gains a different chemical composition and microstructure in the surface when nitrogen, carbon and/or boron is sent at a temperature of 500-1000oC as interstitial atom. Details of these processes are provided below:

e.1.1. Carburizing (cementation): It is based on the principle of introducing carbon as interstitial atom. A hard surface resistant to wearing and a solid core are obtained after the process. The process is performed at 800-1050oC.

e.1.2. Carbonitriding: It is performed by introducing nitrogen with carbon as primary interstitial atom. The process is performed at 800-900oC.

e.1.3. Nitriding and nitrocarburizing: It is performed by introducing carbon (nitrocarburizing) with nitrogen (nitriding) as primary interstitial atom. The process is performed at 400-610oC.

e.1.4. Boronizing: It is based on the principle of introducing boron as interstitial atom. The process is performed at 850-1000oC.

e.2. Thermal processes: The hardening is obtained by changing only the microstructure without changing chemical composition of the material during the heat treatment process. It is applied to steel materials with at least 0.35% C.
e.2.1. Surface hardening with induction: Metallic material is placed in the middle or against an electrical magnetic field and it is heated at 800-900oC upon which it is cooled gradually.

e.2.2. Surface hardening with flame: Metallic material is heated to 800-900oC with flame and subsequently it is cooled suddenly or gradually.

e.2.3. Surface hardening with laser: Metallic material is heated to 900-1400oC with laser and subsequently it is cooled suddenly or gradually.

There are limits for the application of heat treatment processes in the heat treatment industry:

a. In general, heat treatment is the last process applied for eliminating the stress of the carbon or low alloy parts. Therefore, mechanical properties of the treated materials should not be affected adversely.

b. Stress relief treatments between cutting processes can be applied to pre-treated materials. Stress relief effect is applied in slightly reduced mode in order to prevent loss of mechanical properties.

c. Many austenite stainless steel materials require rapid cooling after stress relief or solution treatment at high temperature. In these cases, slight bending or permanent stresses are unavoidable. Dimensions of the part that requires stress relief, treatment or normalization depend on the specifications and capacities of heat treatment machines. Providing machine-equipment of suitable size is important for large parts.

Certain requirements may arise during heat treatment applications carried out in the heat treatment industry.

a. Many stress relief processes are applied under open atmosphere and there are also protective environments. In open atmosphere, alloys change color and an oxide layer is formed depending on the type of alloy and temperature. Therefore, cleaning is required after the process.
b. In general, normalization is applied to semi-finished steel parts under open atmosphere and oxide layer formation or decarburizing problem does not arise as they are subsequently cleaned through machining. In addition, sometimes, a protective environment may be required. For example, during normalization before partial surface hardening of parts with final dimensions.

c. Annealing processes can be applied under protective environments such as open atmosphere or salt, controlled gas atmosphere or vacuum. Some annealing processes may require selection of an environment that provides long-lasting protection.

d. There is always bending/buckling risk when high temperature processes are applied on delicate, thin-walled vessels and large, heavy parts. Special supports and tools are required during heat treatment in order to prevent this problem.



1.2.3. Strategic Importance of Heat Treatment Industry in the Economy and Sectoral Relations

1.2.3.1. Strategic Importance of Heat Treatment Industry in the Economy

Heat treatment industry has a strategic importance for the economy because of the sectors it provides heat treatment services.

1. Heat treatment processes are carried out on ferrous and nonferrous metals, composite materials and nano materials that are used by the other industrial sectors. without prior notice. Therefore, competitive power of the other sectors is directly dependent on the presence of an advanced heat treatment industry.

2. Activities of the heat treatment industry are usually provided for sectors using medium, high, and advanced technologies. High-tech sectors develop in parallel with the heat treatment industry.

3. An advanced heat treatment industry is essential for the development of industries such as machinery, automotive main industry, automotive sub-industry, defense, aerospace, base metal industry, metal items industry which are very important for countries and reflect industrialization. This increases the added value of these industries incrementally.

4. The heat treatment industry provides strength, long economic life, safety and quick forming properties to critical and vital metal inputs of many important sectors. Metal parts that were not heat treated are not used in the production and products of these sectors.

5. Sectors conduct a significant part of research and development, innovation and design work on heat- treated metals. Therefore, an advanced and innovative heat treatment industry also supports the technological developments in other sectors.

6. The heat treatment industry provides countries with significant advantages in global industrial competition. With the know-how and knowledge gained in the heat treatment industry, competitive power is achieved for many sectors of the industry.

7. Heat treatment industry is the steppingstone for other industries to achieve international standards in their products. For this reason, an advanced heat treatment industry also ensures achievement of international product standards.
8. The development of innovative materials, composite materials and innovative metals required for sustainability is possible with the advancements in the heat treatment industry.
9. Many industries gain competitive power and participate in global supply chains thanks to the advanced heat treatment industry.

10. A well-developed heat treatment industry also generates considerable foreign exchange revenue. Both exports and substitution of imports bring foreign currency revenues.11. In the new conditions that emerged after the pandemic, countries aim to consolidate critical production processes in

their countries, ensure supply security and reduce dependency on foreign procurement with domestic supply. In this context, the existence of domestic heat treatment industries gains even more importance.

12. In these new post-pandemic conditions, close supply has become important. In this respect, regionalizations and integrations within regions will increase. Presence of a heat treatment industry capacity in a quality and quantity that will meet the nearshoring needs will be important.

13. In the conditions of this new era, the use of rare metals is increasing due to technological advances, bringing a strategic competition in this field. Heat treatment applications for products produced from rare metals are also decisive in this competition.

14. The need for compliance and sustainability brings new regulations to the products of many sectors that undergo heat treatment, especially the iron and steel sector. The EU Green Deal is the pioneer of these regulations. In this context, the existence of a heat treatment industry compatible with sustainability becomes important.

15. The energy sector is undergoing a significant transformation with the transition from fossil fuels to renewable energy. In sectors with high energy intensity, energy efficiency also becomes more important. In this context, it is critical for the general industry to have a heat treatment industry that uses renewable energy sources and has high energy efficiency.

1.2.3.2. Relations of Heat Treatment Industry with Other Sectors

The heat treatment industry is in contact with all sectors using heat treated metal inputs. Industries with the highest level of heat treatment processes, hence closest to heat treatment industry, are as follows: Automotive and automotive supply industry, rail systems, defense industry, aviation and space industry, machine industry, medical device industry, base metal industry, metal goods industry, energy industry, white goods industry, consumer materials and construction materials industry. The following are the most relevant sectors and samples of heat-treated critical products.

Heat treatment is used for almost all aspects of life in the above-mentioned sectors

- For example: • Improving the electrical conductivity of wires,
- Resistance of submarines to high pressures,
- Increasing the strength of rails in railway tracks,
- Strength of implants used in human body in the healthcare sector,
- Improving the strength of domestic heating systems,
- Resistance of aircraft to atmospheric pressure,
- Stress relief in space shuttles,
- Increasing the number of shots with weapons and strength of the gun barrel,

• Increasing flexibility and durability in space roof systems in buildings.

Source: Prepared by the working team.

Table 1: Sectors Associated with Heat Treatment Industry

MAIN SECTORS	CRITICAL PRODUCT EXAMPLES
Automotive	Engine components Driveline, pistons, axle shafts Injector nozzles Main chassis All metallic components Brake systems Suspension and steering components Rims
Fittings	Bolts and nuts Washers and pins Screws, nails
Rail Systems	High speed train equipment and infrastructure Railway transmission lines, rails Light rail systems Bogie systems Wheel and brake systems
Defense Industry	Rocket and rocket systems Launch pads Armored vehicles Unmanned aerial vehicles components and parts Warplanes and helicopters Landing gear and engines Barrel and barrel bearing Armor Light and heavy weapons Submarine parts Warship parts
Aerospace Industry	Commercial and private aircraft parts Hydraulic systems and pipes Landing gear Jet engine parts and turbines Spacecraft and satellite systems Launch and control facilities, propulsion systems Helicopter engines/main gearboxes, main rotor
Machinery and Mold Industry	Tunnel excavators and breakers Molds used in glass, ceramics, plastic and metal industries Construction and construction machinery Mining machines, rock drills Lifting and transport vehicles (forklifts) Cranes Engines Machine tools
Ship Industry	Shaft and propellers Gear systems Crane systems



MAIN SECTORS	CRITICAL PRODUCT EXAMPLES
Sanitary Wares	Stent Implant materials, implant teeth Surgery equipment Other health equipment and supplies, surgical instruments Imaging systems components and parts
Energy sector	Nuclear power plant turbines and equipment Power transmission lines Power plant turbines and machinery, combustion chambers Grounding elements Lightning Rods Petro-chemical plant equipment Drilling and extraction pipes Field production equipment
Renewable energy	Renewable power plant turbines and equipment Vanes, valves, bearings, shafts Fuel cells Solar panels Gearboxes, gearboxes for wind turbines
Construction and Infrastructure Materials Industry	Industrial plant steel structures Steel building column beams Industrial grates Plumbing materials Roofing systems and elements Locks
Agriculture and Livestock Sector	Tractor components and parts Agricultural machinery, tools and components Irrigation apparatus Mill rolls Greenhouse constructions
Base Metal Industry	Drilling and Cutting Tools; bending cutting blades, turning and planer tool holders, metal saws, powder metallurgy products
Non-Ferrous Metal Manufacturers	Production of aluminum, copper and copper alloys (brass, bronze)
Iron and Steel Industry	Rolling products, casting and forging parts, round and flat product production
Textile and Footwear Sub-Industry	Sewing needles Bijouterie Shoe sole steel Nose camber and heel
Electrical Equipment and Electronics Industry	White goods components and parts Consumer electronics components and parts Household and kitchen appliance components and parts Small appliances and parts Heating utensils
Consumer Supplies	Watches ATV vehicles, garden equipment, cameras





Heat treatment line manufactured in our country

Coil annealing furnace

1.2.4. Companies Conducting Heat Treatment Processes

There are two types of heat treatment operations. The first is the commercial heat treatment carried out by companies in the heat treatment industry. The second is in-house captive heat treatment carried out in other industries that require heat treatment in their business and utilize heat treatment within their capacity in their manufacturing processes. A certain number of these companies mainly use heat treatment facilities for their own businesses while also providing heat treatment services to other companies.

1.2.4.1. Commercial Heat Treatment Companies

Commercial heat treatment companies form the basis of the heat treatment industry. The business line of these companies is heat treatment. However, commercial heat treatment processes make up about 15 to 20 percent of the total heat treatment performed.

Commercial heat treatment companies can accumulate know-how in this area, offer a wide range of services and use ever-evolving technology. Innovation and R&D activities are related only to heat treatment. They create and use specialized, experienced and qualified labor force. Current capacities are constantly full and therefore have higher business efficiency.

1.2.4.2. Industrial Companies Conducting Internal Heat Treatment Processes

On the other hand, companies that make heat treatment within their own structure mostly operate in the sectors that produce industrial products by producing or using metal inputs in the manufacturing industry. Heat treatment processes form a certain phase in the industrial production process. Mostly large-scale capacities are created. It is not the main business line of the company. Therefore, production technology is renewed less frequently, limited number of qualified staff is employed, the existing capacity is used in limited manner, capacity is mostly idle and therefore heat treatment labor force output is low. Despite all these factors, companies conducting internal heat treatment processes account for about 80-85% of total heat treatment market. Companies that conduct internal heat treatment processes are mainly located in sectors such as base metal industry, metal items industry, machinery industry, automotive industry, transportation industry, defense and aviation industry.



GLOBAL HEAT TREATMENT INDUSTRY

The second part of the report analyses and evaluates the Global heat treatment market. The importance of heat treatment industry, the requirement for industrialization, important countries, market size, related sectors and global trends and projections are given place.

2.1. Function and Nature of Heat Treatment Industry

Heat treatment industry is a branch of industry that has a vital and critical function in the manufacturing industry. However, heat treatment is an intermediary process, no final product is manufactured. Therefore, heat treatment is not considered as a process for end consumers and mostly, its importance is overlooked.

However, in industrialized countries, many metal, composite materials and ceramics containing materials used in industries such as automotive, aerospace, defense, machinery, construction and infrastructure materials, white appliances and consumer electronics are subjected to heat treatment. These industries do not use any input that is not heat treated. Therefore, the existence, development and competitiveness of other industries depend on the presence of the heat treatment industry.

Heat treatment industry is a capital-intensive industry. It uses industrial and large-scale furnaces and equipment. The heat treatment industry is also an energy-intensive industry, and the operating costs are high. Given all of these aspects, the heat treatment industry is also decisive in the costs and competitiveness of other industries.

Heat treatment is carried out as an internal process by companies from commercial heat treatment industry and other manufacturing industry branches.

2.2. Heat Treatment Industry as a Precondition of Industrialization

Industrialization is mainly based on the ownership of production and product technologies. Accordingly, heat treatment produces for and drives technological process in a number of medium and high-technology industries, primarily machine industry and automotive, as well as aviation and space, defense, white appliances, energy equipment, healthcare equipment, rail systems, shipbuilding, electrical appliances and electronics.

Heat treatment industry applies heat treatment to metal, composite and ceramic material inputs used by all abovementioned industries as well as others. This treatment is a vital contribution to the products of these industries. In other words, if the inputs are not heat treated, the end products of these industries become unusable. The heat treatment industry performs a vital and critical function for the development and industrialization of other industries. It is not possible to operate a car, fly a plane or use a machine with inputs that are 70 percent metal unless they heat treatment process is applied. Heat treatment adds durability to the components in the space craft that is the only vehicle used for journey to Mars. The heat treatment industry is the most important area for the development of technology and innovation in this field. Progress in the heat treatment industry results in stronger, long-lasting, smooth-surfaced, easy-to-shape, flexible, durable inputs.

Therefore, heat treatment industries and heat treatment production technologies are available in all industrialized countries. Heat treatment industry is a precondition of industrialization.



2.3. Important Countries and Developments in Heat Treatment Industry

There are advanced countries in terms of technology, competitive power, production capacity and production fields in heat treatment industry. Some of these countries are developed countries and some of them are developing countries.

USA

The USA continues to lead the world in the field of technology and standards in the heat treatment industry. The USA is very innovative in the field of production technologies for the heat treatment industry. The automotive, aerospace and defense industries continue to be the driving sectors in the heat treatment industry. In addition, the USA has created international standards like NADCAP in the aviation, space and defense industries and has been leading the world markets by revising these standards. The USA has been supporting the domestic industry, especially the metal industry, in recent years. Accordingly, the heat treatment industry capacity is developing and growing.

Germany

Germany, together with the United States, is a global decisionmaker in the heat treatment industry, technology, standards, inputs and production capacity and leads others especially in the fields of chemicals and production technology. Germany maintains its leadership in technology and in- novation capacity. The heat treatment industry in Germany is also pioneering in the setting of industrial standards within the EU. Germany also leads the way in harmonization with the green deal regulation of the European Union, and in this context, it is making greener production in the heat treatment industry.

Japan

Japan has a production technology like the USA and Germany, and its competitive power comes from the technologically and innovative advancements. In Japan automotive, rail systems, metallic construction and infrastructure materials support the heat treatment industry. Technology and innovation activities for heat treatment industry equipment in Japan are supported by the state. In recent years, Japan has started to shift its heat treatment activities to these markets in the face of the development of Asia in the metal industry.

