Energy Transition Center

Executive Summary:
Electrification of Türkiye’s Residential and Industrial Process Heat

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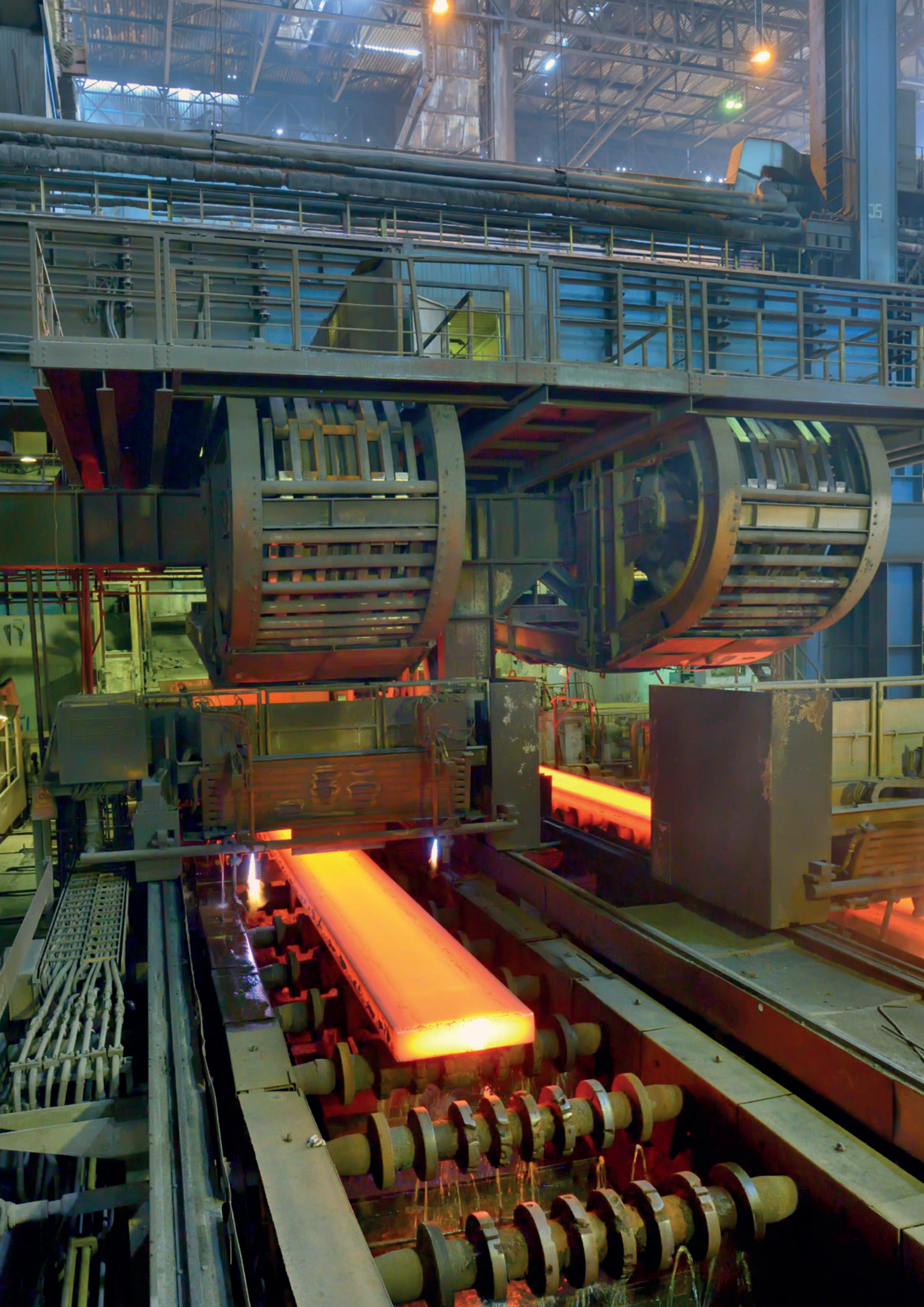


Executive summary

Electrification refers to the process of converting a machine or system into a state that consumes power. Examples of electrification include the transition from gasoline vehicles to electric vehicles, from gas boilers to heat pumps, and from gas cookers to electric ones. Electrification is a crucial strategy for decarbonizing the energy sector. Despite significant progress in decarbonization through the use of renewable energy in power generation, energy-intensive end-user sectors such as industry, buildings, and transport remain heavily reliant on fossil fuels. Electrification of these sectors, where current renewable energy utilization is limited, enables the replacement of fossil fuels with power generated from renewable energy sources. When combined with digital technologies, electrification ensures smart and efficient energy use, resulting in significant savings for end-use sectors. The efficiency achieved through electrification and the replacement of fossil fuels with zero-emission power in end-use sectors make it possible to reduce greenhouse gas emissions arising from energy consumption. In this regard, the most significant contribution of electrification to Türkiye is the reduction of fossil fuel dependency in final consumption. This is important for reducing energy imports and the current account deficit of Türkiye, which shows high external dependency in energy, as well as for maintaining energy security.

In October 2021, Türkiye ratified the Paris Agreement and subsequently declared its commitment to achieving a net zero greenhouse gas emission economy by 2053. This ambitious target necessitates a transition from fossil fuels to a renewable energy-based system, as well as the decarbonization of energy-intensive sectors such as industry, buildings, and transportation. Additionally, the target requires a shift towards energy-efficient, low-carbon, and high-value-added production methods for industry. While ensuring supply security, economic access to energy, and emissions mitigation are crucial factors in Türkiye's energy transition, numerous policies are being rapidly developed to address these concerns. Among the most significant strategies within the context of electrification are those that aim to promote the direct use of electricity by these sectors (e.g., through the use of electric vehicles or heat pumps in buildings) or indirectly (e.g., through synthetic fuels or green hydrogen obtained by electrolysis). The power system is therefore the backbone of Türkiye's efforts to achieve its net zero emission targets and decarbonize its economy.

When fossil fuels used as raw material in industry and in the transport sector are excluded, power consumption comprises only 28% of the final energy consumption in Türkiye (ETKB, 2021). 6% of the final energy consumption is provided directly from renewable resources (biomass, geothermal and solar energy), while 66% of energy need is met from waste heat, natural gas, coal, and oil, as shown in Figure 2. Therefore, even if complete decarbonization of the power sector is fulfilled, this does not mean that the entire energy use is decarbonized. In this respect, increase in the share of power use in all sectors and obtaining the necessary power from renewable energy is an important strategy for decarbonization.

Figure 1: *Total final energy consumption (2021)*

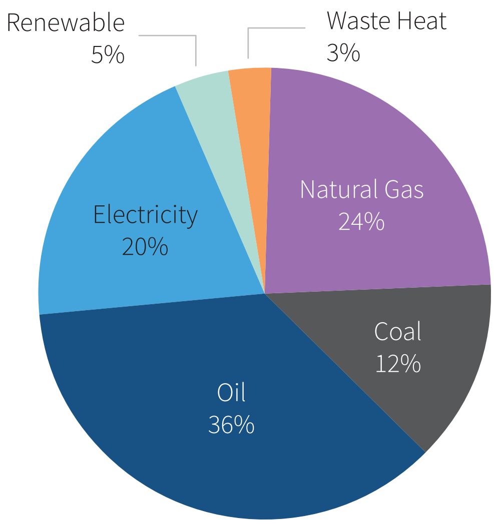
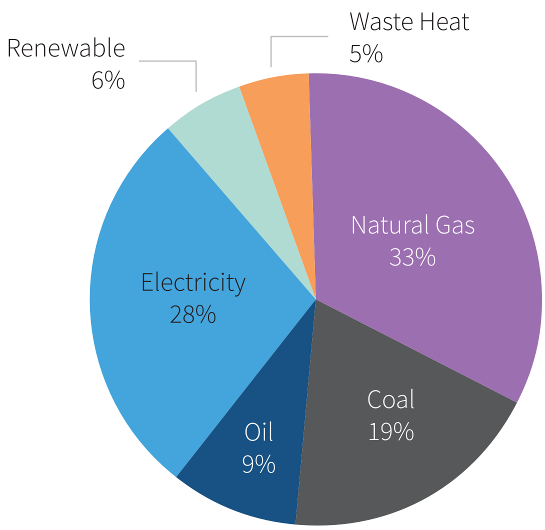