South Korea

South Korea has an innovative and competitive heat treatment industry that produces technology. Automotive, shipbuilding, white appliances, machinery and electronics industries support the heat treatment industry. In South Korea, the efficiency of commercial heat treatment companies is higher and small volume of production is carried out for high number of industrial companies. Especially in recent years, South Korea has been contributing to the competitiveness needed by the heat treatment industry by focusing on innovative works in the industry.

China

The consolidation of company and heat treatment capacity, which is formed more than necessary, continues in China. While heat treatment industry companies develop production technologies, they also take measures to reduce energy consumption and carbon emissions. With its last five-year development plan, China has set a goal of global leadership in many sectors. The heat treatment industry is also in a technology-oriented transformation process as part of these goals.

India

The industry that drives the development of heat treatment industry in India continues to be the automotive industry. In India, heat treatment processes are mostly carried out internally by the industrial companies. However, with extensive infrastructure investments and automotive sales to the EU market, commercial heat processors have been growing rapidly in recent years and have created new capacities. India remains dependent on foreign production technology. The need for sustainability adaptation necessitates transformation in the heat treatment industry.

Central European Countries

Poland, the Czech Republic, Slovakia and Hungary are the new European production centers in the heat treatment industry. Industrial capacity, especially the automotive industry, is developing in these countries. Accordingly, the heat treatment industry continues to grow rapidly. As countries are dependent on countries like Germany and Austria about the production technology, commercial heat treatment operations expand with the participation of foreign actors. The need to comply with the EU's green agreement rules also leads to a significant transformation in these heat treatment industries.

Canada and Mexico

Canada and Mexico show presence in the heat treatment industry with the support of investors from the USA as they are countries that quickly adopt the international heat treatment standards of the USA. With the renewed NAFTA agreement, the heat treatment industry in Canada and Mexico has preserved its advantages, and the efforts of the USA to increase industrial investments within itself have also increased the business potential.

Russia

Russia has important technology know-how in the heat treatment industry. In recent years, especially new investments in the metal industry and modernization investments in existing industries have accelerated the demand for the heat treatment industry. However, commercial heat treatment activities are still very limited in Russia and are mostly carried out within industrial companies.

2.4. Developments in the Global Heat Treatment Industry and the Effects of the Covid-19 Outbreak

The developments in the world heat treatment industry are analyzed and evaluated in this section and under four subheadings. First, the developments in the important sectors served by the heat treatment industry and the effects of the Covid-19 outbreak are given. Secondly, the scale of the heat treatment market and regional developments are presented. Thirdly, the developments in the furnaces and equipment used in the heat treatment industry are evaluated. Finally, the standards used in the world heat treatment industry are provided.

2.4.1. Developments in the Sectors Served by the Heat Treatment Industry

The heat treatment industry applies heat treatment to the inputs of all sectors using metals, ceramics and composites on a global scale. However, there are leading sectors for the heat treatment industry. These are automotive industry, machinery industry, aerospace industry, rail systems, defense industry, consumer materials, construction and infrastructure materials, casting base metal industry and metal goods industry and fittings industry.

As of 2015, the distribution of the sectors served in the heat treatment industry is as follows: automotive industry, 33 percent; machinery industry, 15 percent; construction and

infrastructure materials industry, 13 percent; fittings and hand tools, 12 percent; aerospace-defense industry, 11 percent; base metal and metal industry, 11 percent; other industries, 5 percent.

In the period from 2015 until 2020, the demand in the heat treatment industry was largely determined by the developments in these sectors. In this context, developments in these sectors are analyzed and evaluated. The Covid-19 outbreak shaped 2020 in all sectors. Therefore, the impacts of the outbreak on the sectors are also evaluated.

Automotive Sector

The automotive industry is the largest market in the heat treatment industry. For this reason, developments in the automotive industry are also decisive for the business volume of the world heat treatment industry. In this framework, production developments in the automotive industry are evaluated for the period of 2015-2020. After reaching 90.78 million in 2015, the global automotive production increased in 2016 and 2017, reaching 97.3 million in 2017. Automotive production decreased in 2018 and 2019. In both years, the protectionist measures experienced around the world and the increase in expectations for electric vehicles, and the slowing effect it has created on demand led to a decline in automotive production. In 2020, the world automotive industry faced a sharp shrinkage caused by the pandemic. Automotive production decreased to 77.62 million in 2020. When evaluated for the global heat treatment industry, the increase in automotive production in 2016 and 2017 supported the heat treatment volume. However, the sharp shrinkage in production in 2018 and 2019, and especially in 2020, adversely affected the world heat treatment volume.

Source: OICA.

YEARS	AUTOMOBILE	COMMERCIAL VEHICLES	TOTAL
2015	68,539,516	22,241,067	90,780,583
2016	72,105,435	22,871,134	94,976,569
2017	73,456,653	23,846,003	97,302,534
2018	70,498,388	25,136,912	95,634,593
2019	67,149,196	24,637,665	91,786,861
2020	55,834,456	21,787,126	77,621,582

Table 2: Global Automotive Production



Machinery Industry

The machinery industry is the second largest market of the heat treatment industry. Machinery and equipment investments and related machinery production determine the heat treatment volume.

Machinery and equipment investments amounted to 4.23 trillion dollars in 2015. The shrinkage in global trade in 2015 and 2016 also negatively affected machinery and equipment investments. In 2017 and 2018, machinery and equipment investments grew again and increased to 4.88 trillion dollars in 2018. With the protectionism in world trade experienced in 2019, the growth in machinery and equipment investments has stagnated. Investments amounted to 4.92 trillion dollars. In 2020, with the effect of the pandemic, the world machinery and equipment investments decreased by 8.0 percent to 4.53 trillion dollars.

When the world machinery and equipment investments and machinery production are evaluated in terms of heat treatment industry, after the positive effect of the growth in 2017 and 2018, the stagnation in 2019 and the pandemic and the shrinkage in 2020 adversely affected the global heat treatment volume.

Construction Materials Industry

The global construction materials market moves in parallel with the developments in the world construction expenditures. Construction expenditures include expenditures on public-private, infrastructure, residential and non-residential building investments. The growth in the global construction materials market is shaped by the demand arising from construction expenditures.

In 2018, especially with the recovery in developed countries, the construction materials market grew by 3.2 percent and reached 6.07 trillion dollars. Again in 2018, contribution of developing countries to the growth in the construction materials market increased. The slowdown in the global construction industry in 2019 also affected the construction materials market. In 2019, the construction materials market grew by 2.6 percent and reached a size of \$6.23 trillion. In 2020, the shrinkage experienced in the global construction industry with the Covid-19 outbreak also negatively affected the construction materials market. In 2020, the construction materials market dropped to \$5.86 trillion, a 5.8 percent drop. The construction materials market experienced shrinkages in both developed and developing countries. When evaluated in terms of the heat treatment industry, the stable growth experienced in the construction materials sector from 2015 to 2019 has positively affected the heat treatment industry business volume. However, with the

effect of the pandemic in 2020, the shrinkage in the world construction materials market has this time negatively affected and limited the business volume of the global heat treatment industry.

Source: World and Türkiye Machinery Manufacturing Sector Report, 2021, MAKFED.

Table 3: Global Machinery and Equipment Investments (Billion Dollars)

YEARS	WORLD INCOME	FIXED CAPITAL INVESTMENTS	MACHINERY AND EQUIPMENT INVESTMENTS
2013	77,084	18,957	4,740
2014	79,155	18,920	4,540
2015	74,937	17,731	4,225
2016	76,159	17,781	4,170
2017	80,834	20,087	4,450
2018	85,893	21,659	4,880
2019	87,345	21,992	4,920
2020	84,358	20,115	4,525

Fittings Industry Sector

Fittings continue to be among the largest markets of the heat treatment industry. The demand and market for fittings is also shaped by the developments in the sectors using the fittings, especially in the automotive and aerospace industry. The global fittings market has shown a steady and gradual growth between 2015 and 2018. The market grew by an average of 2.8 percent annually between 2015 and 2018, and the market size will reach 95.0 billion dollars in 2018. The growth performance of the market slowed down in 2015 and 2016 due to the slowdown in the global economy and the shrinkage in global trade. Growth accelerated again in 2017 and 2018. In 2019, with the protectionism in global trade and the stagnation in many sectors where fittings are used, especially in the automotive sector, the fittings market dropped to 94.6 billion dollars. In 2020, with the impact of the pandemic, the fittings market declined to 90.2 billion dollars with a 4.7 percent drop.

When evaluated in terms of the heat treatment industry, the stable growth between 2015 and 2018 also positively affected the heat treatment industry business volume. The limited shrinkage in 2019 and the shrinkage caused by the pandemic in 2020 adversely affected the global heat treatment industry.

Metal Goods Industry Sector

The metal goods industry continues to provide an important business volume for the heat treatment industry. In this context, the growth in the global metal goods industry still drives the business volume of the heat treatment industry. The global metal goods industry showed relatively slow growth with 1.8 percent and 0.9 percent in 2015 and 2016, respectively. With the sharp declines in metal prices and the shrinkage in global trade, the growth in the metal goods industry slowed down. In 2017 and 2018, with the recovery in the world economy, the global metal goods industry grew by 3.6 percent and 4.5 percent, respectively. In 2019, this time, trade wars and protectionism in global trade, especially on metals, limited the growth of the metal goods industry. With the pandemic emerged in 2020, the global metal goods industry production shrank by 6.3 percent this time. When evaluated in terms of its effects on the heat treatment industry, the growth in the metal goods industry in 2017 and 2018 contributed positively to the heat treatment industry business volume. However, in 2019, and especially due to the pandemic, negative effects were experienced on the business volume in 2020.

Table 4: Scale of the Global	2015	86.1
Fittings Market	2016	87.5
Billion Dollars	2017	92.6
	2018	95.0
	2019	94.6
Source: TechNavio, Global Fastener Market 2026.	2020	90.2

Table 5: Growth in the Global	2015	1.8	
Metal Goods	2016	0.9	
Industry Industrial Growth	2017	3.6	
(Annual, Percent)	2018	4.5	
	2019	1.6	
Source: UNIDO, World Manufacturing Production Statistics, 2020.	2020	-6.3	



Aerospace and Defense Industry Sector

Airplanes, space vehicles and defense industry tools and equipment used in the transportation of passengers and cargo in the aviation sector also have a key place in the heat treatment industry's business volume. Developments in these sectors are decisive in the business volume of the heat treatment industry.

The demand for aircraft used in the aviation industry is determined by developments in passenger and freight transportation. When evaluated in this respect, passenger transportation increased by 27.3 percent between 2015 and 2019, reaching 4.54 billion people in 2019. Freight transport also expanded by 12.2 percent in the same period. With the growth in passenger and freight transportation, the demand and production of aircraft used in airlines also increased. However, the pandemic occurred in 2020 had the most negative impact on the aviation industry. In particular, there was a sharp shrinkage in passenger transport. The shrinkage in freight transport remained more limited. The aviation industry entered a very difficult period.

When evaluated in terms of the heat treatment industry, the aviation industry continued to create a significant demand until 2019 and positively affected the global heat treatment industry business volume. The shrinkage and troubles caused by the pandemic also caused significant losses in the heat treatment industry business volume.

Spacecraft is also a growing market for the heat treatment industry. Both developed countries and developing countries, especially China and India, increase space missions; and more spacecraft, satellites, etc. are produced and sent every year. Developments in the field of spacecraft have not been affected by the pandemic. The heat treatment industry is positively affected by the growth in this area.

After 2015, geopolitical tensions and hot conflicts have increased around the world. A search for a new balance began to be experienced between the USA, China and Russia. Geopolitical tensions such as North Korea and Iran increase the speed of armament. Again, hot conflicts, especially in Syria, increase the demand and production of weapons. There is a significant growth in the production of new generation war weapons. On the other hand, countries focus on establishing their own defense industries. With all these developments, the increase in production and demand in the defense industry has accelerated in recent years. When evaluated in terms of the heat treatment industry, the increase in demand and output in both spacecraft and defense industries positively supports the growth in the heat treatment industry business volume.

Rail Systems

Investments and use of rail systems on a global scale show a steady and rapid growth. Rail systems are used more for smart public transportation in cities. Rail systems are mainly transforming into electric vehicles. Again, for the purpose of compliance with sustainability, transportation by rail systems is becoming more popular. Rail systems investments in China's one-generation road project also bring growth in itself. When evaluated in terms of the heat treatment industry, the business volume provided by the rail systems is growing and its share among the sectors is increasing.

Source: IATA Airline Industry Economic Performance 2020.

Table 6: Global Air Freight Figures

YEARS	PASSENGER CARRIED (MILLION)	CARGO TRANSPORTED (MILLION TONS)
2015	3,569	54.8
2016	3,817	57.0
2017	4,095	61.5
2018	4,378	63.5
2019	4,543	61.5
2020	1,763	55.9

Sectoral Distribution of Business Volume in the Heat Treatment Sector

As of 2015, the distribution of the sectors served by the heat treatment industry is as follows: automotive industry 33 percent, machinery industry 15 percent, construction and infrastructure materials industry 13 percent, fasteners and hand tools 12 percent, aerospace and defense industry 11 percent, metal goods industry 11 percent, rail systems 2 percent, white goods industry 2 percent and other sectors 1 percent.

As a result of the developments experienced in the sectors in the period of 2015 -2020 and explained in detail above, and of the effects of the covid-19 outbreak in 2020, distribution of the business volume in the heat treatment sector by sectors was realized as follows.

Accordingly, the share of the automotive industry, which had a share of 33 percent in 2015, decreased to 30 percent. The machinery industry increased to 16 percent from 15 percent. The infrastructure and construction materials also increased to 14 percent. The shares of fittings and household appliances as well as aviation, space and defense industries have not changed. The share of the metal goods industry also decreased by one point. The share of rail systems increased by one point.

Source: Global Heat Treatment Market Reports, 2020-2021.

Table 7: Sectoral Distribution of Business Volume in the Heat Treatment Sector (Percent)

SECTORS	GLOBAL (2015)	GLOBAL (2020)
Automotive Industry	33	30
Machinery Industry	15	16
Infrastructure and Construction Materials	13	14
Fittings and Hand Tools	12	12
Metal Goods Industry	11	10
Aerospace and Defense Industry	11	11
White Appliances Industry	2	2
Rail Systems	2	3
Other	1	2



2.4.2. Scale of the Global Heat Treatment Market and Developments

The size of the world heat treatment market is shaped by the developments and growths in the sectors served. In the section above, the developments regarding the 2015-2020 period for all important sectors are presented. In this context, developments in the scale of the world heat treatment market are also presented and evaluated in this section. In the sectors served in the 2015-2020 period, 2016 was generally a stable year. In 2017 and 2018, rapid growth was experienced in almost all the sectors served. 2019 was a stable year again. Many sectors served have shrunk, especially due to trade protectionism. In 2020, shrinkages were experienced in all the sectors served as a result of the pandemic. In parallel with these developments, the size of the world heat treatment market grew by only 2.5 percent in 2016, reaching 90.7 billion dollars. In 2017, the market grew by 5.8 percent, the highest annual growth of this period. In 2018, the market grew by 2.9 percent. Thus, in 2018, the market saw the largest business volume with 98.8 billion dollars. In 2019, however, the market shrank by 2.7 percent this time, dropping to 96.1 billion dollars.

The effect of the pandemic was severely experienced in the sector in 2020. The market shrank to 84.5 billion dollars, a 12.0 percent drop, in 2020.

Asian region continues to increase their share over the years in the distribution of the world heat treatment market by regions. While the share of the Asian region in the world's total heat treatment volume was 38 percent, it rose to 42 percent in 2020. The share of Europe was 32 percent in 2016 and dropped to 30 percent in 2020. North America's share also fell from 25 percent to 23 percent. Europe and North

Chart 1: Global	2015	88.5
Heat Treatment Market	2016	90.7
size Billion Dollars	2017	96.0
	2018	98.8
	2019	96.1
Source: Global Heat Treating Market Report, History and Forecast 2016-2027.	2020	84.5

Note: The report dated 2021 contains actual figures from 2016 to 2020 and forecasts for the period 2021-2027. The actual data in the report is used in the chart above.

America suffered share losses especially after the shrinkage they experienced with the pandemic in 2020. The shares of Central and South America and the Middle East and Africa remained unchanged.

Source: Global Heat Treatment Market Reports, 2020-2021.

Table 8: Distribution of Business Volume by Regions in the Heat Treatment Industry (Percent)

	2016	2020	
Asia	38	42	
Europe	32	30	
North America	25	23	
Central and South America	3	3	
Middle East and Africa	2	2	

2.4.3. Development of Furnaces Used in Heat Treatment Industry and Market Scale

There are over 300 manufacturers of heat treatment equipment on a global scale. The equipment manufacturers operate in thirty-four countries spread over almost every continent. The United States, China and Germany are the most important equipment manufacturers. There is considerable competition in the production of heat treatment industry equipment and furnaces. Competition is increasingly focused on technological developments and furnace designs. Reduction of carbon footprint with energy efficiency is Reduction of carbon footprint with energy efficiency is a decisive factor.

Following is the distribution of industries served by the heat treatment industry: Vacuum technology furnaces and equipment are mostly preferred in automotive and aerospace industries, metal items industry and health equipment. Conventional atmospheric furnaces will continue to be used predominantly in the shipbuilding industry, construction equipment, rail systems and heavy equipment industries.

After 2015, there have been developments in the market of furnaces used in the metal heat treatment industry according to the demands of the sector. The heat treatment furnace market size remained stagnant in 2015 and 2016. Furnace investments also increased in parallel with the growth in the transaction volume of the heat treatment industry in 2017 and 2018, and the size of heat treatment furnace market reached 11.20 billion dollars in 2018. In 2019, heat treatment furnace investments again stagnated and amounted to 11.35 billion dollars. In 2020, with the effect of the pandemic, the market shrank by 6.0 percent, dropping to 10.67 billion dollars.

Due to Industry 4.0 compliance, increased automation and digitalization, countries such as Japan and South Korea have begun to focus on producing fully automated equipment and furnaces. High automation makes it possible to use double and

Table 9: 2015 Scale of Global **Metal Heat** 2016 Treatment **Furnaces** Market 2017 Billion Dollars 11.70 2018 2019 Source: Grand View 2020 10.67 Research, Global Heat Treatment Furnace Market 2027, 2021 April.

multi-chamber furnaces in large-scale manufacturing industries. In manufacturing industry, the production technologies and processes are digitalized, and continuous processes are adopted. All processes are connected automatically to each other and do not stop at any stage. Thus, the entire production process can be controlled, standards and quality are ensured at every stage, operation costs are reduced, and excessive capacity creation is avoided.

Therefore, furnace control systems have also changed dramatically. Heat treatment processes and furnaces and manufacturing process flows are integrated to increase efficiency. In the near future, automatic and continuous integration with fully intelligent furnaces and equipment will be provided; thus, problems and interruptions will be signaled in advance. Due to global warming trends and high carbon emissions generated by heat treatment furnaces, there is a rapid change in the design and technology of the furnaces as well as investment decisions made for these machines. There is a significant trend towards reducing the environmental impact of furnaces. The purpose is to process at lower temperatures, eliminate heat losses and reduce the duration of heat treatment processes in furnaces. Heat treatment phases are integrated to reduce the duration and simplify the heat treatment process. Surface treatments create limited destruction at low temperatures.

The driving forces behind the developments in heat treatment industry technologies are as follows: Reduction of heat treatment duration, minimizing the total footprint in the environment, minimizing the bending and destruction during heat treatment, reduction of material costs and reduction of operating costs for furnaces.

2.4.4. International Standards in Heat Treatment Industry

Quality standards and procedures in the heat treatment industry are increasingly common and internationally used. The developments in information and communication technologies and the development of the international supply chain led to the increasing, and common use of standards in the heat treatment industry. AMS2750E is the most widely used standard in heat treatment industry in the global scale. Common standards for heat treatment increase the quality of heat treatment on a global scale. NADCAP standards used in the aerospace industry and NADCA # 207-2016 and AMS2759 international standards used in other industries are examples of common and international standards. The use of these standards ensures that the supply chain works efficiently and quickly in the automotive and aerospace industry. Heat treatment industries of Asia and other developing countries are also added to the global supply chain by using these standards. In the coming years, heat treatment processes will transform into single hybrid processes from dual and multiple processes. (Boiling, cooking, roasting, heating and cooling, pasteurization, evaporation, condensation, drying and similar processes applied to raw materials and semi-processed products at various stages of the process are still carried out in several stages and separate equipment is used for each stage.) In hybrid processes, all the stages mentioned are performed with a small number of equipment/machine). For this reason, the number of international standards will also decrease. In this process the CQI-9 NADCA and AMS 2759 / 1-6 standards will become more widely used for all types of heat treatment.

PART

PROJECTIONS AND TRENDS IN THE GLOBAL HEAT TREATMENT INDUSTRY

Table 10: New Global Conditions after the Covid-19 Outbreak and Its Effects on the Heat Treatment Industry

In the third part of the study, projections and trends in the world heat treatment industry are given. It covers the period till 2025 with regard to projections and trends. Among the projections and trends include development projections in the sectors served by the heat treatment industry, scale of global heat treatment industry market and regional distribution projections, furnaces and equipment projections, technology, material and process projections. Again, the general trends in the global heat treatment industry, the European Union green deal regulations and their possible effects are also included.

3.1. New Conditions after the Covid-19 Outbreak and Its Effects on the Global Heat Treatment Industry

With the Covid-19 outbreak, new conditions are formed around economic activities. These conditions will affect the heat treatment industry as well as all the industries. Restructuring global supply chains is based on reducing dependency on Asia. With this trend, new production sites and capacities will be created in the heat treatment industry in regions other than Asia. Again, with regionalization, heat treatment activities will be carried out more within the regions, and the entire supply chain will be formed within the regions. Nearshoring will lead to the creation of new production sites and the trend of security of supply will lead to an increase in domestic supply.

Climate change and sustainability adaptation will affect the metal industry the most. With the regulations in this area, reducing carbon emissions, increasing energy efficiency, and using renewable energy in the heat treatment industry become mandatory. The heat treatment industry will make modernization investments for this transformation. Integrations with automation and smart systems are required in production and more broadly in all business processes. Again, the connections between the commercial heat treatment industry companies and the companies served will increase. It is predicted that productivity will increase with automation and smart systems.

With the digitalization trend, companies in the heat treatment industry will move all their business processes to digital platforms. Digital infrastructure investments will be made. With digitalization, the need for competent human resources in this field will also increase.

High commodity prices will both increase heat treatment costs and create fluctuations in demand. High freight prices, on the other hand, will make domestic and domestic procurement more attractive.

Export restrictions in metals and rare metals will also increase localization and domestic supply in the heat treatment industry. With the change in working conditions, the heat treatment industry will also adopt and apply mixed working models.

NEW GLOBAL CONDITIONS

Restructuring in Global Supply Chains	 Creation of new production sites Creation of new capacities
Regionalization	 Collaborations within regions Formation of value chains within regions
Nearshoring Security	 More supply from nearby suppliers Capacity increases at nearby suppliers More domestic supply
Climate Change and Sustainability Adaptation	 Reducing carbon emissions Using renewable energy in production Energy efficiency Less chemical and water consumption Modernization of existing capacities
Automation and Intelligent Systems	 Integrations for systems Integrations with customers Productivity increase
Digitalization	 Moving all business processes to digital platforms Digital infrastructure investments Need for new human resources
High Commodity Prices	 Increases in input costs Fluctuations in demand
High Freight Prices	 Decreased remote supply Increasing domestic supply
Export Restrictions on Metals and Rare Elements	 Localization in heat treatments Fluctuations in heat treatment demand
Change in Working Conditions	Application of mixed working methods
New Material Uses	 The use of iron and steel will stagnate. The use of new composite materials will increase. The share of new materials in heat treatments will also increase.

EFFECTS ON THE HEAT

TREATMENT INDUSTRY



3.2. Projections on the Sectors Served by the Heat Treatment Industry

The new conditions that emerged after the pandemic will shape the projections in the global heat treatment industry. Another key factor that will shape the projections in the global heat treatment industry will be the developments in the sectors served by the heat treatment industry. In this framework, general expectations regarding the sectors served by the heat treatment industry are included.

Automotive Industry

Recovery in the automotive industry after the pandemic will take time. A slow growth in sales and production is expected in the coming years. Supply problems such as semiconductor supply in 2021 will continue for another period. This will slow down the recovery in the automotive industry. Many countries are announcing schedules for the transition to fully electric vehicles. Therefore, production will largely focus on electric and hybrid vehicles. With this orientation, transformations will also occur in the main and sub-industry production centers. New capacity and model investments will be made, mainly for electric vehicles. Developments in technology and innovation will further increase the importance and necessity of heat treatment in the automotive industry.

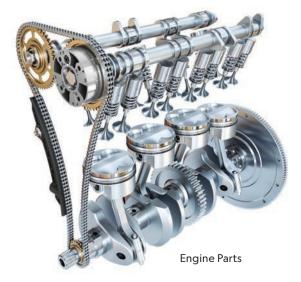
When evaluated in terms of its effects on the heat treatment industry, the great transformation in the automotive industry will also lead to major changes between customers and suppliers in the heat treatment industry. In the new period, many different inputs will be used in production. Therefore, heat treatments will also diversify. Various and new materials and processes will be used. This will require new technology and diversification investments in the heat treatment industry. The effect on the heat treatment industry business volume will remain below the averages of the previous period.

Machinery Industry

In the new period after the Covid-19 outbreak, important trends have emerged. The effects of these trends on the machinery industry dynamics will be as follows.

First, countries will transfer production to their own countries in many sectors for the purpose of supply security and capacity investments made for this purpose. Secondly, new capacity investments are made with the tendency of nearshoring. With the aim of sustainability compliance, existing machinery parks are replaced with new machines that emit less emission, which are high in energy efficiency, and that consume less water and are quiet. Industry 4.0 compliance and digitalization trend also lead to rapid change in existing machine parks with digital and smart machines. With the tendency of safe and hygienic production, the existing production parks are renewed with machines with more advanced technology and high hygiene capacities. Industries have turned to digitalization in all their processes. The digitalization of all business processes also necessitates inter-process harmony. For this reason, all equipment in business processes is renewed in a manner to be compatible with each other.

Sectors increasingly include electronic commerce in their sales. Accordingly, infrastructures are renewed for compatibility with electronic commerce in business processes. Rapid developments in material technologies, use of new materials, increasing use of rare elements and rapid developments in product technologies also necessitate the use of machinery and equipment compatible with these developments in the sectors. When evaluated in terms of its effects on the heat treatment industry, rapid growth will be experienced in the machinery industry and the heat treatment industry will be one of the sectors with the highest impact on business volume.





Some engine components requiring heat treatment



Heat teratment is used in satellite systems.

Infrastructure and Construction Materials Industry Big packages for infrastructure investments are being implemented in the USA. In Europe, on the other hand, due to the need to adapt to the green deal, the building stock will be significantly renewed and renovated. In developing countries, the construction sectors will continue to grow with a focus on housing and infrastructure. It is estimated that the construction of non-residential buildings will be limited. Due to the need for sustainability compliance, there will also be significant developments in construction materials. When evaluated in terms of its effects on the heat treatment industry, traditional growth will be experienced in the infrastructure and construction materials industry, and its effect on the business volume will again be close to the averages of the past.

Aviation, Space and Defense Industry

It is estimated that the return to the pre-pandemic period in the aviation industry may occur in 2024-2025. Therefore, the demand and production of aircraft used in the aviation industry will continue to remain weak. In the space industry, the rapid increase in production will continue. In the defense industry, the localization efforts of the countries and the need for new generation and new technology-based defense vehicles will provide a high growth in production. When evaluated in terms of its effects on the heat treatment industry, the impact of the aviation industry will be limited, while the space and defense industries will make a high contribution to the heat treatment industry business volume. The aviation, space and defense are the industry that uses the highest quantity of metals in addition to special metal and composite materials. For this reason, commercial heat treatment companies will continue to develop new products and solutions for the aerospace and defense industry.



Aircraft Parts



Tank Parts



Unmanned Aerial Vehicles



Fittings and Hand Tools Industry

Fittings and hand tools industry will develop depending on the developments in their sectors. Relatively slow growth in the automotive and aviation industries will also limit the fittings industry. Demand for fittings will grow rapidly in the fields of defense industry, machinery industry and rail systems industry. There will also be changes in the functions, materials and criteria of fittings.

As to the effects on the heat treatment industry, the contribution of the fittings industry to the heat treatment industry business volume would be around the averages of the past.

Rail Systems

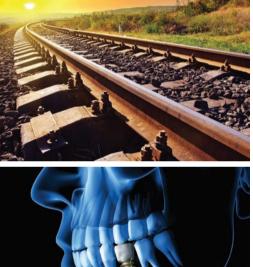
Due to the need for compliance with sustainability, the need and demand for rail systems in transportation is increasing. Accordingly, a significant increase is expected in rail systems new and modernization investments. Again, the use of rail systems in transportation and urban transportation by developing countries will increase and related investments will continue. Investments in the expansion of the high-speed train network will also continue around the world. When evaluated in terms of its effects on the heat treatment industry, the contribution of the rail systems industry to the heat treatment industry business volume will be high.

Metal Goods Industry

Metal goods industry will continue to expand in specific areas. Health equipment is one of them. A rapid growth is expected in the production of metal sanitary ware with the needs arising after the pandemic.

As to its effects on the heat treatment industry, the contribution of the metal goods industry will be close to the past period averages with the changing products and materials. New technologies, materials and processes will be used in heat treatments in this area.





Health Sector and Implants



Health Sector and Prostheses

3.3. European Union Green Deal and Its Effects on the Heat Treatment Industry

A principal issue that will shape the developments in the heat treatment industry is the European Union green deal and the carbon border adjustment mechanism planned in addition to this agreement. Third countries will be affected especially by carbon border adjustment mechanism.