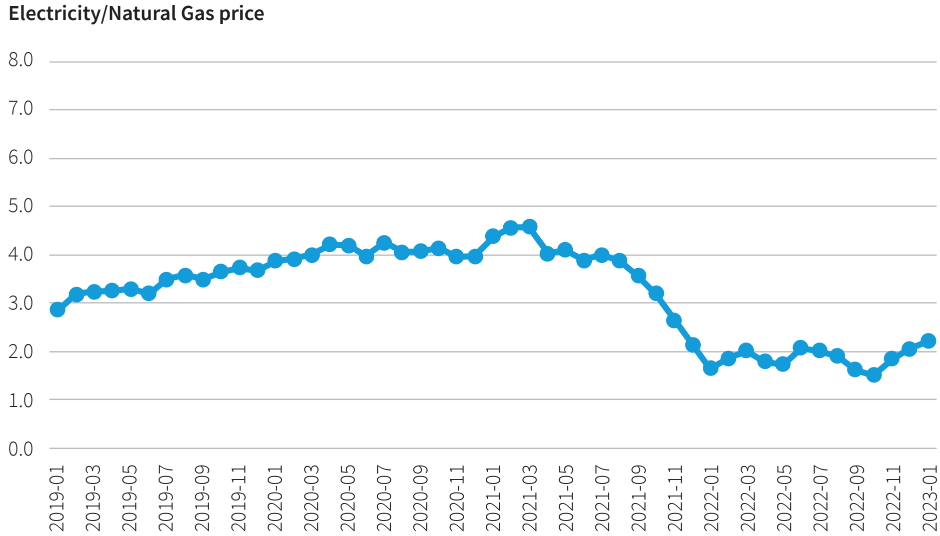
Figure 2: *Final energy consumption excluding transport and raw materials in industry (2021)*



As shown in Figure 1, the share of electricity in total final energy consumption is about 20% in Türkiye. Transition to electrification can be defined as increase in the share of power in final energy consumption. Within the scope of this report, **both replacement of fossil fuel use directly with power utilization and increase in the share of already electrified processes in the forthcoming years through new investments** is defined as electrification. Yet, indirect electrification methods, such as production of hydrogen by means of electrolysis and subsequently using this as a fuel, are beyond the scope of this report.

Today, the need for heat in industry and buildings are mainly met by fossil fuels. Traditionally, fossil fuels are preferred to electricity due to past investments and relatively lower overall costs of these fuels. Since power generation depends mainly on fossil fuels, increases in fossil fuel prices generally resulted in rising electricity prices. The ratio of retail electricity prices to natural gas prices for the last four years is given in Figure 3. In the figure, wholesale power market prices and natural gas market prices published by EXIST are shown in order to exclude subsidy effects on prices.

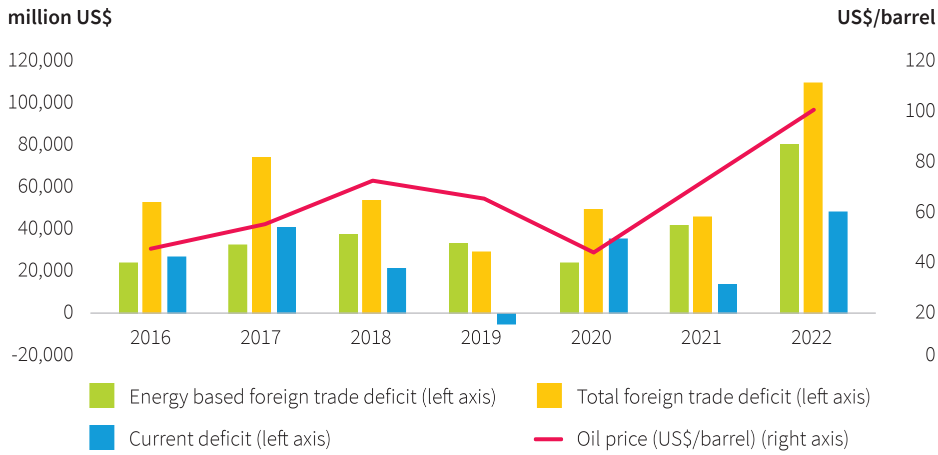
Figure 3: *Ratio of spot electricity prices to natural gas prices*[1]



As can be seen in Figure 3, electricity prices in recent years have been 1.5 to 4.6 times higher with respect to natural gas prices. On the other hand, due to spread of renewable energy sources, **electricity prices are on the way to be independent from fossil fuel prices such as natural gas and coal.** Therefore, the use of electricity in final consuming sectors is likely to become increasingly more economic. From the perspective of energy, direct use of electricity is significantly more efficient than fossil fuels. This indicates that in terms of economy, electricity prices will become more favorable for all end-use sectors in the coming years.

Imports of energy constitutes a high share of Türkiye's current account deficit (Figure 4). **Therefore, increase in electrification in parallel to the increase in renewable energy will help the country to reduce this deficit.** Even if the entire power required by heat pumps were to be produced in natural gas plants, 50% savings in natural gas imports would be achieved, thanks to high coefficient of performance (COP) values.[2]

Figure 4: *Development of energy based and total foreign trade deficit, current account deficit and oil prices during 2016-2022 (million US$)*



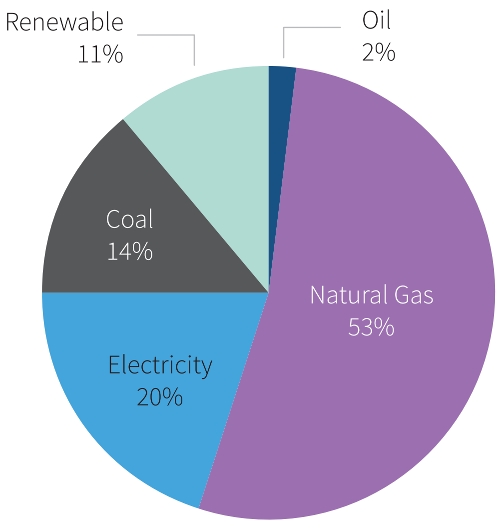
[1] Including distribution costs and taxes.
[2] 0.55 kWh natural gas generates 0.33 kWh power. With COP=3 heat pump, 0.33 kWh power generates 1 kWh heat. On the other hand, 0.55 kWh natural gas generates 0.50 kWh heat in one gas tank.

Electrification will reduce Türkiye's dependence on imports both through higher efficiency and through the use of power generated from renewable energy. It will also strengthen energy supply security, reduce energy costs, and contribute to decarbonization of the energy sector. Within the scope of this study, electrification of both residential heating and industrial process heat are analyzed.

Residential buildings

In Türkiye residential buildings are mainly heated with fossil fuels. While 60% of buildings are heated with natural gas and 34% with coal, the share of electricity is only around 6% (TSI, 2021). Distribution of energy consumption in residences is shown in Figure 5.

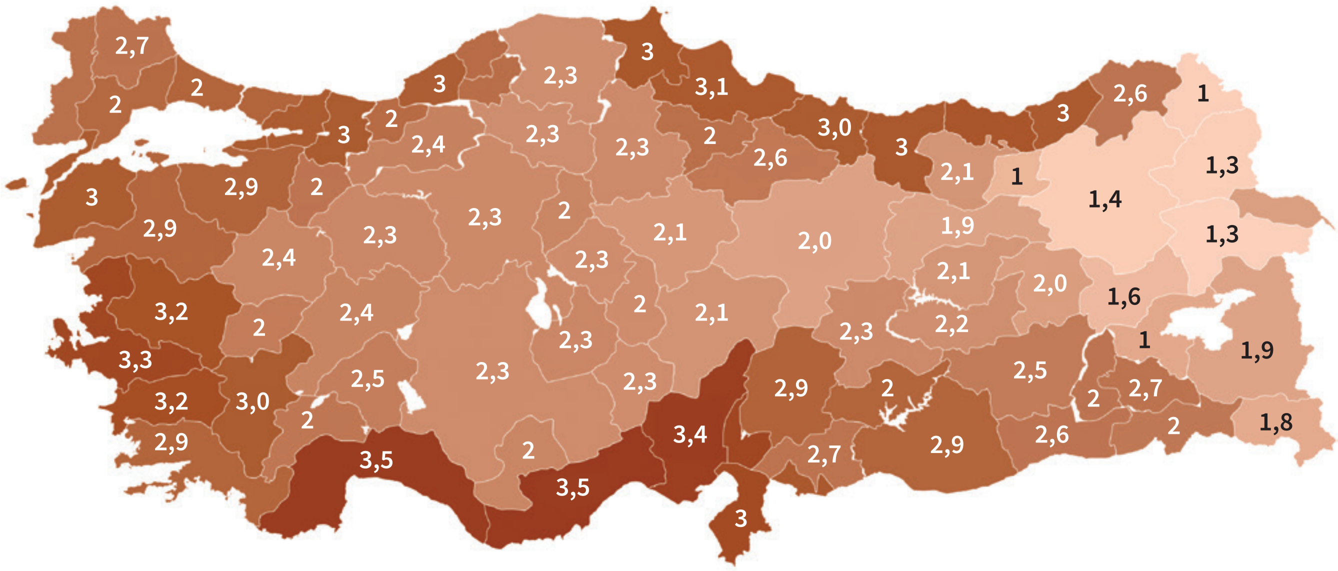
Figure 5: *Distribution of energy consumption in residential buildings*



With regard to electrification, the heat pump is deemed the most suitable heating technology for buildings due to its exceptional efficiency. While natural gas combi/boilers boast an efficiency of 85-90%, heat pumps have the ability to generate heat up to approximately 3 to 5 times the amount of consumed power (IEA, 2022). The performance coefficient of a heat pump (COP) is determined by the ratio of obtained heat to consumed electrical energy. As the input and output temperatures of a heat pump converge, the COP increases. Therefore, if the input temperature is elevated using ground source heat pumps or the output temperature is lowered using ground heating, the efficiency of the heat pump is enhanced. However, ground heating is not commonly utilized in Türkiye and outdoor temperatures during winter are typically low, particularly in the central and eastern regions of the country. Consequently, as illustrated in Figure 6, the COP[3] of residential air source heat pumps in Türkiye averages approximately 2.75.