3.3.1. EU Green Deal

With the European Green Deal announced on December 11, 2019, the EU has set the target of increasing the greenhouse gas emission reduction by 2030 to at least 55 percent compared to the 1990 level and transforming Europe into the world's first climate-neutral continent by 2050. The first Climate Law, which constitutes the legal framework for the 2030 and 2050 climate targets set forth by the green deal, was published in the EU Official Journal on July 9, 2021. Thus, the commitment of the European Green Deal to be EU climate neutral by 2050 has become a binding obligation. To achieve the targets enacted by the European Climate Law, the draft "Fit for 55" green package, which includes a series of legal regulations, was presented by the European Commission on July 14, 2021. The draft package contains interrelated and complementary policy measures. With the 55 compliance regulations, a comprehensive implementation strategy has been brought to the legally binding European Green Deal. The regulations are still in the proposal stage and the negotiation and approval process is expected to last until the end of 2022. Regulations of Fit for 55 may also be implemented by the European Union's trading partners. It is important for many countries, especially Türkiye, to comply with the Fit for 55 regulations. At the forefront of these regulations is the carbon border adjustment mechanism.

3.3.2. Carbon Border Adjustment Mechanism

The main objective of the Carbon Border Adjustment Mechanism (CBAM) is to determine the import price for selected sectors, taking into account the carbon content of the goods. The related proposal was announced by the European Commission on July 14, 2021.

The regulation is aimed to start with a transition period of 3 years as of January 1, 2023 (No carbon tax will be paid on imports). During the transition period envisaged between 2023 and 2025, only the reporting obligation regarding the CBAM mechanism is expected to be fulfilled. It is aimed to start the implementation that imposes financial obligations on January 1, 2026.

Selected sectors subject to regulation were determined as iron and steel, cement, aluminum, electricity and fertilizer in the first stage. The sectors will expand later.

An authorized CBAM authority will be established in member countries. The authority will authorize the importers. Goods in regulated sectors can only be imported by importers (declarants) authorized by the authorized CBAM authority. Importers will regulate the imported product information and the carbon emissions information that occurred during the production of this product.

The EU will set reference limits for carbon emissions in production, which will lead to a carbon tax on imports. If these reference limits are exceeded in the imported product, the importer will have to pay the tax to be calculated to the EU authorities.

Naturally, importers will either not import taxed imports or will prefer imports/manufacturers/suppliers that do not have tax liability. Or they will import but will demand the resulting carbon tax from the manufacturer/supplier. This will happen with more payments.

For taxes to be paid, it is aimed to receive 30 or 50 Euros per ton of emissions above the reference value in production. After the transition period, CBAM will enter into force in 2026 and the payment obligations of EU Importers and suppliers will begin.

3.3.3. Carbon Border Adjustment Mechanism and Its Effects on the Heat Treatment Industry

Among the sectors that will be subject to the transition process to the Carbon Border Adjustment Mechanism are the iron and steel sector and the aluminum sector, which constitute the largest business volume of the heat treatment industry.

Carbon emissions in production will be calculated for the import of products in these sectors to the EU. Carbon emissions in three stages will be taken into account in the calculation of carbon emissions in production. These are,

1. Direct carbon emissions at the production stage,

2. Carbon emissions during the production and use of the energy used,

3. Carbon emissions arising from the production of the inputs used and the services received,

In the calculation of the total carbon emission of the imported product, the carbon emission created by the heat treatment industry appears in the third stage above.

In this framework, the heat treatment industry will have to produce carbon emissions within the reference values to be determined by the EU while providing services for the imported product.

Companies that produce and export heat-treated products will also prefer heat treatment industry companies that generate carbon emissions within the EU reference values in order to pay less or no carbon tax.

The border carbon regulation mechanism will be able to push the producer/exporter companies to do heat treatment by themselves, instead of receiving services from commercial heat treatment companies to control carbon emissions resulting from heat treatment.

For this reason, commercial heat treatment companies will have to make improvements to keep their carbon emissions within the reference values to be determined by the EU during the transition period. Again, heat treatment companies will have to measure, monitor, and certify their carbon footprints.



3.4. Projections on the Market Scale in the Global Heat Treatment Industry

In this part of the study, projections regarding the business volume of the world heat treatment industry are presented. While making projections about the business volume of the world heat treatment industry, first the effects of the new conditions that emerged with the Covid-19 outbreak on the heat treatment industry were taken into consideration. Then, the development expectations in the sectors served by the heat treatment industry were addressed. Finally, the possible effects of the EU green deal were evaluated.

Within the framework of all these factors, it is estimated that the business volume of the world heat treatment industry will grow by 1.5 percent in 2021. The most important reason for the slow growth is the slow recovery in the automotive and aviation industries. The business volume is expected to grow by 2.0 percent in 2022. Growth is expected to be 3.0 percent in 2023, 2024 and 2025.

Within the framework of these forecasts and expectations, it is predicted that the global heat treatment industry business volume, which was 84.5 billion dollars in 2020, will reach 96.0 billion dollars in 2025. In the 5-year period, an annual average growth would be 2.5 percent.

3.5. Technology, Material, Process, Digitalization and Investment Projections in the Heat Treatment Industry

In this part of the study, technology, energy efficiency, furnaces, materials, processes and digitalization projections are included in the heat treatment industry.

Technology Projections

The heat treatment industry is an energy-intensive industry with an impact on the environment due to carbon emissions. For this reason, production technologies in the heat treatment industry tend to focus on improvements in these fields. Thus, reducing the costs of other industries and increasing their competitiveness are also targeted. Many areas of the heat treatment industry are expected to develop technologically. Examples of technology development projections are as follows:

• Cementation/carbonitriding transition technologies to low pressure vacuum processes,

• Transition technologies to oil or high-pressure gas quenching,

• Technologies for the use of single-piece heating and quenching of parts and/or small batches (versus large batches),

• Design change to allow lower temperature atmosphere applications (e.g., nitriding, nitrocarburizing technologies),

• Expanding hybrid technologies (e.g., combining both

Chart 2: Growth Projections	2020	84.5
for the Global	2021	86.0
Heat Treatment Market	2022	87.7
Billion Dollars, 2020-2025	2023	90.4
	2024	93.1
Source: Prepared by the working team.	2025	96.0

vacuum and atmosphere properties),

• Advanced cooling techniques and cooling technologies,

• Implementation of artificial intelligence-based modeling and simulation software capable of equipment control and process optimization,

• Implementation of next-generation smart sensors, real-time data collection methods and analytics (including cloud-based computing),

• Accelerating the implementation of lean manufacturing strategies; the use of make-to-order technologies that eliminate high labor costs (through automation and controls), simplify operations (i.e., reduce the number of production steps), and make-to-order

• Continuing the transition from heat treatment sections to integrated production cells.

Projections on Furnaces

Electrical furnaces are used at increasingly higher levels. Energy efficiency is higher, and losses are lower. Heat control and regulation are better. It can be used at higher temperatures. There is no risk of explosion thus, it is safer. There is no pollution and CO2 emission. Installation costs are very low. Installation and operation are relatively easier. Automatic mode can be initiated easily. However, operational costs are higher. Larger furnaces may be required for the same heating process. Renewal and replacement costs are higher. It is predicted that the demand for electric furnaces of companies in the heat treatment industry will increase more rapidly in the upcoming period. Electrically heated furnaces, boilers and other equipment will be more preferred. Electric furnaces will provide energy costs and increase operating efficiency.

Awareness in the heat treatment industry about the regulations and restrictions on carbon emissions and energy efficiency is increasing significantly. The number of regulations and restrictions regarding furnace/boiler emissions, standard temperature, and wastewater is increasing and the restrictions are tightening, especially for the heat treatment industry.

Therefore, the demand for furnaces using fuel, diesel and gas is decreasing. Existing ones are renewed with electric furnaces. New investments are made with electric furnaces. Another trend and projection in furnaces is the increase in demand for vacuum furnaces that operate with ambient and vacuum pressure and have high energy efficiency. Vacuum technology is becoming the dominant heat treatment technology in the coming period. Demand for atmosphere, gas, high pressure furnaces is decreasing.

Vacuum furnaces will also be preferred with their ability to meet the high needs of heat treatment companies in the coming period. These abilities include energy saving, minimum maintenance requirement, optimization of heat treatment processes (especially diffusion-related processes), environmentally friendly by-products and emissions, adaptability/flexibility for new and advanced materials, process controls including smart sensors, ability to make designs based on heat treatment modeling and simulation, and equipment/process integration.

Vacuum furnaces can adapt to material, technology and process changes more quickly and easily.

Another important trend and projection for furnaces is that heating would develop with the induction method. Thanks to electromagnetic induction and heat treatment technology, product cycle times are shortened, and part diversity is increased. In many induction applications, the heating time is less than a few seconds and, in some cases, only a fraction of a second.

Induction equipment is more competitive with technical ability, performance stability, delivery time, machine longevity and price. In addition, induction equipment can provide new elements such as equipment flexibility, traceability of component heat treatment quality, digital connectivity, and the ability to store and access process data. Induction heat treatment equipment is also capable of machining piece by piece with component traceability, readiness for automation and digitization of process control and monitoring. With this feature, it will have a very critical function for the heat treatment industry.

Induction heat treatment equipment has turned into advanced control/monitoring systems that could not be

used before with the microprocessor and microcontrollers it carries and the continuous developments in these technologies. With these capabilities, digital data collection is also possible.

Energy Efficiency Projections

Increasing energy efficiency in the heat treatment industry is still one of the top priorities. It is predicted that the following applications will gain weight in order to increase energy efficiency.

Heat Generation: Regarding heat generation, significant energy savings can be achieved by focusing on aspects such as control of air-fuel ratios, pre-combustion air, use of oxygenenriched combustion air, use of fuel conditioning. **Heat Transfer:** Regarding heat transfer, significant energy savings can be achieved by focusing on aspects such as improving heat transfer with advanced burners and controls, improving heat transfer within a furnace.

Enabling Technology: Regarding enabling technology, significant energy savings can be achieved by focusing on installing high return combustion systems, using a programmed heating temperature setting for half load operation, monitoring and controlling carbon gas oxygen, unburned hydrocarbon and carbon monoxide emissions, maintaining furnace pressure control, ensuring correct sensor positions.

Material Projections

Today, the heat treatment industry mostly performs heat treatment for steel, cast iron, aluminum, copper, nickel, brass, titanium, metal alloys and other metals. It is projected that the following changes will be experienced in heat treated materials in the coming period.

Steel and cast iron will continue to have the highest share in the materials in the sector, but a significant decrease is expected in their share.

The prominent need in all products in which metals are used is being light weight. Accordingly, the use of aluminum and copper and their alloys will increase more rapidly. Especially in the automotive and aerospace industries, these two metals will be used more.

The use of copper will see an additional demand with the energy revolution and the transition to renewable energy. Copper will stand out with its high thermal conductivity and high corrosion resistance. Aluminum will be the fastest growing metal in heat treatment volume.

The use of composite materials will grow faster. Heat treatments for more durable, lightweight and long-lasting



composite materials will increase.

The needs for customized products and materials for the use of various sectors are increasing. The need for different combinations of ferrous and non-ferrous metals is developing. For this reason, innovative composite materials come to the fore beyond traditional alloys, and the need for heat treatment for them is also growing. Heat treatment also makes composite materials more durable and functional. The use of rare metals and elements will become widespread. The need for specific heat treatment for these will increase. The use of steel will continue to be used extensively in the machinery industry, railway-rail systems, renewable energy equipment, sanitary ware, defense industry and building materials industries.

Process Projections

The processes used in the heat treatment industry today basically have two separate functions. The processes also differ according to these two separate functions. The first one is heat treatments for shaping the product. The second is heat treatments to provide suitable usage properties for metal parts.

Heat treatment to shape the product involves normalizing (air cooling and tempering) processes which remove the residual stress from the previous processes (e.g., cold forming) and / or metallurgical improvement and soften the material. Heat treatment processes aimed at adding appropriate properties to metal parts are carried out to achieve the desired properties with metal parts under working conditions when the heat treatment is completed or nearly completed. The heat treatment processes applied in accordance with the purpose of use vary depending on technical methods. It is projected that both functions and related processes will continue to the same extent in the upcoming period. Prominent processes in heat treatment to provide suitable usage properties of metal parts are hardening, tempering, martempering, austempering and surface hardening. It is projected that hardening and especially surface hardening processes will grow faster within these processes. The demand for surface hardening will increase in industries such as automotive, aerospace, defense industry and white goods using flat materials.

Two main processes are applied in surface hardening. These are thermo-chemical processes and thermal processes. We are entering a period in which thermo-chemical processes will be used more in surface hardening.

Thermo-chemical processes have four sub-processes within themselves. Boriding by carburizing (cementation), carbonitriding, nitriding and nitrocarburizing. It is projected that among these sub-processes, the traditional carbonation method will maintain its weight, but the nitriding process will also be used more.

It is projected that there will be faster growth in the thermal processes, especially in the surface hardening process with induction.

Digitization Projections

Digitization is also affecting the heat treatment industry and has started to take place in business processes. It is projected that the following applications will be followed by digitization in the heat treatment industry in the coming period. The first of the digitization applications in the heat treatment industry is the application of digital meters using special integrated circuits as an alternative to the analog meters that were widely used in the past. Digital meters used within their ratings provide accurate measurement of power supply output electrical parameters. As the response time of digital meters can still be too slow for fast induction heat treatment processes, some manufacturers provide a fast-responding bar chart with a slower responding digital readout of the parameter value in the same meter enclosure. However, further work needs to be done to further reduce the response time of digital meters and circuits.

The need and demand for real-time monitoring of heat treatment processes is increasing. Digital monitoring is a growing application in this regard. The digital monitoring system first verifies critical machine settings to ensure full efficiency in machining parts. Again, digital heat-treatment systems offer control, data acquisition and monitoring in one package, using a computerized front-end with PLC control and human-machine interface (HMI) to provide the best of both technologies. Many manufacturers have developed proprietary solutions for digital monitoring circuits that improve accuracy and minimize response time. For a heat treatment application that requires monitoring, it is imperative to establish a minimum number of really important process parameters. That is why the design of modern induction equipment has become holistic. In this context, digital systems that are more reliable, compact, easier to use and maintain with a simple design with minimum components have been started to be used. With digitization in the heat treatment industry, electronic

records are created and stored, and measures are taken to ensure that they are not changed without being detected. Today, the number of heat treatment jobs is increasing significantly due to small and frequent orders. Speed and flexibility are also gaining importance in heat treatment industry production. For this purpose, the need for digitization is increasing in all business processes, especially in production. Digital, high-quality and reliable equipment produces large batches of small batches more effectively. Digital equipment is more effective in optimizing the metallurgical quality of heat-treated parts.

With digitization, machinery and equipment used in the heat treatment industry also facilitate the horizontal and vertical integration of companies with their suppliers and customers within their eco-systems.

A quick scan of the combustion system with a tablet or phone camera overlays real-time data in view of the actual furnace system. The current status can be compared to the desired status as well as displaying possible maintenance alerts. Videos are easily accessible and step-by-step procedures to ensure correct maintenance activities.

With digitization, online carbon emissions become traceable. Digital equipment monitors the state of the general combustion system and can make the necessary warnings. Maintenance activities are also carried out on time, at the lowest cost and at the optimum time.

Digital applications and solutions have started to provide significant added value in all business processes of the heat treatment industry, especially in heating and combustion control processes.

3.6. Main Trends in the Global Heat Treatment Industry

1. With the change in global supply chains, works of heat treatment industry are returning to countries of origin. Especially developed countries have started to prefer domestic or close supply.

2. With less dependence on Asia, especially on China, the heat treatment industry is returning to the value chains of the developed countries. However, the costs of heat treatments remain higher than in Asia, which pushes prices up. The heat treatment industry will have to increase its efficiency by working leaner, faster and more efficiently in the face of increasing costs.

3. In the heat treatment industry, collective heat treatments are passed as long as the piece(s) are individually processed.
4. The demand for heat treatment for more specific parts will increase. With the development in material technologies, the parts will get smaller, and each part will need separate heat treatment. Quantities to be ordered will decrease but diversify.

5. With the innovations in material technology, the share of special alloys and composite materials in the heat treatment volume will increase.

6. Small and medium-scale companies in the heat treatment industry will begin to specialize in diversified jobs, materials and processes. They will focus on custom work.

7. Large-scale companies with a wide product portfolio and geographical reach will cooperate with companies specialized in local markets and purchases will increase.

8. Large-scale companies will continue to transform into companies integrated into the specialization trend. These companies will continue to provide heat treatment and post-processing services with very different furnace and process capacities. For this purpose, large companies will cooperate or make purchases with engineering, maintenance and service companies for heat treatment companies.

9. Another area of cooperation will increase between furnace manufacturers and commercial heat treatment companies, and between heat treatment companies and service companies. Collaborations will focus on technology and innovation. These collaborations have started to be seen especially between commercial heat treatment companies and automotive companies. **10.** With digitalization, technological developments, and the increase of high-quality materials, the qualifications of the employees in the heat treatment industry will change and the need for qualified human resources will increase.

11. With regard to the equipment used in the heat treatment industry, the share of vacuum technology and lower temperature processes is increasing. Vacuum furnaces with higher process capacities and functions stand out. The heat/ temperature degrees used in heat treatments in the industry will continue to be reduced.

12. Heat treatment is increasingly becoming digital. Mass heat treatment processes are reduced, and heat treatment processes are integrated with other manufacturing processes. Digitization provides automation, visualization (three dimensions), real-time process controls and connectivity. The machines become intelligent and production processes do not stop.

13. Heat treatment standards, processes of application procedures and furnace-equipment designs are becoming increasingly global. Zero accident furnace design philosophy is gaining importance.

14. It is aimed to shorten the duration of heat treatment operations. For this purpose, the importance of nano and thermo/chemical surface applications, precision technologies and MIM processes in heat treatments is increasing.
15. 3D Design-Production-Manufacturing technology influences the heat treatment industry as well as every industry of the manufacturing industry. With the use of this technology, the use of composite and new materials will become widespread. For this reason, the demand for metal heat treatment will be limited.

16. Energy sources used in heat treatment furnaces are being renewed. For increased energy savings and less energy consumption, resources such as microwave, laser and infrared rays is considered.

17. In the new global conditions, companies will focus on high-tech, innovative and niche businesses rather than traditional and standard businesses in order to increase their profitability. Companies will also be more flexible and faster in the face of new global supply trends in this field.

18. In the face of the regulations that have become effective with the European Union green deal, heat treatment companies will make new investments in order to comply with sustainability.

19. Innovative financial models are developing due to the high investment need in the heat treatment industry. Furnace and other equipment manufacturers have started to offer rented alternatives besides direct sales.

20. To increase competitiveness in the heat treatment industry, companies will focus on after-sales services, the development of metallurgy, engineering, technical expertise and practical skills, and the training of the existing workforce.

HEAT TREATMENT INDUSTRY IN TÜRKİYE





The fourth part of the report analyzes and evaluates the developments in the heat treatment industry in Türkiye. First, the history of the heat treatment industry is given. Then, the development of the market size of the heat treatment industry between the years 2015 and 2020 is presented. In this context, the effects of the pandemic are also evaluated. Then, the numerical indicators of the commercial heat treatment industry between 2015 and 2020 are given. Finally, the projections for 2025 in the Turkish heat treatment industry are presented and a roadmap is created for the sector and companies.

4.1. Development of Heat Treatment Industry in Türkiye

The first heat treatment processes in Türkiye were performed in the Mechanical and Chemical Industry (MKE) Corporation. Machinery Chemical Industries was moved to the Republican era as a continuation of the institutions that produce defense equipment since the 15th century under various titles and statues.

In 1921 Atatürk brought some of the looms, equipment, materials and masters from the military factory located in Istanbul to Ankara and collected them under the newly established Military Fabrics General Directorate, thus the MKE was laid in Ankara. MKE has become a school for the heat treatment industry. Like MKE, State Railways has become the second school of the heat treatment industry with the heat treatment activities it includes.

The first private industry ventures in heat treatment industry emerged in Istanbul in 1940's and 1950's. The first initiatives took place in the workshops and were performed by skilled craftsmen. The first attempts were made in at a workshop scale with the help of craftsmen.

Since the beginning of the 1960s, Türkiye has entered a planned development period and public and private sector industrial investments, especially in the basic metal industry, have gained momentum. Accordingly, the demand for heat treatment started to expand. In this period in the field of commercial heat treatment in Istanbul and in other provinces where other industries established, there were also attempts by masters and those returning from Germany. However, the scales are still small and workshop size.

From the beginning of 1970's onwards, the capacities of the industries such as automotive, white appliances,

machinery, shipbuilding and building materials in Türkiye have been forced to move from workshop size to factory size and institutionalization. Accordingly, at the end of 1970's, commercial heat treatment initiatives started to be established throughout Türkiye. MKE continued to provide human resources in this period.

1980's became the period of export-oriented growth in industry, with the aim of economically opening to the world. This transformation also affected the heat treatment industry. The 1980s initiatives are now becoming bigger businesses. Until the end of the 1980s, heat treatment processes in the salt baths of the workshops were started with new technologies and furnaces. In the 1990s, the atmosphere and automatically controlled furnaces, which are high-tech products and capable of mass production, have been used.

The customs union process that was executed with the European Union in 1996 marked the onset of a new period in Turkish industry. As a result, product quality and standards have been improved, foreign capital investments have accelerated, and new production capacities have started to be established. During this period, the first vacuum hardening furnace investments were made in commercial heat treatment companies. This transition also positively affected heat treatment industry, and the number of heat treatment enterprises and their production capacity started to grow. The recent technology was also accessed in this period. Starting in early 2000's, with the normalization and amelioration in economy, there were foreign capital investments in the heat treatment industry. The number of important foreign players who came to perform manufacturing and trade in heat treatment processes, furnaces and chemicals rapidly increased. With the developments in the automotive, white appliances and defense industries, there has been an increase in quality and capacity for heat treatment suppliers. Therefore, commercial heat treatment companies also ventured in high value-added and qualified works starting in the second half of 2000's and focused on obtaining quality certificates and compliance certificates for international standards. The development of the heat treatment industry in Türkiye is not only limited to the commercial heat treatment companies. Starting in early 1980's, heat treatment units were created at important, large-scale companies that operated in other



industries in Türkiye, particularly in base metal industry, metallic goods industry, automotive industry, household goods industry and defense industry.

Today commercial heat treatment companies and other industrial companies that perform heat treatment in their fields continue to carry out qualified heat treatment operations by using advanced technology.

4.2. Developments in Turkish Heat Treatment Industry Market Size (2015-2020)

This section, which includes the developments in the scale of the heat treatment market, first provide information about the developments and growths in the sectors served by the heat treatment industry. The market size of the heat treatment industry is determined by the developments in the sectors served. Secondly, developments in heat treatment market sizes are presented. The market size in the heat treatment industry includes the heat treatments for finished products.

4.2.1. Developments in the Sectors Served by the Heat Treatment Industry

The heat treatment industry mainly provides services for sectors such as automotive industry, machinery industry, metal goods industry, fittings, building materials industry and white goods industry in Türkiye. For heat treatment works in these sectors, either commercial heat treatment companies receive services or companies in this sector carry out heat treatment activities within their own structure. In this context, developments in the sectors receiving heat treatment services are evaluated at this stage. The best indicator to measure the demand to be created for the heat treatment industry is the industrial production growth in these sectors. The industrial production growth in the following sectors is presented with the assumption of accepting 2015 as 100.

Source: Turkish Statistical Institute Industrial Production Statistics.

Table 11: Developments in the Production of the Industries Served by the Heat Treatment Industry; Production Index (2015=100)

SECTORS	2016	2017	2018	2019	2020	
Automotive Sub-industry	110.5	127.9	128.0	120.5	111.0	
Machinery Industry	100.9	110.4	110.6	103.7	112.5	
Metal Goods Industry	105.6	118.5	112.0	111.5	120.7	
Construction Materials	105.7	112.1	92.6	82.4	84.2	
Fittings	98.8	113.3	119.6	124.5	133.1	
Metal Tools	95.8	102.8	100.3	100.6	110.0	
White Appliances Industry	105.9	118.3	122.0	120.9	120.6	
Defense Industry	115.9	131.2	121.4	157.3	212.7	
Rail Systems	104.1	101.5	111.2	111.4	110.4	
Shipbuilding Industry	106.5	113.2	126.1	147.5	166.6	
Base Metal Industry	98.9	105.9	105.6	94.4	96.8	

Automotive Industry

The production capacity in the main industry in the automotive industry in Türkiye remained largely the same after 2015. Accordingly, the static capacity of the main industry had a limiting effect on the domestic production of the sub-industry. On the export side, the developments in the world automotive industry and the course of production were decisive. In this context, the production of the automotive supply industry increased by 28.0 percent until 2018, with a similar increase in the demand for the heat treatment industry. The automotive industry is one of the sectors most affected by the pandemic in 2020. Accordingly, the sub-industry production decreased by 7.9 percent in 2020. The heat treatment industry business volume was also adversely affected by this decline in 2020.

Machinery Industry

The developments in the machinery industry are determined by the machinery and equipment investments in the world and in Türkiye and the resulting machinery demand. After 2015, machinery and equipment investments around the world fluctuated and remained weak. In Türkiye, especially in 2018 and 2019, machinery and equipment investments decreased and the demand for machinery also decreased. Depending on these developments, production in the machinery industry increased by only 3.7 percent between 2015 and 2019. In 2020, a significant increase was experienced in the demand for machinery within the conditions created by the pandemic, and machinery production grew by 8.5 percent.

Metal Goods Industry

Production in the metal goods industry increased between 2015 and 2017. However, due to the financial fluctuation experienced in 2018 and the economic recession in 2019, metal goods industry production declined. Thus, the production increase in the metal goods industry between 2015 and 2019 was 11.5 percent. Pandemic conditions, on the other hand, increased the demand for metal goods, especially in the second half of 2020. Accordingly, industrial production grew by 8.3 percent in 2020. Heat treatment demand from the metal goods industry decreased in 2018 and 2019. In 2020, it increased again.

Construction Materials

Demand for construction materials comes from the construction industry. From 2015 to 2017, there was a moderate growth in the construction industry. In 2018 and 2019, the construction industry shrank. In 2020, significant support was provided to the housing and construction sector in the conditions created by the pandemic. However, the construction industry shrank by 5.5 percent in 2020. Depending on these developments, industrial production of construction materials dropped by 17.6 percent between 2015 and 2019. In 2020, industrial production grew by 2.2 percent with the support of exports. The heat treatment demand of the building materials industry also shrank between 2015 and 2020, negatively affecting the heat treatment industry business volume.

Fittings

The fittings industry is shaped by the developments in the industries in which its products are used. Industrial production of fittings grew by 24.5 percent between 2015 and 2019. The protection measures brought to the import of fittings were effective in this growth. Imports have become expensive, so domestic supply and production has increased significantly. This growth in the production of fittings has also positively affected the heat treatment industry business volume. Industrial production of fittings grew by 6.9 percent in 2020, especially with the effect of foreign demand and exports.

White Goods Industry

The white goods industry in Türkiye maintains its gradual and stable growth. Between 2015 and 2020, both the production capacity increased and the stable growth in domestic and foreign demand continued. Depending on these developments, the white goods industry production increased by 22.0 percent until 2018. Production dropped in 2019 due to the recession in the economy. In 2020, production remained almost the same under the pandemic conditions. The increase in production in the white goods industry had a positive impact on the heat treatment industry business volume until 2018. The effect remained stable in 2019 and 2020.

Defense Industry

Türkiye has been carrying out many important projects in the field of localization in the defense industry in recent years. In this context, there is a rapid growth in defense industry production. Defense industry production grew by 57.3 percent between 2015 and 2019. In 2020, industrial production showed a leap with new projects. The defense industry has a positive effect on the heat treatment industry business volume.

Rail Systems

While Türkiye focuses on rail systems investments after 2015, it has turned to domestic production of the infrastructure materials and train-wagon systems used. In this context, rail systems industrial production also grew by 11.2 percent between 2015 and 2018. In 2019 and 2020, the increase in production stagnated. The rail systems sector has made a relatively limited contribution to the heat treatment industry business volume.



4.2.2. Scale of the Heat Treatment Market (2015-2020)

The scale of the heat treatment market is calculated and presented as the sum of the works performed by the companies that carry our heat treatment activities. The scale of the market covers the heat treatment of finished products. In a previous study conducted in 2016, the size of the total heat treatment industry market in Türkiye was calculated as 3.05 billion TL or 1.12 billion dollars for 2015. The developments in the size of the market from 2015 to 2020 are presented below. Industrial production index data of the Turkish Statistical Institute and producer price index data of the institution are also used. Accordingly, production in the heat treatment industry increased by fluctuating over the years and shrank by 3.0 percent in 2020 due to the pandemic. A total production increase of 25.0 percent was realized in the 2015-2020 period. The heat treatment industry producer prices, on the

Table 12: Scale of the Heat Treatment Market

other hand, increased over the years with some fluctuations. Producer prices in the heat treatment industry increased by 126.8 percent in the 2015-2020 period.

When calculated with the help of these data, the size of the heat treatment industry market nominally was 3.05 billion TL in 2015 and reached 8.63 billion TL in 2020. The market grew by 183 percent in nominal terms between 2015 and 2020. In the same period, real growth was 25.0 percent, while price increases and nominal growth were higher.

The total heat treatment industry market size is calculated in Turkish lira and in nominal terms above. At this stage, the size of the market is calculated in US dollars. Accordingly, the size of the market, which was 1.12 billion dollars in 2015, increased to 1.34 billion dollars in 2018. However, in 2019 and 2020, the size of the market decreased in terms of US dollars due to both the slowdown and decline in production and the depreciation of the Turkish lira. The size of the market was realized as 1,225 billion dollars in 2020.

Source: Data from Turkish Statistical Institute were used.

	IEAT TREATMENT INDUSTRY PRODUCTION GROWTH (%) (REAL GROWTH BY QUANTITY)	HEAT TREATMENT INDUSTRY PPI (%)	HEAT TREATMENT INDUSTRY MARKET (MILLION TL)
2015	-	-	3,045
2016	4.8	9.0	3,480
2017	9.6	11.7	4,260
2018	8.2	37.4	6,330
2019	3.6	14.9	7,535
2020	-3.0	18.0	8,625
2015-2020 Cumu	lative 25.0	126.8	-



Source: Calculation of the Working Team.