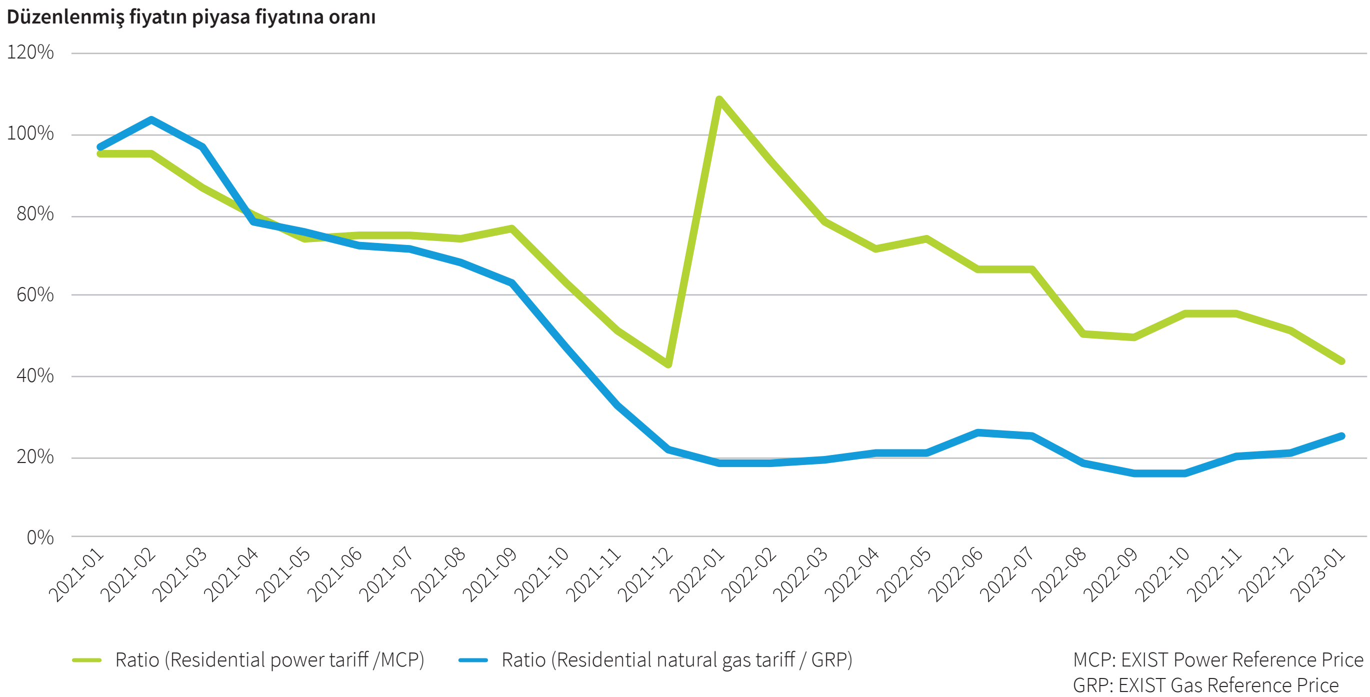
[3] Ground source heat pumps should be considered below COP=2.

Figure 6: Average COP values of air to water heat pumps by cities



Price ratios shown in Figure 3 indicate that, in terms of operating costs, heat pumps may compete with natural gas, on the condition that COP value is over 2 and that both power and natural gas are supplied from the free market. However, in Türkiye **subsidies are provided both for retail power tariffs and natural gas tariffs.** Currently, residential natural gas tariffs are subsidized more than residential power tariffs. In figure 7 below, subsidy levels of residential power and natural gas prices with respect to spot market prices are shown. For instance, while regulated power prices in January 2023 are 44% of EXIST day ahead market clearing prices (MCP), regulated natural gas prices are about 25% of gas reference price (GRP).

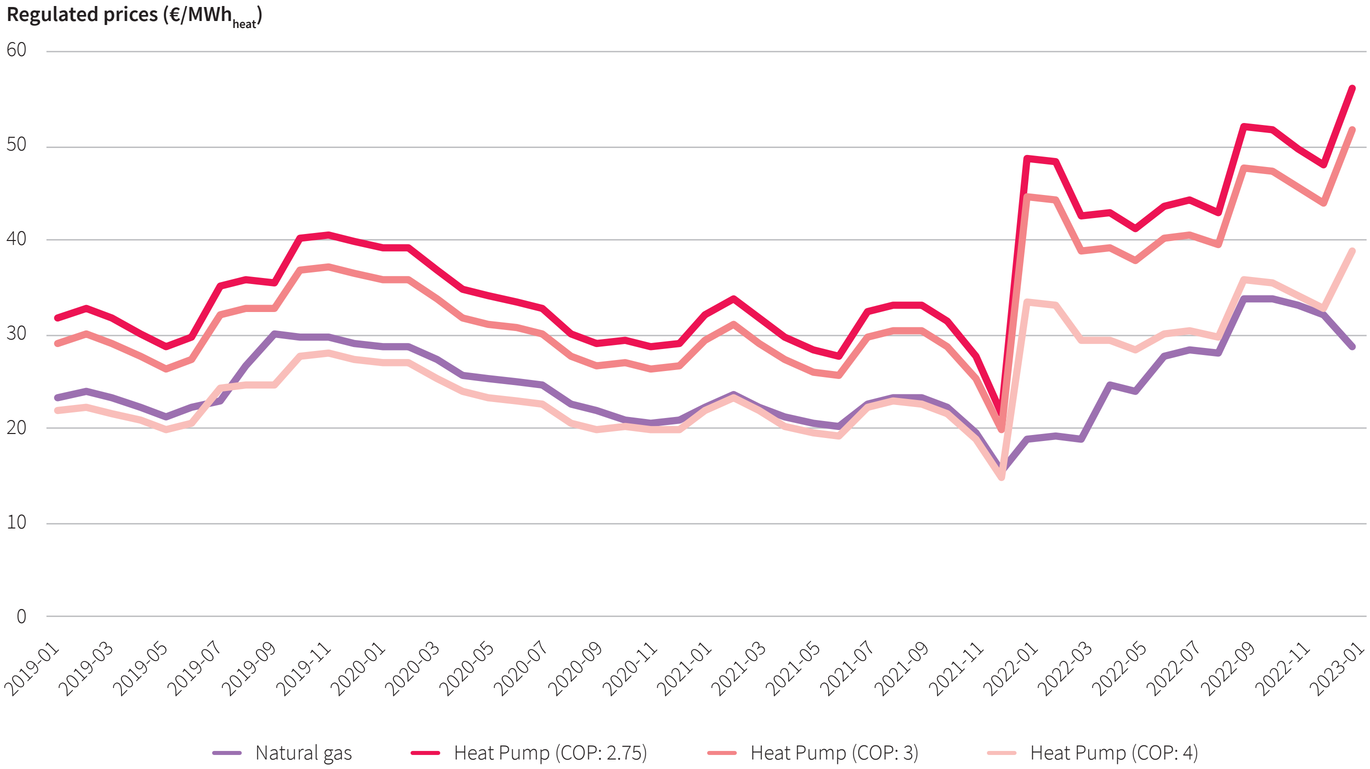
Figure 7: Subsidy level of residential power and natural gas prices wrt spot market prices[4]



[4] For regulated power prices >8kWh/day category is considered.

As illustrated in Figure 8, the current state of affairs indicates that heat pumps can only be competitive when the COP ratio exceeds 4, taking into account both regulated power and natural gas tariffs. However, achieving this ratio is impractical in Türkiye. Consequently, when considering subsidized tariff prices, it can be inferred that natural gas prices receive higher subsidy levels and are more advantageous, albeit indirectly. It is important to note that subsidies that appear to be detrimental to heat pumps are ultimately reflected in the country's budget and, consequently, impact the final consumer. Eliminating or reducing subsidies would not only eliminate the indirect cost on the final consumer but also positively contribute to the proliferation of heat pumps. Conversely, it is essential to recognize that spot prices established in the market do not accurately reflect real market costs due to factors such as market maximum settlement price, which affects the functionality of the market application. Therefore, the establishment of cost-based free market conditions is equally significant.