Table 13: S	Scale of the Heat Treat	tment Market	
YEARS	HEAT TREATMENT INDUSTRY MARKET (MILLION TL)	ANNUAL AVERAGE (DOLLAR/TL RATE)	HEAT TREATMENT INDUSTRY MARKET (MILLION DOLLARS)
2015	3,045	2.72	1,120
2016	3,480	3.02	1,152
2017	4,260	3.65	1,167
2018	6,330	4.72	1,341
2019	7,535	5.68	1,327
2020	8,625	7.04	1,225



4.3. Key Indicators and Developments in Commercial Heat Treatment Industry

The main players of the heat treatment industry are the companies that carry out commercial heat treatment activities. Commercial heat treatment companies make up the total heat treatment industry size with companies that perform heat treatment within their own structure. In this context, this part of the report analyzes and evaluates the main indicators and developments of the commercial heat treatment industry.

4.3.1. Developments in Commercial Heat Treatment Industry Company Indicators

The developments regarding the companies operating in the commercial heat treatment industry are evaluated. Here, an important source of information regarding numerical indicators is the Union of Chambers and Commodity Exchanges of Türkiye.

According to the data prepared by the Union of Chambers and Commodity Exchanges of Türkiye (TOBB), covering companies that received a capacity report, the key sizes of companies operating in the commercial heat treatment industry for the end of 2015 and 2020 are also presented below. According to TOBB data, the number of companies operating in twelve provinces at the end of 2015 was 92 and the number of people employed was 3,025. As of the end of 2020, 107 companies are operating in fourteen cities and the employment is 3,770. The production capacity of 92 companies in 2015 was calculated as 237,400 tons. In 2020, the production capacity appears to be 500,000 tons.

TOBB data is aggregated with the data of companies that received a capacity utilization report that year. The data of companies that did not obtain a capacity utilization certificate

Source: Turkish Union of Chambers and Commodity Exchanges.

Table 14: Commercial Heat Treatment Industry Company Information

2015				2020	l		
CITIES	NUMBER OF COMPANIES	EMPLOYMENT	PRODUCTION CAPACITY (TON)	CITIES	NUMBER OF OMPANIES	EMPLOYMENT	PRODUCTION CAPACITY (TON)
Adana	4	130	5,998	Adana	5	224	25,305
Ankara	10	231	41,315	Ankara	12	250	97,657
Bursa	9	249	17,152	Bursa	11	340	25,000
Çorum	1	7	•	Denizli	1	8	•
Hatay	1	195	•	Hatay	2	703	•
Mersin	1	215	•	Mersin	1	211	•
Istanbul	36	925	81,891	Istanbul	33	615	99,144
Izmir	10	396	40,671	Izmir	8	460	38,126
Kayseri	1	6	*	Kayseri	1	6	•
Kocaeli	8	220	20,847	Kocaeli	12	289	57,906
Konya	8	277	12,508	Konya	14	491	34,113
Manisa	3	174	•	Manisa	5	138	12,893
				Sakarya	1	25	•
				Samsun	1	10	•
Total	92	3,025	237,400	Total	107	3,770	500,000

in that year are not included here. However, TOBB data still provides important information for the commercial heat treatment industry.

The number of new producers recently entered the sector in the commercial heat treatment industry has been limited. Existing companies continued to provide growth in the sector. However, the growth of the companies in the sector is also slow. Although the companies have an intense working schedule, small-scale structures continue. Companies need to become medium-sized. As a matter of fact, upon the rise of the pandemic, Europe's increasing imports of many products from Türkiye instead of Asia increases the heat treatment business potential. However, the small-scale nature of commercial heat treatment companies will limit the evaluation of this potential.

4.3.2. Developments in Total Production Capacity of the Heat Treatment Industry

The production capacity in the heat treatment industry in Türkiye consists of two groups. First one is the companies that are mainly engaged in commercial heat treatment. The second one is the production capacity and production of companies that perform heat treatment at their own.

As of 2015, the heat treatment industry's production capacity in Türkiye is predicted to be 1,430 thousand tons in total. The capacity of commercial heat treatment companies is 280 thousand tons, while the production capacity of companies performing their own heat treatment processes is 1,150 thousand tons. As of 2015, 20 percent of the heat treatment production capacity is owned by commercial heat treatment companies.

Between the years 2015 and 2020, the heat treatment industry production capacity increased with new investments. It is estimated that the production capacity of commercial heat treatment companies increased by 45,000 tons in this period. Thus, the production capacity increased from 280 thousand tons to 325 thousand tons.

It is estimated that there was an increase of 250,000 tons in the production capacity of companies that perform heat treatment within their own structure between 2015 and 2020. Thus, their

production capacity increased to 1.4 million tons. In recent years, many existing and new large-scale companies have made in-house heat treatment investments.

Thus, the total heat treatment industry production capacity increased by 20.6 percent or 295 thousand tons between 2015 and 2020, from 1.43 million tons to 1.725 million tons. In the 2015-2020 period, the total production increase in the heat treatment industry was 23.5 percent. Production capacity, on the other hand, expanded by 20.6 percent. Thus, despite the newly created capacities, some of the idle capacities of the previous period were also used.

While the production capacity of commercial heat treatment companies took a 19.6 percent share in the total, this share decreased to 18.8 percent in 2020.

The growth in the heat treatment industry is still in favor of the companies that carry out the heat treatments in-house.

4.3.3. Production in Commercial Heat Treatment Industry

Two topics are analyzed under the topic of production in the heat treatment industry in Türkiye. These are production technology and production qualities.

4.3.3.1. Production Technologies in Turkish Heat Treatment Industry

Heat treatment industry production technology in Türkiye has developed over the years and today the most advanced technology has become available. Production started with traditional methods and salt baths was applied with the use of technical equipment in 1960's years. With industrialization and factory scale production, furnaces have started to be used. In the first stage, second-hand furnaces and equipment were used more widely in the industry.

Today, medium- and small-scale commercial heat treatment companies which account for 80% of total production currently use advanced manufacturing technologies. The technology has been significantly advanced, particularly with the new capacity and renovation investments in 2000's. New technology of furnaces and equipment that are environmentfriendly and energy efficient are used. Use of advanced

Source: Calculated by the working team and sector representatives.

Table 15: Production Capacity of Turkish Heat Treatment Industry (Tons)

	2015	2020
Commercial Heat Treatment Companies	280,000	325,000
Industrial Companies Conducting Internal Heat Treatment Processes	1,150,000	1,400,000
Total	1,430,000	1,725,000



manufacturing technology is also supported by transition to automation and participation of foreign capital companies to respond to the increasing demand for quality standards. The heat treatment companies in Türkiye currently use similar technologies as their European competitors. Türkiye is largely foreign-dependent in manufacturing technologies in heat treatment industry. The new capacities added between 2015 and 2020 also consist of machinery and equipment that are compatible with digitization, automation and sustainability.

4.3.3.2. Production of the Heat Treatment Industry

Heat treatment industry production or activities in the world and in Türkiye are gathered in two groups. The first one is commercial heat treatment companies. The second one is companies that operate heat treatment at their own. There is a similar distribution in Türkiye as well.

Commercial heat treatment companies have shown a significant improvement over the last twenty years. Commercial companies in the heat treatment industry are completing the maturation period. Companies are often small and medium sized and have met especially international standards with technology and quality. Commercial heat treatment companies are working more efficiently with higher capacity utilization rates. Continuous improvement and efficiency enhancement studies are being carried out in order to meet high investment and operating costs. Another advantage of commercial heat treatment companies is continuous renewal by following new production technologies. However, commercial heat treatment companies are faced with problems such as scale, term, and capital.

In Türkiye, many domestic and foreign companies are involved in heat treatment at their own. There are many reasons for companies to do heat treatment processes in their production processes.

The most important of these are accelerating the process, overcoming bottlenecks, achieving quality and standards, and achieving cost advantage with scale. Firms apply heat treatment to critical parts, important parts due to safety and durability issues and precision works at their own. In addition, in areas such as the defense industry, heat treatment processes are also applied at their own to protect know-how. Besides, the heat treatment is applied at their own to meet the special demands of the customers. All production processes of the companies and the traditional attitude of have the furnaces at their own are also effective. In fact, companies start to perform their own heat treatment processes, as these processes reach, for example in fasteners, 70/80 thousand tons per month. Thus, losses occur in the commercial heat treatment market. However, in heat treatment processes, production and product technologies are being rapidly renewed, standards are being developed and expertise is increasing. Companies carrying out internal heat treatment processes make investments one time and the technology they have gets outdated quickly as they are not renewed. Capacity is left idle for a considerable period

and productivity drops. These companies also encounter various difficulties as they are not experts in heat treatment. Very frequent application and management mistakes can be made in the heat treatment process. These investments within the company lead to resource losses and additional costs that cannot be calculated.

One of the reasons for Turkish companies to carry out internal heat treatment processes was that the commercial heat treatment industry did not have sufficient quality and scale during the initial period. However, today commercial heat treatment has the potential to meet the demands of the industry for heat treatment in terms of industry quality and the scale.

For this reason, in accordance with the general trend in the world, the development of commercial heat treatment industry and companies in Türkiye should be provided. The commercial heat treatment companies in Türkiye must also become large scale, highly value- added, know-how accumulating, specialized and innovative companies and they must be supported for this purpose.

In addition, there are still some heat treatment processes that cannot be carried out in Türkiye because standards and quality cannot be met. These works are mostly abroad, and the requirements are met through imports. To substitute imports, commercial heat treatment companies should be supported towards achieving high quality and standards.

4.3.4. Characteristics of Commercial Heat Treatment Industry

In Türkiye, the commercial heat treatment industry is primarily composed of small and medium-sized companies, and it increasingly focus on high value-added heat treatment processes.

Employment and Human Resources

While employing an increasing number of qualified engineers and technical staff, the commercial heat treatment industry continues to be a labor-intensive industry. When evaluated in this framework, there are not enough qualified engineers, technical staff, and unqualified staff. Commercial heat companies in Türkiye often train their own human resources. There are two vocational high schools in Istanbul, and one vocational high school in Bursa and Ankara, which provides training in the heat treatment industry and opened by the private sector initiative. In this school, heat treatment laboratory was established by private sector, teachers were trained, and internship opportunities were provided to the students.

The professional definition of the heat treatment industry has been prepared and put into practice with the joint work of Metal Heat Treaters' Society (MISAD), which is a representative association of the industry, vocational qualification authority and Turkish Employers' Association of Metal Industries (MESS). Assessment criteria have been



prepared along with the definition and employees who are not graduated from vocational high school are getting professional qualification certificate if they pass the post-course examination they attend.

Energy Use

While commercial heat treatment industry is capital and labor intensive, it is also an energy intensive industry. The basic input of the heat treatment industry is energy. Within production costs, energy takes a high share. Natural gas and electricity prices in Türkiye and their costs to industry are high. For this reason, the competitive power of the commercial heat treatment industry is adversely affected. In the European Union, if companies make investments that increase energy efficiency, they will be supported both investments and if they do not meet the criteria, they pay 20-30 percent cheaper energy cost in the business process.

Environment

The commercial heat treatment industry operates as an industry branch with high environmental impact and consequently environmental sensitivity. The industry interacts with the environment in terms of water and energy consumption, the use of chemicals and the wastes generated. For this reason, the heat treatment is an industry to be affected by the European Union green deal regulations.

Export and Import

The heat treatment industry carries out its activities in the domestic market largely due to its characteristics. The industrial inputs to be heat treated are brought by the customers and after the heat treatment the inputs are sent to the production areas. Due to this structure of services, activities are carried out domestically.

The direct activities of the heat treatment industry, which are considered as exports, have significant indirect contributions to export. Industrial inputs brought from abroad by the temporary import method are heat treated and exported to abroad with the exact export record. However, this direct export service is very limited.

The main function of the commercial heat treatment industry arises with the heat treatment processes applied to the inputs used in the exported products and the fact that import is substituted because these processes are carried out in Türkiye. The heat treatment industry in Türkiye offers services to many industries with highest export rates, chief of them being the automotive industry, contributing to their achievement of quality and standards in their products as well as transition to value added manufacturing.

Costs/ Prices and Profitability

Depending on the services offered by the commercial heat treatment, energy costs, charges, prices of chemicals used as input (and exchange rates), transportation costs (closeness), scales, capacity utilization rates, and environmental costs are determinants of costs. Costs in the commercial heat treatment industry tend to increase. Costs of preparation and certification for international standards in the industry also appear as additional costs.

In the prices of heat treatment services, there is stagnation and a downward trend due to the idle capacity that emerged in recent years. Prices are between 0.15 and 0.75 cents per kilogram, depending on the technology level of the work done. The increase in the ability and share of high-tech jobs will move the average prices up.

The share of the commercial heat treatment cost in the total production cost of the heat-treated product continues to be between 1-2 percent. Internationally, this rate is 3-5 percent. The reason for the low share in Türkiye is that the payments made/prices given to commercial heat treatments are kept low. Price competition within the commercial heat treatment industry also strengthens this trend.

Companies that receive service from commercial heat treatment companies give their price offers in TL and the works are carried out in TL prices. However, TL prices, which have remained largely stable, are melting in real terms in the face of high inflation and the increase in exchange rates. These trends in costs and prices lead to reduced profitability.



4.3.5. Competition and Market Conditions in Commercial Heat Treatment Industry

Competition and market conditions for heat treatment industry in Türkiye have just begun to develop and mature. The added value created with heat treatment processes is high. However, there is a discrepancy between the created valueadded and heat treatment costs. In foreign countries, the heat treatment industry receives returns for the value- added it generates. For this reason, heat treatment in these countries amounts to as much as 10 to 15% in total costs while in Türkiye the rate is no bigger than around 3 to 5%. However, there is no difference between the value-added and commercial quality of heat treatment in Türkiye and abroad.

In Türkiye, price policies developed within current market and competition circumstances make it impossible for the heat treatment industry to get returns for the value-added and quality service it provides. Time and price pressures are experienced in the works made by commercial heat treatment companies in Türkiye. Heat treatments are often not included as a stage in the production processes of companies that do business and as an item in their costs and budgets. Heat treatment is not given enough importance and orders are given for very short terms. In turn, there is a significant price pressure on the market.

A significant part of the heat-treated products in Türkiye are exported or used for exported products. Companies exporting these products are also faced with price pressures before buyers. When these companies lower their prices, they try to reduce their costs in the production process, and they pressure the heat treatment prices downwards.

The price policy applied within the current market and competitive conditions often also reduces prices. This practice creates unfair competition as well as creating a reference for the price level of the industry and other companies are also adversely affecting. These pricing practices make a false impression on buyers.

Prices are pressured downward due to the sector inputs without measuring the business potential.

With the current price policy, the profitability of the companies falls, and no renewal investment can be made because the capital accumulation cannot be created. This process leads to further suppression of prices.

Thus, the commercial heat treatment industry cannot get in enough return for the investments and the added value it provides. For this reason, there is a need to improve market and competition conditions. Otherwise, new investment in commercial heat treatment will not be rational with current price and profitability level.

The commercial heat treatment industry in Türkiye is in the process of maturation in terms of market and competition conditions and aims to get out this process by increasing its competitiveness.

4.3.6. Commercial Heat Treatment Industry Market Size

The size of the commercial heat treatment industry market was calculated as 598 million TL or 220 million dollars in 2015. The commercial heat treatment market size also includes heat treatments for finished products.

The size of the market is nominally shaped by the effects of production increase and price increases. The production increase in the commercial heat treatment market between 2015 and 2020 was 22 percent according to the industrial production statistics of TURKSTAT.

The size of the market, which was 598 million TL in 2015, has grown gradually over the years. While the growth remained slower in 2016, faster market growth was realized in 2017 and in 2018 thanks to the real production and price increases, respectively. The growth in the market slowed down in 2019 with limited business growth. In 2020, despite the limited shrinkage in business, the market grew again in nominal terms due to price increases.

Within the framework of all these developments, the size of the market increased to 1,585 billion TL in 2020. The growth of the market in terms of US dollars was limited due to the depreciation of the Turkish lira. The size of the commercial heat treatment market was 220 million dollars in 2015 and 225 million dollars in 2020.

Jobs in the commercial heat treatment industry grew significantly in real terms between 2015 and 2020. This growth was mostly provided by existing producers. In this period, new producers entering the sector remained very limited. Existing companies have grown internally.

Despite the real increase in business/output, turnover in the same period remained broadly the same in terms of foreign currency. The depreciation of the Turkish lira eroded the foreign currency turnover. In the same period, profitability also decreased.

4.3.7. Key Indicators in Commercial Heat Treatment Industry

The number of companies operating in the commercial heat treatment industry in Türkiye increased to 220 in 2020 from approximately 200 in 2015. Approximately 70 percent of these companies are medium-sized companies operating with advanced technology.

The production capacity of commercial heat treatment industry companies was 280 thousand tons in 2015 and increased to 325 thousand tons in 2020. Its share in the total heat treatment industry production capacity dropped to 18.8 percent in 2020 from 19.6 percent.

Approximately 4,000 people were employed in the commercial heat treatment industry in 2015, and it is estimated that the employment will be around 5,000 in 2020.

The turnover of the commercial heat treatment industry is 220 million dollars as of 2015. Turnover increased to \$225 million in 2020. The share in the total heat treatment industry decreased to 18.4 percent.

Source: Calculated by using data from Turkish Statistical Institute.

Table 16:	Scale of Commercial H	eat Treatment Market			
YEARS	MARKET SIZE (MILLION TL)	MARKET SIZE (MILLION DOLLARS)	TL/DOLLAR RATE AVERAGE		
2015	598	220	2.72		
2016	676	224	3.02		
2017	828	227	3.65		
2018	1,228	260	4.72		
2019	1,395	245	5.68		
2020	1,585	225	7.04		

Table 17: Key Indicators in Commercial Heat Treatment Industry

	2015	2020
Number of Companies (Quantity)	200	220
Employment (Person)	4,000	5,000
Production Capacity (Ton)	280,000	325,000
Production Capacity Share (%)	19.6	18.8
Market Size (Turnover) (Million Dollars)	220	225
Market share (%)	19.5	18.4



4.3.8. Relations of Commercial Heat Treatment Industry with Other Sectors

The distribution of commercial heat treatments carried out in Türkiye by the sectors is presented and evaluated below in light of the developments between the years 2015-2020. The pandemic in 2020 caused a significant shrinkage in many industries, especially in the automotive industry. For this reason, there have been changes in the distribution of commercial heat treatments between sectors, especially in 2020.

Accordingly, 60 percent of commercial heat treatments were carried out in the automotive industry in 2015, and it is estimated to drop to 55 percent in 2020. It is estimated that the share of the machinery industry increased from 10 percent to 11 percent, the share of fittings from 7 percent to 9 percent, and the share of the metal goods industry from 3 percent to 4 percent in the 2015-2020 period. It is predicted that there would be no change in the shares of the infrastructure and construction materials industry, white goods industry, rail systems and aerospace and defense industry. Although the aerospace and defense industry has made significant progress in recent years, the demand for the commercial heat treatment industry from these sectors is very limited. Due to the high international standards sought in these sectors, manufacturers mostly carry out their heat treatments in-house. A comparison of the sectoral distribution of heat treatments in Türkiye and in the world for 2020 is presented below. Accordingly, the automotive industry continues to hold more than half of the jobs in Türkiye. In the world, there is a more balanced distribution. In the world, machinery industry, defense-aviation industry, infrastructure and building materials industry and metal goods industry have important shares. The distribution in the world is an important indicator in terms of the development dynamics of the industry in Türkiye.

Source: Working Team and Sector Representatives.

Table 18: Shares of Heat Treatment Sectors in Türkiye (Percentage)

SECTORS	2015	2020
Automotive Industry	60	55
Machinery Industry	10	11
Fittings and Hand Tools	7	9
Infrastructure and Construction Materials	5	5
White Goods Industry	5	5
Metal Goods Industry	3	4
Rail Systems	2	2
Aviation, Space and Defense Industry	1	1
Other	7	8

Table 19: Comparative Sectoral Distribution of Heat Treatment Services in Türkiye and the World (2020, Percent)

SECTORS	TÜRKİYE	GLOBAL
Automotive Industry	55	30
Machinery Industry	11	16
Infrastructure and Construction Materials	5	14
Fittings and Hand Tools	9	12
Metal Goods Industry	3	10
Aviation, Space and Defense Industry	1	11
White Goods Industry	5	2
Rail Systems	2	3
Other	8	2

4.4. Projections on Turkish Heat Treatment Industry

The fourth part of the study presents projections for the heat treatment industry in Türkiye. The projections include the medium-term period and the period up to 2025. The projections cover the general heat treatment industry but focus more on the commercial heat treatment industry. Again, projections are made for the heat treatments applied to the finished products. In this section, firstly, a SWOT analysis made on the commercial heat treatment industry as of 2021 is presented. Then, projections regarding the sectors served by the heat treatment industry are presented. They are followed by growth and development projections made for the total heat treatment and commercial heat treatment markets. It analyzes the possible effects of the European Union green deal (agreement) on the heat treatment industry. Finally, technology, material and process projections in the heat treatment industry are given.

4.4.1. SWOT and Pestel Analysis for the Commercial Heat Treatment Industry

The findings of the SWOT analysis made for the commercial heat treatment industry as of 2021 are presented below.

Strengths

Strengths of the commercial heat treatment industry include the advanced production technology used, the close monitoring and application of the developments in production technology, and the knowledge accumulated in the sector. In addition, many products that are exported undergo heat treatment. For this reason, strong export logistics infrastructure is also seen as the strength of the heat treatment industry. Association under the umbrella of MISAD has also strengthened the heat treatment sector.

Weaknesses

Small scales are the main weaknesses of the commercial heat treatment industry. The industry has not yet reached the scales that will provide optimum efficiency. Skilled labor shortage continues at all levels. Price competition, which causes prices to decline or remain stagnant in the industry, is another weakness. It has high costs compared to industry competitors. Profit margins and profitability remain low.

Opportunities

After the pandemic, global supply chains are changing. With this change, it is predicted that the dependency on Asia will decrease. This trend has already brought an increase in demand for Türkiye. The heat treatment industry will also be positively affected by this increase in demand. Similarly, nearshoring becomes important. Türkiye offers an important opportunity for buyers in its nearby markets. The heat treatment industry will also benefit from this trend. Implemented safeguard measures increase domestic supply. Accordingly, domestic heat treatment industry business volume will be positively affected. Full compliance with the European Union Green Deal will again provide opportunities against competitors who cannot adapt.

Threats

The most important threat to the commercial heat treatment industry remains the continuation of the trend of in-house



heat treatment. Many companies that receive service from commercial heat treatment companies still tend to switch to in house production when it comes to a certain scale. While companies making in-house investments can receive incentives, commercial heat treatment industry companies cannot benefit from investment incentives.

The increase in energy prices, which are rising all over the world and felt more in Türkiye, pose a significant threat. The high inflation and interest spiral environment of Türkiye also poses a threat to the profitability and capital accumulation of the sector. Inputs in the industry are mostly in foreign currency, while sales are in TL. This balance poses a significant threat due to the depreciation of the Turkish lira. The commercial heat treatment industry does not have sufficient capital accumulation for new investments and scale-ups. While the EU green deal offers opportunities, there will be a new threat to competition if adequate harmonization is not achieved. The rapid change in materials and processes in the heat treatment industry also poses threats.

In the PESTEL analysis of the commercial heat treatment industry, the following main findings have been determined for the upcoming period. PESTEL analysis includes political, economic, social, technological, environmental, and legal due diligence. The upcoming period includes the period until 2025.

Political Projections and Implications

The search for the balance of power will continue in the new post-pandemic conditions around the world. It is expected to experience a period in which political tensions will be resolved mostly through diplomacy. The elections to be held in Türkiye in 2023 will be effective in this period with its before and after. Türkiye's geopolitical risks will continue. The pursuit of improvement in foreign policy will remain after the election. Among these projections, there will be a period when uncertainties in the heat treatment industry, especially domestically, will increase and populist policies will come to the fore.

Economic Projections and Implications

While the world economy is recovering after the pandemic, the uncertainty of the future of the epidemic still poses a risk. Despite this, it is projected that the growth in the world economy will continue in the new conditions. However, the distinction between those who are vaccinated and those who are not will grow in the economy. In addition, income distribution will continue to deteriorate. With the effect of the change in the global supply chain, Türkiye will continue to grow mainly in exports, industry, and investments. Populist policies will gain weight in the economy due to the elections. It is projected that the spiral of high inflation, interest rates and increase in exchange rates will continue at least until the elections. The transition to a green economy and a circular economy will accelerate.

Table 20: SWOT Analysis for the **Commercial Heat Treatment Industry**

STRENGTHS

- Advanced production technology,
- Sectoral know-how,
- Export logistics infrastructure that contributes indirectly,
- Association under the umbrella of MISAD.

WEAKNESSES

- Small scales,
- Skilled workforce shortage,
- Intra-industry price competition,
- High costs, Low profit margins.

OPPORTUNITIES

 Increasing demand for Türkiye with change in the global supply chain and nearshoring,

- Increased freight prices,
- Precautionary measures applied in import,
- Opportunity to adapt to the EU green deal, The trend of digitization and automation.

THREATS

• Continuing trend of transition from commercial to inhouse,

- In-house investments can receive incentives,
- Rising energy prices,
- High inflation and interest rates,
- Inputs in dollars sales in TL,
 Depreciation in Turkish lira,
- Insufficient capital for new investments,
- Failure to comply with the EU green deal,
 Rapid change in materials and processes.

Social Projections and Implications

Income inequality and increasing immigration and refugees will be the most important problems in the world and in Türkiye. There is no improvement in this area in the mid-term.

Technology Projections and Implications

Advances in technology will continue in all areas. Due to the outbreak, the importance of biotechnology and health technology is increasing. Digitization is accelerating. Automation and robotic system technologies in production will expand. Intelligent and autonomous product technologies will also develop. There will also be significant advances in green energy and clean energy technologies. The entry

and penetration of technologies into human life will also accelerate.

Environmental Projections and Implications Environmental regulations will become much more stringent towards the goals of the Paris Climate Agreement. Regulations will shape economic and social life. The European Union green deal will lead the way in these regulations. Compliance with sustainability will change all stages of life.

Legal, Democracy Projections and Implications Investments around the world will continue to be directed towards democratic and rule-of-law countries. Every step that our country will take, especially in individual freedoms, labor law, commercial contracts, and receivables, will make it stand out compared to other developing countries, and will increase the number and magnitude of investments.

4.4.2. Development Projections for the Sectors Served by the Commercial Heat Treatment Industry

Development projections in the sectors served by the commercial heat treatment industry will largely shape the growth projections of the commercial heat treatment industry. The growth and developments in the sectors will also determine the demand for the heat treatment industry. In this respect, this part of the study focuses on growth and development expectations in the sectors served by the heat treatment industry.

Development Projections for Automotive Industry and Sub-industry

Production capacity in the automotive industry will increase as much as the initial production capacity of domestic automobile TOGG. In addition, on the commercial vehicles side, the capacity will increase with the FORD investment. It is projected that there will be an increase of close to 500 thousand in annual production capacity in the period until 2025. On the other hand, electric, hybrid, environmentally friendly and lighter vehicle technology has come to the fore in automotive production. For this reason, it is projected that some of the domestic production capacity will be dominated by these technologies. There will be a significant transformation in the sub-industry. With the transition to electric, hybrid and environmentally friendly vehicles, production will be required for these vehicles. In this respect, there will be closures in one part of the sub-industry and new initiatives in another part. As for the heat treatment industry, the automotive industry will support the heat treatment volume to a limited extent in terms of quantity, while it will lead to the need for more technology, material, and process changes. The share of the automotive industry in the heat treatment market will also drop to a limited extent until 2025.

Development Projections for Machinery Industry An above-average growth is expected in the machinery industry until 2025. In the conditions that emerged with the pandemic, machinery and equipment investments will show a rapid growth in 2022-2023 both in the world and in Türkiye. Therefore, the demand for machinery and equipment will also be high. In addition, important incentive programs are implemented in the field of localization for the machinery industry in Türkiye. In the coming period, many new machinery facilities will start production. When evaluated in terms of the heat treatment industry, the machinery industry will be the most important sector creating additional demand in the upcoming period. In this respect, it is projected that the share of the machinery industry in the heat treatment market will rise to 14 percent in 2025.

Development Projections for Fittings and Hand Tools Industry

Fittings and hand tools are one of the sectors to benefit most from the change and nearshoring trend in the global supply chain in Türkiye. In the upcoming period, the demand for the sector will continue to increase, especially from Europe and the region close to it. Domestically, it is projected that protection measures will continue, and additional capacities will be created. Fittings and hand tools will be in rapid growth. When evaluated in terms of the heat treatment industry, the demand of the fittings and hand tools industry for the heat treatment industry will be above the average. It is projected that the share of the fittings and hand tools industry in the heat treatment market will increase to 10 percent.

Infrastructure and Construction Materials

Infrastructure investments in the US and investments in compliance with the green deal in the EU will drive the demand for infrastructure and building materials in these markets. Turkish building materials exports will also be positively affected. A slow growth is expected in the construction sector in the domestic market. Although support for the sector is expected before the 2023 elections, the demand side will remain weak due to high interest rates. When evaluated in terms of the heat treatment industry, the contribution of the infrastructure and construction materials industry to the heat treatment industry business volume will be limited. In this respect, it is projected that the share of the infrastructure and construction materials industry in the total heat treatment industry business volume will decrease to 4 percent.

White Goods Industry

The white goods industry has become one of the largest production capacities in the world. Capacity, technology, and product diversification investments will continue. The white goods industry will be another Turkish industry to benefit most from the change in the global supply chain and the trend of close supply. In the upcoming period, the increase in demand for the industry will accelerate, especially from Europe and the nearby geography. In the domestic market, high inflation and the slowdown in the housing sector will limit the demand for white goods. On the other hand, the demand in \longrightarrow

the aftermarket will increase significantly. In terms of the heat treatment industry, the contribution of the white goods industry to the heat treatment industry business volume will be high. In this respect, it is projected that the share of the white goods industry in the total heat treatment industry business volume will rise to 6 percent.

Metal Goods Industry

The metal goods industry has reached an important capacity. However, it is one of the industries to benefit most from the change and nearshoring trend in the global supply chain in Türkiye. Therefore, new investments and production increase are expected in the coming period. It is projected that the demand for the metal goods industry will remain high due to the developments in the related sectors in the domestic market as well.

When evaluated in terms of the heat treatment industry, the contribution of the metal goods industry to the heat treatment industry business volume will be close to the previous period averages. In this respect, it is projected that the share of the metal goods industry in the total heat treatment industry business volume will remain the same as 3 percent.