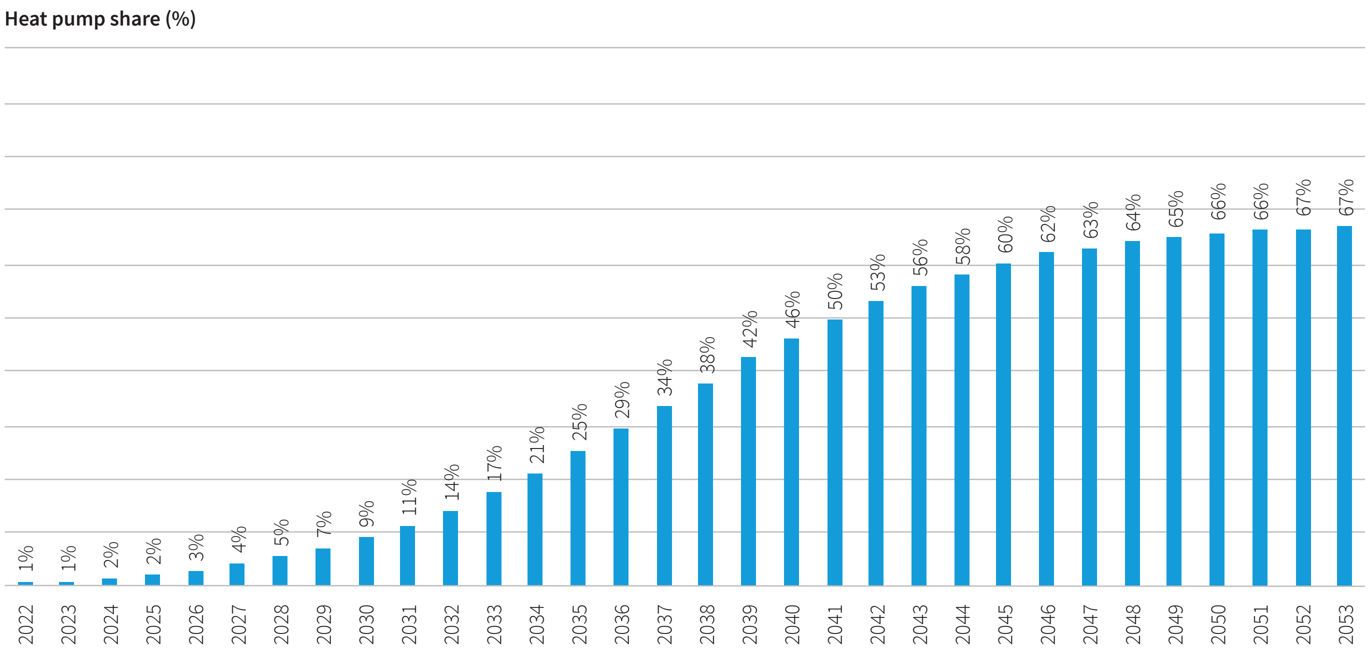
Figure 8: *COP comparison of natural gas and power tariffs within the context of equivalent heat value (€/MWh_{heat})*



On the other hand, in case power is supplied by rooftop solar energy systems (rooftop PV), the energy cost of heat pumps become more economic compared to subsidized natural gas tariffs. However, high initial investment cost of heat pumps at present slows down the transition to a certain extent. With the drop of heat pump investment costs in years, the transition is expected to accelerate.

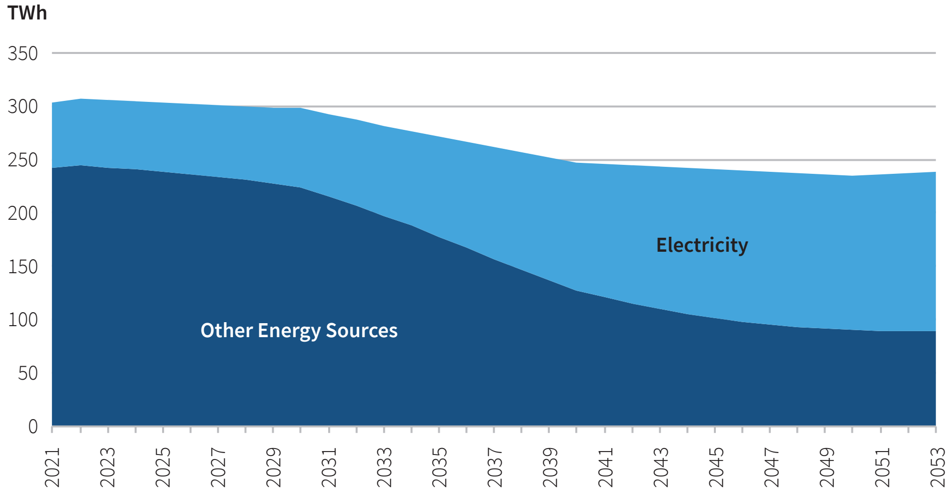
In the forthcoming years, it is unlikely that natural gas tariffs will be subsidized more than power tariffs in line with the net-zero emissions targets. Conversely, the possibility of implementing an additional carbon tax on natural gas prices cannot be ruled out. The proliferation of heat pumps is expected to increase due to various policies supporting electrification. According to SHURA's 'Net Zero 2053: A Roadmap for the Turkish Electricity Sector' study, heat pumps are projected to constitute 67% of residential heating by 2053 (SHURA, 2023). As the use of heat pumps will play a crucial role in achieving decarbonization of residences, it is imperative to identify policies accordingly. Figure 9 illustrates the projected ratio of heat pump usage in residences by 2053.

Figure 9: *Projection of development of heat pump use in residences – Share of residences with heat pump*



On the other hand, examining power consumption projections reveals that residential power consumption accounts for 20% of total energy demand and this ratio is anticipated to reach 63% in 2053 with the effect of heat pump use (SHURA, 2023).

Figure 10: *Share of electricity in residential energy consumption*

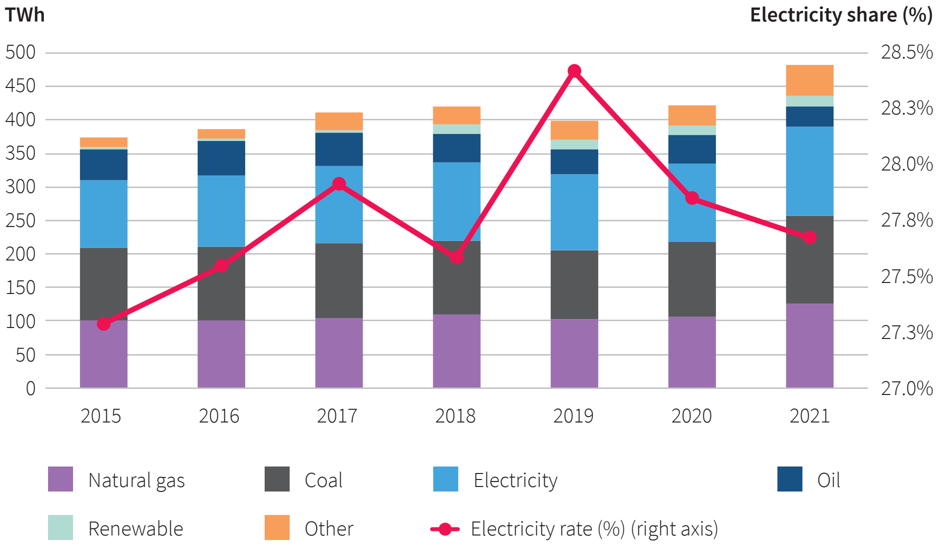


Consequently, heat pumps are expected to spread rapidly in residences thus becoming the main heating source by 2053.

Industry

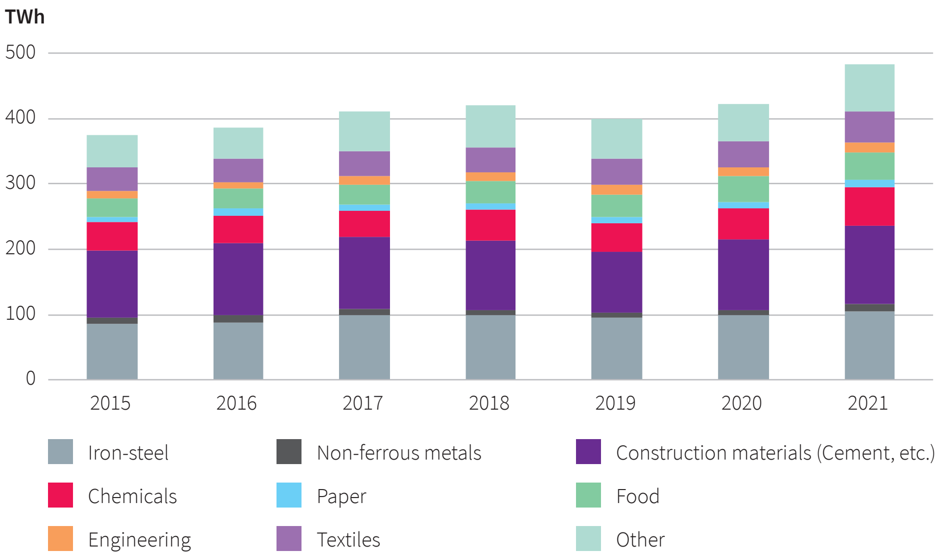
Energy consumption of industry in Türkiye constitutes 33% of final energy consumption, and 71% of coal as well as 36% of natural gas is consumed in this sector.[5] Fossil fuels account for more than two thirds of industry energy consumption. Historical development of industry fuel consumption is given in Figure 11 (MENR, 2015-2021).

Figure 11: *Fuel consumption distribution and electrification rate in industry*



Construction materials, primarily iron-steel and cement, are the highest energy consuming sectors. The total energy consumption of these two sectors accounts for nearly half of industrial energy consumption. Historical development of industrial energy consumption by sector is shown in Figure 12 (MENR, 2015-2021).

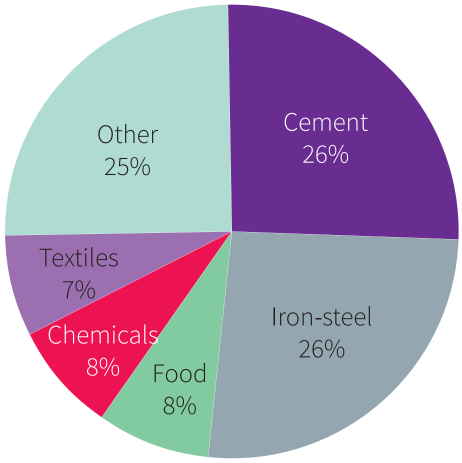
Figure 12: *Final energy consumption in industry sector*



In 2021, fossil fuel consumption of the industry sector was 287.4 TWh. Iron-steel and cement plants account for more than half of total fossil energy demand and 77% of coal consumption in industry.

[5] Türkiye Energy Balance Table, 2021

Figure 13: *Fossil fuel consumption shares in industry sector (2021)*[6]



Current widespread use of electric arc furnaces in iron-steel sector is a significant advantage in decarbonization. However, main processes in iron-steel and cement sectors require extremely high temperatures (>1,450 °C), making transition to electricity difficult with existing technologies. Fortunately, promising technologies like electrolysis, plasma heating, microwave, etc. are being developed for electrification of these sectors. Additionally, emission mitigating solutions such as use of renewable hydrogen as fuel and increase in the share of biomass are promising for these sectors.

Technical electrification potential for chemicals, food, textiles, and other sectors is higher in comparison to steel and cement industries. Due to lower temperature requirements, heat pumps up to 150-200°C and electric boilers up to 500°C can be used in these sectors. In these sectors, technically 52% of heat demand is suitable for heat pumps and 27% for boilers.

With maximum electrification in industry, 57 TWh of the 90 terawatt hours (TWh) of heat required in 2053 would be met with electricity instead of fossil fuels. **As a consequence of electrification, the share of direct use of electricity in industry is anticipated to rise to 46% in 2053 from the 28% level in 2021.** The industrial power consumption projection is shown in Figure 15. In addition to electrification, biomass use particularly in the cement industry, green hydrogen use in iron-steel industry and replacement of natural gas use with synthetic fuels (green hydrogen, synthetic methane, and biogas, etc.) will ensure reaching net-zero emission by 2053.

[6] Türkiye Energy Balance Table, 2021

Figure 14: *Additional power demand to substitute fossil fuel use in industry in Türkiye[7] (TWh)*

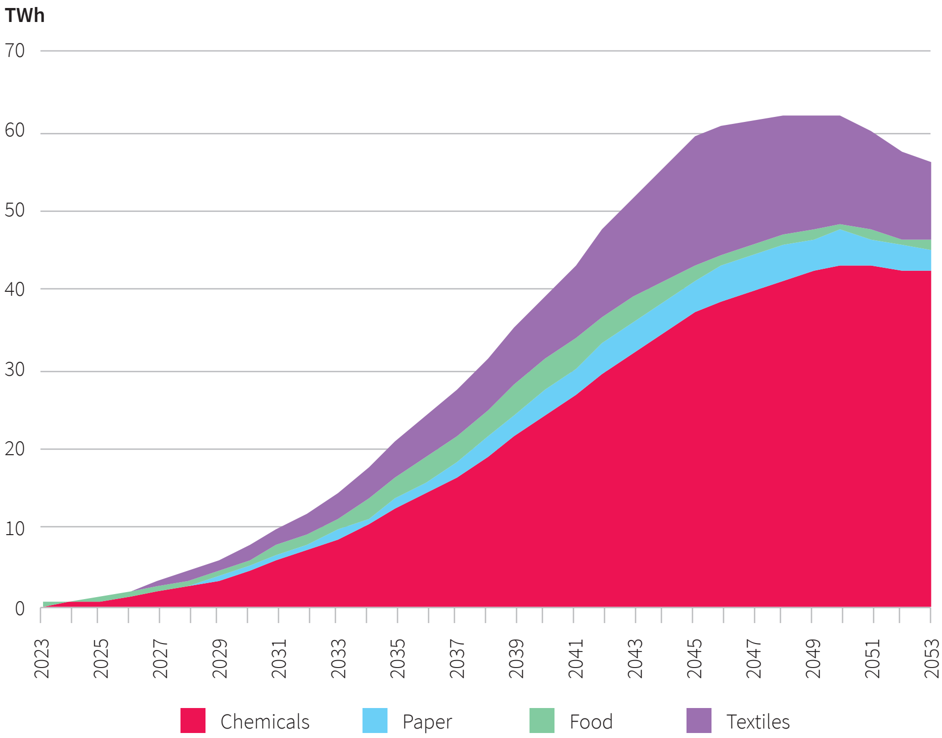
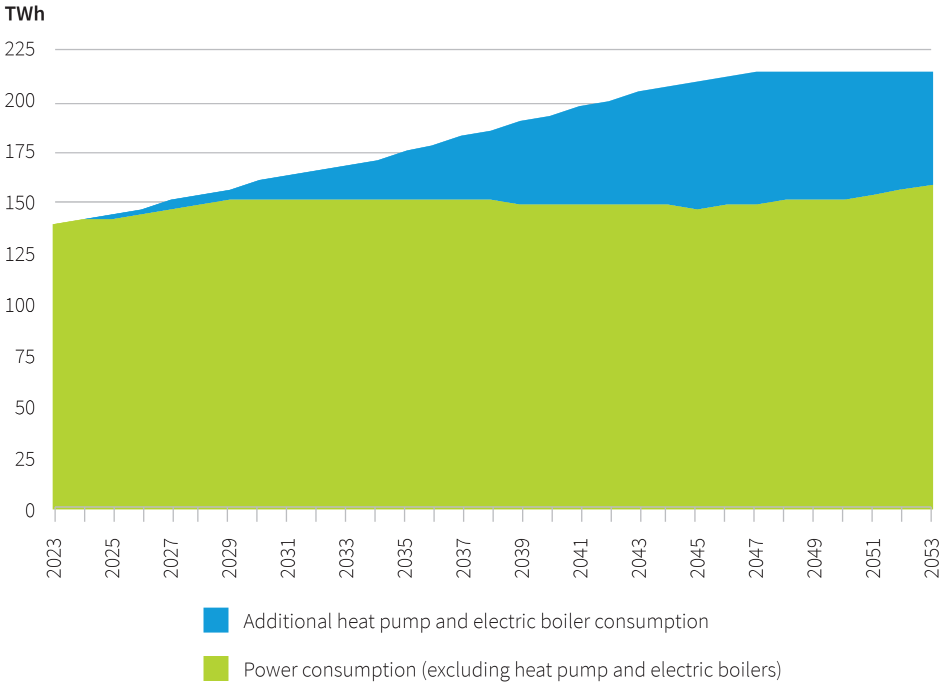


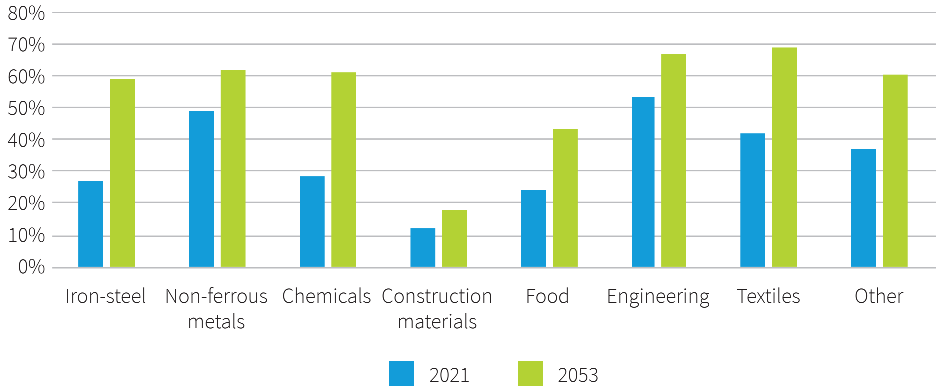
Figure 15: *Industrial power consumption projection of Türkiye (TWh)*



[7] Additional power consumption arising from transition of processes using fossil fuels to electricity use is modelled. Subsequent investments like new electric arc furnace iron-steel plants are not included in these figures.