Aviation, Space and Defense Industry

There is a significant development in the defense industry in Türkiye. In the coming period, many new projects will be put into production. Advances in technology and production, especially in unmanned aerial vehicles, will continue. In terms of the heat treatment industry, the contribution of the aerospace and defense industry to the heat treatment industry business volume will be high. In this respect, it is estimated that the share of the industry in the total heat treatment industry business volume will increase to 3 percent.

Rail Systems

Türkiye aims to expand the high-speed train network, renew existing train lines, joining regional train lines, while it aims to use light rail systems and subway systems in urban transportation. For this reason, important infrastructure investments and equipment production will be realized in the field of rail systems in short, medium, and long terms. When evaluated in terms of the heat treatment industry, the contribution of rail systems to the heat treatment industry business volume will be high. In this respect, it is estimated that the share of the industry in the total heat treatment industry business volume will increase to 3 percent.

4.4.3. Projections on the Market Size of Turkish Heat Treatment Industry

In this part of the study, projections are made for the market size of the Turkish heat treatment industry. The results of the SWOT analysis and PESTEL analysis made for the industry are used in the projections. Again, growth and development projections in the sectors served in the heat treatment industry are used. Separate estimates are made for the total heat treatment industry and for the commercial heat treatment industry. In this framework, first, the annual

Table 21: Projections on Sectoral Distribution of Heat Treatment Services in Türkiye (Percent)

SECTORS	2020	2025
Automotive Industry	55	50
Machinery Industry	11	14
Fittings and Hand Tools	9	10
Infrastructure and Construction Materials	5	4
White Goods Industry	5	6
Metal Goods Industry	3	3
Aviation, Space and Defense Industry	1	3
Rail Systems	2	3
Other	8	7

Table 22: Projections on Business Volume in Turkish Heat Treatment Industry (Percent)

YEARS	INCREASE IN TOTAL HEAT TREATMENT INDUSTRY PRODUCTION/BUSINESS VOLUME	INCREASE IN COMMERCIAL HEAT TREATMENT INDUSTRY PRODUCTION/BUSINESS
2021	12	10
2022	4	4
2023	3	3
2024	4	4
2025	4	4
2021-2025 Cumulative	30	27

Source: Prepared by the working team.

Table 23: Projections on Monetary Aggregates in the Heat Treatment Industry (Million Dollars)

YEARS	TOTAL HEAT TREATMENT INDUSTRY PRODUCTION/ BUSINESS VOLUME	COMMERCIAL HEAT TREATMENT INDUSTRY PRODUCTION/BUSINESS VOLUME
2020	1,225	225
2021	1,300	240
2022	1,380	255
2023	1,450	265
2024	1,540	280
2025	1,630	295

increase expectations in production or business volume in the heat treatment industry are put forward. Then the size of the market is predicted in monetary terms.

4.4.3.1. Projections on Business Volume in the Heat Treatment Industry

In the heat treatment market, business volume projections are made for each year and at the end, the cumulative growth expectation between 2021 and 2025 is put forward. High business volume increases were experienced in 2021. In 2022, business volume growth will slow down due to the base effect. In 2023, however, it is projected that the growth in business volume will slow down with the uncertainty created by the elections to be held. It is projected that the heat treatment industry business volume will grow close to the average in 2024 and 2025. Within the framework of these projections, the total heat treatment industry production or business volume will grow by 30 percent between 2021 and 2025, and the commercial heat treatment industry production/business volume will grow by 27 percent.

4.4.3.2. Projections on Monetary Aggregates in the Heat Treatment Industry Market

The monetary size projections of the market in the heat treatment industry are calculated and presented below. Calculations are in US dollars. Two variables are used in the calculation. The first one is the projections on production or business volume increases made above for each year. The second is the assumption that there is 2 percent inflation or price increase in dollars for each year. Therefore, variables



such as price changes and fluctuations in the value of Turkish Lira are excluded from the calculation.

There is a rapid expansion in the total heat treatment market, especially in 2021. However, in 2021, the Turkish Lira will again depreciate significantly, which will negatively affect the size of the market in dollar terms.

The growth in the market slows down after 2021. The size of the market, which was 1.225 billion dollars in 2020, is expected to grow by 33 percent until 2025 and reach 1.63 billion dollars in 2025.

The commercial heat treatment market will also show similar growth over the years. The market, which was 225 million dollars in 2020, is expected to grow by 30 percent until 2025 and reach 295 million dollars.

4.5. Possible Impacts of the EU Green Deal and the Carbon Border Adjustment Mechanism on the Turkish Heat Treatment Industry

In July 2021, the European Union announced the necessary regulatory proposals to achieve the targets set by the green deal. These proposals will be negotiated, approved, and enacted by the end of 2022.

In this framework, the EU also announced its Carbon Border Adjustment Mechanism (CBAM) proposal. CBAM will start on January 1, 2023, and a transition period will be applied for the first three years without any financial obligations. Thus, the obligation of companies exporting to the EU to actually pay a carbon tax at the border will be on January 1, 2026, at the earliest. Companies exporting to the EU have gained significant time for harmonization.

Among the sectors that will be subject to the transition process to the Carbon Border Adjustment Mechanism are the iron and steel sector and the aluminum sector, which constitute the largest business volume of the heat treatment industry. Türkiye exports these products to the EU to a significant extent.

Carbon emissions in production will be calculated for the export of products in these sectors to the EU. Carbon emissions in three stages will be taken into account in the calculation of carbon emissions in production. These are:

1. Direct carbon emissions at the production stage,

2. Carbon emissions during the production and use of the energy used,

3. Carbon emissions arising from the production of the inputs used and the services received.

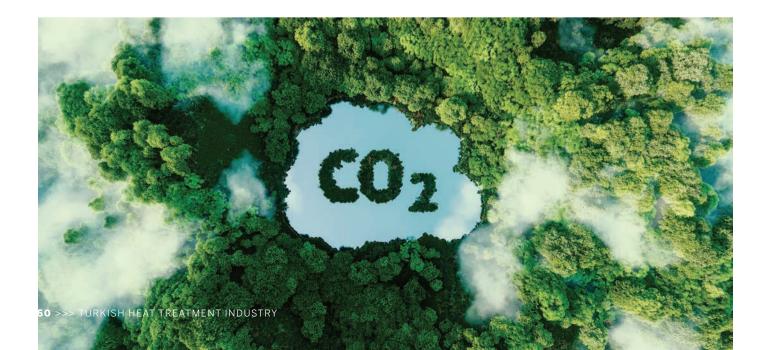
In the calculation of the total carbon emission of the exported product, the carbon emission created by the heat treatment industry appears in the third stage above.

In this framework, the heat treatment industry will have to produce carbon emissions within the reference values to be determined by the EU while providing services for the exported product.

Companies that produce and export heat-treated products will also prefer heat treatment industry companies that generate carbon emissions within the EU reference values in order to pay less or no carbon tax.

The border carbon regulation mechanism will be able to push the producer/exporter companies to do heat treatment by themselves, instead of receiving services from commercial heat treatment companies in order to control carbon emissions resulting from heat treatment.

For this reason, commercial heat treatment companies will have to make improvements to keep their carbon emissions within the reference values to be determined by the EU during the transition period. Again, heat treatment companies will have to measure, monitor, and certify their carbon footprints.





RECOMMENDATIONS FOR THE HEAT TREATMENT INDUSTRY



RECOMMENDATIONS FOR THE HEAT TREATMENT INDUSTRY

Problems of Turkish heat treatment industry, solution recommendations and development of the heat treatment industry are given in the fifth part of the report.

1. Definition and Independent Evaluation of the Heat Treatment Industry

Problem:

The heat treatment industry is not included independently in the current regulations (law, communique, incentive etc.), its visibility is reduced within the metal goods industry and an incomplete definition is made implying quenching.

Solution Proposal/ Requirement:

Heat treatment industry must be addressed independently and with its official name in the regulations. New and up-todate definition must be provided in the current legislation. Public regulations about the heat treatment industry (business life, environment, etc.) must be made independently.

Related Institutions:

Ministry of Industry and Technology, Ministry of Commerce, Ministry of Labor and Social Security, Ministry of Environment, Urbanization and Climate Change, Local Authorities.

2. Heat Treatment Industry Is Classified within Highly Dangerous Works Group

Problem:

Heat treatment industry is classified within "highly dangerous works" group. In global practice, heat treatment industry is not classified within "highly dangerous works" group thanks to technological advancements and new process methodologies.

Solution Proposal/ Requirement:

Heat treatment must be classified as dangerous work. Thus, occupational health and safety regulations of heat treatment industry must be amended.

Related Institution: Ministry of Labor and Social Security

3. Limitation of Maximum Daily Working Hours in the Industry with 7.5 Hours

Problem:

Maximum daily working hours in the heat treatment industry are limited with 7.5 hours. However, furnaces and production processes in the heat treatment industry do not stop for 24 hours due to the nature of this process. Processes take longer than one shift. Also, things have become semi-automated.

Solution Proposal/ Requirement:

Current heat treatment technology eliminated the laborintensive aspect of the sector. Working environment has high standards with respect to occupational health and safety. Therefore, this limitation should be removed.

Related Institution:

Ministry of Labor and Social Security.

4. Need for, and Placement of, Qualified Human Resources

Problem:

The heat treatment industry uses medium-high and high technology industries, and in this respect, it is an industrial branch that performs high-tech and value-added activities. The industry needs qualified engineers, technical staff and workers and R&D specialists.

Solution Proposal/ Requirement:

In the Metallurgical and Materials Engineering departments of universities, heat treatment classes must be made compulsory, and it should be taught in 4-year faculties and 2-year vocational high school programs. Professional qualification certificate trainings for workers must be supported with internal training expenditures. The number of heat treatment departments should be increased in the vocational high schools and scholarship paid internship opportunities should be offered to students in order to encourage them to study this program. After graduation, on-the-job training/ induction training programs must be organized in collaboration with Turkish Labor Agency (İŞKUR) and part time working must be supported by İŞKUR.

Audits aimed at preventing off-the-record employment must be increased and unfair competition must be prevented in the industry.

Related Institutions:

Ministry of National Education, Ministry of Labor and Social Security

5. Uncertainty in Environmental Regulations and Support Requirements

Problem:

There is uncertainty in the definition and classification of environmental regulations in the heat treatment industry. Therefore, diverse, and wrong applications and investments are observed. License cancellations are also observed.

Solution Proposal/ Requirement:

A special environmental regulation must be enacted for the heat treatment industry and classification, job description, inputs used, wastes generated, disposal of wastes must be clarified, and environmental practices must be unified. In addition, environmental investments of companies must be supported.

Related Institutions:

Ministry of Environment, Urbanization and Climate Change, Local Governments, Ministry of Industry and Technology.

6. Special Consumption Tax on Heat Treatment Oils

Problem:

Oils used directly as cooling media in heat treatments are subject to SCT, as are solvents and benzol-type products added to fuel oil, and mineral oils.

Solution Proposal/ Requirement:

SCT must be lifted for oils used in the heat treatment industry.

Related Institution:

Ministry of Treasury and Finance.

7. Inability to Benefit from Eximbank Loans

Problem:

Since the heat treatment industry does not export directly, Eximbank may not use its loans directly. However, a significant part of the heat-treated inputs is used in the exported final products. The application of access to Eximbank loans through final exporting companies does not work.

Solution Proposal/ Requirement:

Companies that apply heat treatment to the inputs of companies that export final products in the heat treatment industry should be able to use Eximbank loans directly. For this purpose, Eximbank should start a new program and heat treatment companies should be provided with an Eximbank loan at a rate to be determined within the scope of TÜİK data on their turnover.

Related Institutions:

Eximbank, Ministry of Commerce, Ministry of Treasury and Finance.

8. Classification and Promotion of the Heat Treatment Industry as a High-Tech Industry

Problem:

The heat treatment industry carries out high-tech operations and serves to medium-high and high-tech industries. On the other hand, since metal goods are classified within the industry, they are considered as medium-low technologyintensive industries and benefit from incentives in this way.

Solution Proposal/ Requirement:

The heat treatment industry should be classified as a high-tech industry and should be supported. In particular, investment incentives should be provided in this context.

Related Institutions:

Ministry of Commerce, Ministry of Industry and Technology.

9. Inadequacy of Monitoring in Imports

Problem:

Even though many products imported and used as input must be heat treated, these products are imported without applying heat treatment. These products are, then, cause quality and standard related problems and create unfair competition against quality domestic production. Again, second-hand and old technology heat treatment furnaces and machines are included in the integrated plant investments and imported.

Solution Proposal/ Requirement:

Strict inspections must be applied about the import of heattreated products. Sample tests must be performed before customs clearance. Thus, unfair competition crated by imports must be prevented.

Related Institution:

Ministry of Commerce.



10. Uniform Quality and Business Standards in the Industry

Problem:

Current market and competition conditions of the industry must be improved.

Solution Proposal/ Requirement:

Minimum quality and business standards must be created in the industry and an auto-control mechanism must be established.

11. On-site Incentive for Investments Needed for Harmonization with the European Union Green Deal

Problem:

Significant investment is needed in the commercial heat treatment industry to comply with EU Green Deal regulations. There is a need for new investments in areas such as the transition to machine parks with low carbon emissions, renewable energy investments, energy efficiency, waste management and recycling.

Solution Proposal/Requirement:

Adaptation investments to be made by existing commercial heat treatment industry companies should be included in the scope of investment incentives regardless of region.

Related Institution: Ministry of Industry and Technology.

12. Inability of Most of the Commercial Heat Treatment Industry Companies to Benefit from Investment Incentives

Problem:

Most of the commercial heat treatment companies are located in the first and second regions and their onsite new, expansion and modernization investments do not receive incentives. On the other hand, companies operating in other sectors that invest in heat treatment can receive investment incentives according to their regions.

Solution Proposal/ Requirement:

New/expansion and modernization investments of existing commercial heat treatment companies should benefit from investment incentives regardless of region.

Related Institution: Ministry of Industry and Technology.

13. Recommendations for Increasing Commercial Heat Treatment Business Volume

Problem:

Business volume is growing slowly in the commercial heat treatment industry and the scales remain small. The tendency of companies to invest in heat treatment within their own structure is still strong.

Solution Proposal/ Requirement:

a. Long-term supply agreements should be made between commercial heat treatment companies and companies that are growing in business volume and want to do in-house heat treatment.

b. Cooperation agreements should be made between companies whose business volume is growing and wanting to do heat treatment within their own structure and commercial heat treatment companies, companies should provide the machinery parks, production and operation should be done at the commercial heat treatment company's facility and by the commercial heat treatment company.

c. The equity capital of the heat treatment companies is insufficient for new investments and therefore investment loans should be provided to the companies by the Development and Investment Bank.

14. High Energy Prices

Problem:

The heat treatment industry is an energy-intensive industry. Increases in electricity and natural gas prices significantly reduce profitability. In addition, the industry must use renewable energy. However, renewable energy price tariffs are also very high. Recently, there has been a rapid transition to the use of electric furnaces, and therefore electricity prices have become even more critical.

Solution Proposal/ Requirement:

Energy prices should be reduced to reasonable levels by reducing taxes on electricity, renewable energy and natural gas prices used in industrial facilities.

Related Institutions:

Ministry of Energy and Natural Resources, EMRA, Ministry of Treasury and Finance.









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