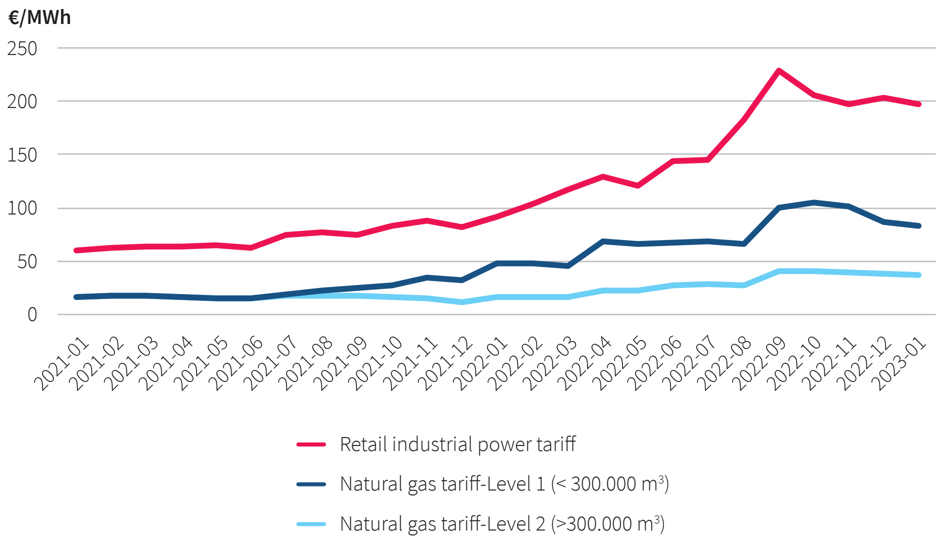
Electrification levels of major industrial sectors are shown in Figure 16. In these calculations electrification rates are modelled to increase due to three reasons: (1) Replacement of fossil fueled processes with electricity, (2) Increase in the share of processes currently using electricity, (3) Energy efficiency applications in fossil fuel burning processes. To exemplify, the increase in electrification in sectors such as cement, where transition to electricity is difficult, is mainly due to increased efficiency in fossil fuel use together with switching to processes where electrification is possible. The main increase in iron-steel sector is due to increasing share of electric arc furnaces. In other sectors, the main reason for the increase in electrification is the substitution of fossil fueled processes with electric ones.

Figure 16: *Comparison of projected electrification levels in industrial sectors (2021 - 2053)*



Although equipment, installation and related process change costs of electrification in industry are generally high, initial investment costs are less of a determining factor than operational costs (IEA, 2022). Therefore, electrification decisions mostly depend on a comparison of operational costs and particularly the prices of natural gas and electricity. In Figure 17, current natural gas and electricity tariffs are shown.

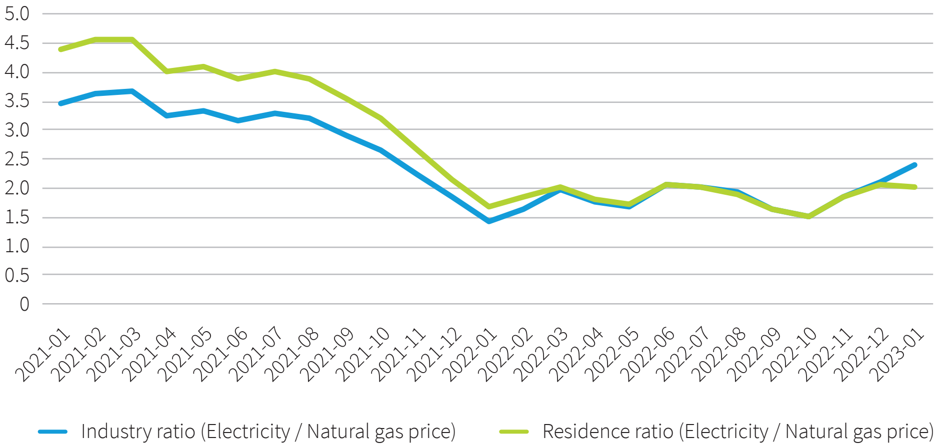
Figure 17: *Electricity and natural gas prices for industry (€/MWh)*[8]



[8] Including distribution costs.

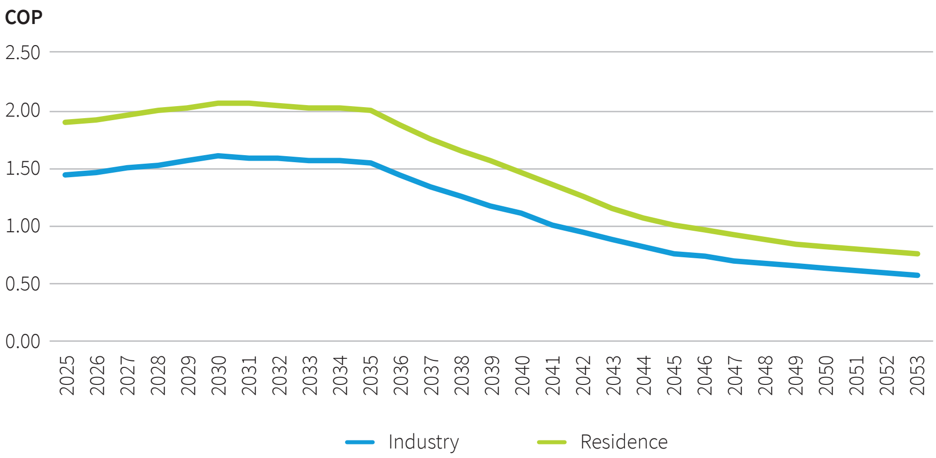
As spot power market prices currently depend mostly on short term marginal costs of natural gas plants, both power and natural gas prices tend to move in parallel. In Figure 18, the ratio of retail power prices to natural gas prices is shown. EXIST reference prices are taken as energy prices and are assumed to include distribution costs and taxes. On the basis of 2022 price levels, it is seen that the energy cost of a heat pump with a COP value 2 on the average will be lower. The average COP value of industrial heat pumps is above 2.5 and using the existing waste heat they can reach higher temperatures, nearly up to 150⁰C.

Figure 18: *Free market industrial retail power to natural gas price ratio*[9]



As the proportion of renewable energy in the power system rises, it is expected that electricity prices will deviate from natural gas prices and become more cost-effective. Furthermore, if additional taxes are imposed on fossil fuels, such as a carbon tax, in line with net-zero targets, this divergence will accelerate. Consequently, in the medium and long term, electricity prices will be more economical compared to natural gas prices. This will increase the economic viability of heat pumps, and the COP value required for fuel cost break-even will consistently decrease. Figure 19 illustrates the break-even COP values based on the projected electricity and natural gas costs.

Figure 19: *Break-even COP values for heat pumps*



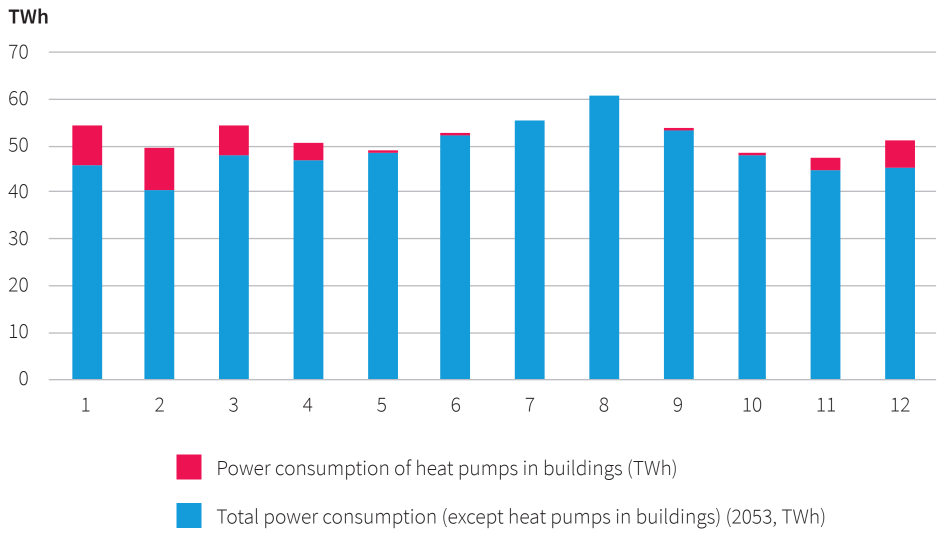
[9] Distribution costs and taxes included.

Taking into account free market retail electricity and natural gas prices, the payback period for a residential heat pump installation in 2023 (with a COP of 3.0 and consumption of 1,000 m^3/year) is calculated to be approximately **11.9 years.** The initial investment costs and anticipated decrease in electricity prices will result in a reduced payback period of **9.2 years if installed in 2030, and 3.2 years if installed in 2040.**[10] Beyond 2041, the divergence of electricity prices from natural gas prices will render electric heaters more economically viable than natural gas heating.

In short, with the increase in electrification both in buildings and in industry, a steep acceleration of power demand is anticipated. On the other hand, due to heat insulation investments and energy efficient devices, a reduction in energy demand in buildings is expected. Moreover, high technology industries with lower energy intensity will grow more rapidly than traditional industries. Energy savings obtained with the effect of these factors will meet a major part of the additional power demand arising from electrification. According to SHURA's "Net Zero 2053: A Roadmap for the Turkish Electricity Sector" study, power demand between 2021 and 2053 increases on average by 2.8% per annum (CAGR) in buildings and 1.5% per annum (CAGR) in industry (SHURA, 2023). Between 2010-2022, power consumption in Türkiye has increased by an annual rate of 3.8% (CAGR) on average. Therefore, power demand increase rates in the future are expected to remain under historical rates in spite of the increase in electrification.

Nevertheless, as heat pumps will operate mostly in winter months, monthly consumption profiles will vary. For example, in 2053 when 67% of buildings will be heated by heat pumps, their consumption will constitute 19% of total power consumption in January and 22% of total power consumption in February. In spite of this, the highest monthly demand throughout the year is expected to be in August, where heat pumps are used the least. In other words, the total effect on the grid arising from the winter load brought by heat pumps will be limited.

Figure 20: *Monthly additional load effect of heat pumps (2053)*[11]



[10] Heat pump CAPEX is assumed to decrease by 10% every 10 years.
[11] For monthly loads without heat pumps, monthly power consumption profile of 2022 is used.

Meanwhile, additional consumption of heat pumps will lead to 3-4 kW/residence increase in grid connection capacity of buildings. In addition, heat pumps will operate in the same time ranges regionally under cold weather conditions. Such a conduct will increase the synchronicity factor of the distribution network. Therefore, local grids will inevitably need to be strengthened for heat pump use. However, as the grid has to be reinforced already for charging needs of electric vehicles, marginal infrastructure cost of heat pumps may be reduced.

From an energy efficiency perspective, the utilization of heat pumps in both buildings and industrial settings serves to not only replace fossil fuel consumption with electricity, but also to decrease the overall energy demand. In accordance with the first law of thermodynamics, which dictates the conservation of energy, direct heaters such as natural gas, coal, or electric boilers can only achieve a maximum efficiency of 100%, a feat which is not practically attainable. Conversely, heat pumps do not generate heat through the combustion of fuel, but rather transfer heat between two environments, as is the case in the cooling cycle. The energy consumed by a heat pump is utilized to convey heat energy from the exterior environment to the interior environment. Consequently, depending on the temperature differential between the exterior and interior environments, the conveyed energy may exceed the consumed energy, resulting in heating efficiencies that surpass 100%.

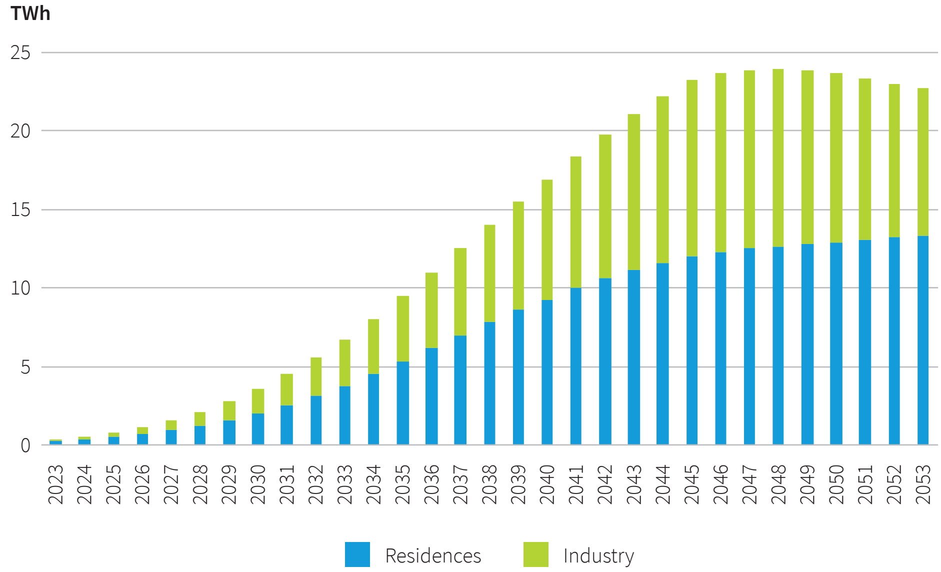
In Türkiye, the mean coefficient of performance (COP) value for heat pumps in buildings is 2.75. This indicates that 2.75 kWh of thermal energy can be obtained by utilizing 1 kWh of electricity. The high efficiency of heat pumps results in a 64% enhancement in final consumption efficiency. It is expected that the heat efficiency in buildings will increase to 71% by 2053, owing to the rising efficiency rates of heat pumps and better insulated buildings. Consequently, despite the increase in the number of buildings by 2053, the total energy requirement of residential buildings will decrease, as illustrated in Figure 10. **As per the net-zero targets, it is projected that 36.6 TWh of electricity will meet 128 TWh of residential heating energy in 2053, and electrification alone will yield 91.4 TWh of energy efficiency.**

The mean COP for industrial heat pumps is anticipated to be 2.5. By substituting 2.5 kWh of fossil fuel energy with 1 kWh of electricity, a 60% energy efficiency can be achieved. Additionally, the utilization of an electric boiler will yield a 10% efficiency gain in comparison to a natural gas boiler. This is due to the fact that while natural gas boilers exhibit an efficiency of approximately 90%, electric heating attains 100% efficiency. Consequently, **by the year 2053, the electrification of industry is expected to supplant 90.1 TWh of fossil fuel energy with 56.6 TWh of electricity, resulting in a final energy efficiency of 35.5 TWh.**

Upon examination of the overall benefits, **it is evident that the implementation of electrification will result in a noteworthy reduction of 127 TWh in the total final energy demand of both residential and industrial sectors by the year 2053.** This reduction is particularly significant when compared to the current fossil fuel consumption of the country, which stands at 287.4 TWh as of 2021. Furthermore, **this transition will lead to a reduction of 22.8 billion m3 in natural gas imports and a decrease of 43.6 million tons in CO_2 emissions by the year 2053.**

Compared to 60 billion m3 natural gas consumption of Türkiye in 2021, the reduction in natural gas imports is a considerable quantity (EXIT, 2021). Remaining fossil fuels will be substituted with green hydrogen, biomass, and synthetic gases, as foreseen in SHURA "Net Zero 2053: A Roadmap for the Turkish Electricity Sector" report (SHURA, 2023).

Figure 21: *Annual reduction in natural gas imports within final energy consumption due to electrification (billion m^3)*



In the forthcoming period, increased electrification in Turkish households and industries, in alignment with net-zero objectives, will be contingent upon the policies and applications that are implemented. The policy recommendations that have been proposed for the dissemination of electrification in Türkiye are as follows:

The primary factor impeding the advancement of heat pumps is highly subsidized residential natural gas tariffs. While residential power tariffs are also subsidized, Figure 7 demonstrates that there are fewer subsidies in comparison to natural gas tariffs when compared to free market prices. Conversely, if subsidies for both regulated residential power tariffs and natural gas tariffs were eliminated, the operational costs of heat pumps would become more economical than natural gas combis. **Therefore, while it may not be feasible to completely eliminate subsidies in retail power and natural gas tariffs due to socio-economic considerations, it is possible to equalize subsidy levels to encourage the adoption of the most cost-effective and environmentally-friendly heating method.**

Determining tax policies to promote competitive energy prices in a manner supporting clean technologies is important. Clean technologies and emissions mitigation should be incentivized by revising existing taxes on electricity and natural gas. Annulment of TRT share (2%) and energy fund (1% at first, later 0.7%) from electricity prices in 2022 and reduction of VAT from 18% to 8% for households (changed to 10% as of 10.07.2023) are positive developments in this regard. Thanks to these developments, currently there is less tax burden on electricity prices which facilitates transition to heat pumps.

Application of Electricity and Coal Gas Consumption Tax (ETV or BTV) as 5% on power price for residential and commercial/official consumers and as 1% for industrial consumers[12] constitute a **disadvantage for heat pumps and other electric technologies over natural gas.** Coal gas is a fuel no longer used for residential heating and it has been replaced with natural gas. Therefore, it should be more appropriate to change the expression "coal gas" in the definition of this tax, replacing the definition as Electricity and Natural Gas Consumption Tax. Since the tax rate on coal gas consumption is 5%, municipality consumption tax (BTV) on electricity and natural gas will be equated.

Alternatively, when carbon tax or pricing is put into effect, a portion of the collected fund can be transferred to YEKDEM mechanism. In this way, renewable energy incentives would be met by fossil fuel consumption and the load on electricity prices would be reduced.

An initial investment financing mechanism may be made available for the installation of heat pumps. In order to facilitate the transition of residences to heat pumps, the provision of attractive finance packages would be beneficial for the supply of equipment that enables energy efficiency, the generation of renewable energy, and project packages that combine heat pump usage. For instance, a fixed price per kWh of electricity may be paid over a period of seven years, while gradual phasing out of subsidies may result in an increase in natural gas prices during the same period, thereby incentivizing the use of heat pumps. Furthermore, low-interest loans should be made available for heat pump installations, similar to those offered for building heat insulation investments.

To promote the adoption of heat pumps and other electric technologies in residential and industrial settings, it would be advisable to develop business models and services that incorporate finance packages. Business models such as Energy as a Service have the potential to address the technical and financial requirements of users by offering feasibility studies for heat pumps, installation services, energy management related to the grid, management of demand-side consumption, and procurement of necessary financing.

The Ministry of Energy and Natural Resources (MENR) assesses projects aimed at transitioning to electric technologies as part of its energy efficiency support initiatives. A grant of up to 30% of the investment amount, limited to 5 million TL, is provided for such investments. However, to be eligible for this support, the facility must have a minimum energy consumption of 500 toe. **It is recommended that the gradual reduction of this minimum limit be implemented to expand the coverage of potential beneficiaries.**

The reevaluation of policies pertaining to the expansion of natural gas pipelines from a net-zero perspective is of utmost importance. It is currently a public policy to promote the widespread use of natural gas throughout the country, as evidenced by Target 1.3.5 of the MENR Strategic Plan (2019-2023), which aims to increase the number of settlements with access to natural gas pipelines. However, settlements without access to natural gas pipelines are prioritized for the implementation of heat pumps. Therefore, it is imperative to review plans for the expansion of natural gas

[12] Law on Municipal Revenues, Article 34.

distribution networks, particularly in mild climate regions such as the south and west of the country, and to evaluate the substitution of such plans with heat pumps. **In this regard, the strategic target of expanding natural gas pipelines should be replaced with the objective of promoting the adoption of heat pumps and other electric technologies.**

In Türkiye, there is a growing focus on topics, such as new housing requirements, decreasing number of inhabitants per household, urban transformation and enhancing earthquake resistance, particularly in major cities. **During the reconstruction phase, both standalone heat pumps and integrated solutions will be of little significance when considering the total cost of a building/apartment, as compared to the cost of expanding the natural gas network. Buildings and cities that are compatible with the renewed electricity system and digital technologies, and meet the sustainability parameters, will offer numerous benefits.** Zero-emission buildings are energy-efficient, capable of generating their own energy from renewable sources, and can use clean energy for heating/cooling through electrification, efficient faucets for water conservation, rainwater collection, greywater systems, rooftop solar energy for water heating, and hot water storage beneath the building. Zero-emission smart buildings that are both earthquake-resistant and use clean energy sources efficiently will be the driving force behind the decarbonization of the building sector, which accounts for 26% of final energy consumption, and will support the energy transition.

It is feasible to set up an annual net metering/billing system between solar energy power generation and heat pump consumption. The two systems operate on opposing schedules, with heat pump power consumption peaking during periods when solar energy generation is at its lowest. Consequently, excess solar energy generated during summer months is sold, while power required by heat pumps during winter is purchased from the grid. This disparity results in rooftop solar energy system owners incurring higher distribution fees and electricity taxes. Technically and economically, it is possible to balance and reconcile energy in real-time. **To promote the integration of roof solar photovoltaic (SPP) and heat pump systems, an annual balancing possibility can be implemented for buildings with integrated systems.** However, this implementation may have adverse effects on the grid. Therefore, it may be prudent to set a limit on annual balancing and compensate for a portion of generated power corresponding to heat pump consumption. This approach would enable excess energy generated during summer to be utilized by heat pumps during winter, thereby reducing the payback period for heat pump investments and encouraging the adoption of roof SPP/heat pump systems. Once sufficient adoption is achieved, it would be appropriate to discontinue monthly/annual balancing applications and transition to real-time balancing.

The imposition of taxes on fossil fuel use in residential and industrial settings will have an indirect effect of encouraging the adoption of heat pumps and other electric technologies. The most viable alternative to electricity-powered heat pumps is natural gas, which is both cost-effective and efficient. In light of this, it is imperative to incorporate the environmental impact of fossil fuels into their pricing structure by imposing a carbon tax that is commensurate with their emission levels. **This approach will not only benefit the proliferation of heat pumps but also facilitate the adoption of electric vehicles (EVs) for the decarbonization of the transportation sector.**

Also, regarding exports to the EU, Carbon Border Adjustment Mechanism (CBAM) will gradually enter into effect after 2026. The EU is Türkiye's largest export market, worth 103 billion dollars and comprising a 40% share in total exports in 2022 (Ministry of Trade, 2023). **This will encourage carbon-free industrial processes and pave the way for electrification.**

During the transition to electric technologies, it is possible to ensure the initial use of these systems in new residential and industrial buildings through tax incentives or installation support. Furthermore, the transition of systems in older buildings can also be evaluated within this framework. Türkiye stands out as a country with the potential to become a significant heat pump manufacturer and installer, given its strong position integrated into international value chains of engineering sectors, especially electrical equipment and machinery, presence of prominent global companies, and the engineering capacity required for industrial solutions. In addition to its domestic market potential, Türkiye can achieve increased exports through provision targeted incentives without requiring significant financing. **In addition to savings from fossil fuel imports, heat pumps, may contribute positively to the external trade balance through additional export income created by this new sector.**

In conclusion, irrespective of financial feasibility or fossil fuel price levels, **certain legal obligations can be implemented to achieve net-zero targets** and terminate fossil fuel use in the energy system, thereby increasing electrification. **It is recommended that coal and natural gas use in buildings and industry be limited after a certain date.** For instance, in Germany, a legislation has been proposed to ban the installation of new fossil-fueled systems for heating purposes (Euractiv, 2023). Similarly, in Türkiye, Article 20 of the Regulation on Control of Heating Based Air Pollution, published on 13.01.2005, prohibits the use of coal and fuel-oil for heating in regions with access to natural gas networks. After 2030, a similar application can be implemented to limit natural gas use in new buildings, taking into account the recently discovered natural gas production capacity.

About Istanbul Policy Center at the Sabancı University

Istanbul Policy Center (IPC) is a global policy research institution that specializes in key social and political issues ranging from democratization to climate change, transatlantic relations to conflict resolution and mediation. IPC organizes and conducts its research under three main clusters: The Istanbul Policy Center–Sabancı University–Stiftung Mercator Initiative, Democratization and Institutional Reform, and Conflict Resolution and Mediation. Since 2001, IPC has provided decision makers, opinion leaders, and other major stakeholders with objective analyses and innovative policy recommendations.

About European Climate Foundation

The European Climate Foundation (ECF) was established as a major philanthropic initiative to help Europe foster the development of a low-carbon society and play an even stronger international leadership role to mitigate climate change. The ECF seeks to address the “how” of the low-carbon transition in a non-ideological manner. In collaboration with its partners, the ECF contributes to the debate by highlighting key path dependencies and the implications of different options in this transition.

About Agora Energiewende

Agora Energiewende develops evidence-based and politically viable strategies for ensuring the success of the clean energy transition in Germany, Europe and the rest of the world. As a think tank and policy laboratory, Agora aims to share knowledge with stakeholders in the worlds of politics, business and academia while enabling a productive exchange of ideas. As a non-profit foundation primarily financed through philanthropic donations, Agora is not beholden to narrow corporate or political interests, but rather to its commitment to confronting climate change.

SHURA Energy Transition Center

Bankalar Caddesi,
Minerva Han, No:2, Kat:3
34420 Karaköy / İstanbul
Tel: +90 212 292 49 51
E-mail: info@shura.org.tr
www.shura.org.tr

SHURA is founded by

İPM | IPC İSTANBUL POLİTİKALAR MERKEZİ SABANCI ÜNİVERSİTESİ KAMPUSU ISTANBUL POLICY CENTER AT SABANCI UNIVERSITY

European Climate Foundation

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