SHURA
Energy Transition Center

The Most Economical Solution for Turkey's Power System: Energy Efficiency and Business Models

About SHURA Energy Transition Center

SHURA Energy Transition Center, founded by the European Climate Foundation (ECF), Agora Energiewende and Istanbul Policy Center (IPC) at Sabancı University, contributes to decarbonisation of the energy sector via an innovative energy transition platform. It caters to the need for a sustainable and broadly recognized platform for discussions on technological, economic, and policy aspects of Turkey's energy sector. SHURA supports the debate on the transition to a low-carbon energy system through energy efficiency and renewable energy by using fact-based analysis and the best available data. Taking into account all relevant perspectives by a multitude of stakeholders, it contributes to an enhanced understanding of the economic potential, technical feasibility, and the relevant policy tools for this transition.

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Disclaimer

This report and the assumptions made within the scope of the study have been drafted based on different scenarios and market conditions as of the end of 2019. Since these assumptions, scenarios and the market conditions are subject to change, it is not warranted that the forecasts in this report will be the same as the actual figures. The institutions and the persons who have contributed to the preparation of this report can not be held responsible for any commercial gains or losses that may arise from the divergence between the forecasts in the report and the actual values.

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Executive Summary

Turkey has joined the global energy transformation trend

The urgent need for minimising the adverse effects of climate change requires the transformation of the energy sector through energy efficiency, renewable energy and electrification as the sector is responsible for two-thirds of the global greenhouse emissions. The energy supply and demand stand out as the largest source of carbon dioxide (CO_2) emissions in all greenhouse gases. According to the fossil fuel based CO_2 emission statistics published by the International Energy Agency, the global energy sector emitted a total of 33 gigatonnes CO_2 by end of 2019. In 2019 energy sector CO_2 emissions peaked, and although since then emission levels have been stable, with the impact of the COVID-19 pandemic it is currently following a declining trend. The increasing share of electricity generation from renewable energy sources is one of the main reasons in limiting the growth in CO_2 emissions from the energy sector.

In Turkey, 44% of the total electricity generation was sourced from renewable energy sources by the end of 2019. Among all types of renewables, the share of wind and solar energy has increased rapidly in recent years representing a share of 10% in total electricity generation. Over the past four years, renewable energy capacity represented more than half of the annual net installed capacity additions in Turkey's power system. Although increasing renewable energy's share in power system during the transition to a low carbon economy is of great importance, benefiting from the enormous potential of energy efficiency opportunities available in Turkey is equally important for a complete transition.

Compared to the renewable energy sources that gained an important ground in Turkey's energy strategy in recent years, energy efficiency has long been at the centre of all strategies as one of the top ranking local energy resources. The reason for this is the high diversity, low costs, and multiple side benefits of energy efficiency technologies and solutions. At the same time, for countries such as Turkey where energy consumption is rapidly growing, attaining energy efficiency in new power plants, industrial facilities and buildings investments is technically much easier, however investment costs can be partially high.

Between 2002 and 2018 Turkey's total final energy consumption increased by 90%. It turns out that the electricity consumption has a significant share in this increase, in proportion with the population and economic growth. In the same period, Turkey's average energy intensity, or the total primary energy supply per gross domestic product, improved by an average annual rate of more than 1.5%. In addition to structural changes in the economy and the sectors, the main reason behind this improvement is the energy efficiency investments in end-use sectors. Energy efficiency trends in Turkey show similarities with the rest of the world where the global primary energy intensity has improved by 1.7% on average in 2018 and 1.6% in 2019.

Per capita electricity consumption in Turkey is relatively lower than in other countries. However, Turkey's electricity intensity is at medium-high level compared to rest of the world. As of 2018, Turkey's energy intensity reached 800 kilowatt-hours (kWh) per 1000 $US_{(2011)}$.

Electricity sector at the core of energy transformation

Turkey's total primary energy supply increased by 3.3% between 2000 and 2018, reaching 144 million tonnes of oil equivalent (Mtoe) from 79 Mtoe. Final energy consumption has reached 109 Mtoe from 62 Mtoe in the same period, growing 3.3% every year. While Turkey's total final energy consumption represents three quarters of the total primary energy supply, electricity demand has only 20% share in total final energy consumption as of 2018.

Today, Turkey's total electricity generation reached the level of almost 305 terawatt-hours (TWh) per year. Due to the negligible levels of cross-border electricity trade, almost all of the total electricity production in the country is directed to the end users. While the share of electricity consumed in buildings corresponds to 42% of total consumption, the share of industrial electricity demand is around 39%. A large part of the remaining 19% share cannot reach the end user due to power plants' own consumption, and losses in the transmission and distribution grids.

In 2000, the ratio of power plants' own electricity consumption and grid losses to total electricity generation in Turkey was around 24.4% (30.0 TWh). This ratio decreased to 16.6% (49.3 TWh) in 2018. Similarly, the efficiency of electricity generation from fossil fuel-fired power plants increased by an average of 5 points in the 2000-2018 period, exceeding the 40% level. Although the decrease in losses and increase in efficiency in electricity generation has great significance in terms of Turkey's import-dependent power system, domestic resource use is still limited. In 2018, 20% of electricity production was from hydropower, 15% domestic lignite, 7% wind, 3% solar, 2% geothermal energy and 2% other coal power plants, and a total of 149 TWh electricity was produced from domestic resources. In other words, share of domestic resources equalled only half of the total electricity production. While this ratio rose further by the increase in the share of renewable sources in 2019, Turkey continues to be an import-dependent country in terms of electricity generation.

In addition to its significance in import-dependency, the electricity sector has a special importance in terms of its contribution to the global climate change problem and greenhouse gas emissions. Electricity sector's share in Turkey's total CO_2 emissions reached around 40% in 2018. Today, around 450 grams (g) of CO_2 is emitted for generating one kWh of electricity. Moreover, a coal-fired power plant with average efficiency emits twice CO_2 emissions per kWh. For all these reasons, transformation of the electricity sector through renewable energy, energy efficiency, and electrification that create synergies from these two main pillars of energy transition; and acceleration of this transition through digitalisation and information technologies that are increasingly needed for the management of electricity systems will play a key role in transition to a low-carbon economy.

The Scope and Purpose of SHURA's "The Most Economic Solution for Turkey's Power System: Energy Efficiency and Business Models" Study

The transition to a low-carbon economy requires the accelerated deployment of renewables on the supply side, reduction of losses on the grid side, reduction of electricity demand through energy efficiency improvements, and increasing flexibility for grid integration of renewables. Among these, energy efficiency is the first option as a low-cost and local resource. Thanks to the long years of policy, research

and business efforts of the public sector, private sector and the academia, Turkey currently owns a strong analytical capacity on energy efficiency. The energy efficiency potential, costs and benefits of Turkey's energy efficiency has been evaluated by many organisations to date but how the potential emerging from such assessments can be realised remains to be answered.

Turkey's energy efficiency strategy has developed further over a long period of policy making, including a period of harmonisation with the European Union's energy efficiency legislations in recent years. Assessment of Turkey's energy efficiency potential and how it can be turned into investments is becoming a more crucial issue in the context of accelerating the implementation of Turkey's National Energy Efficiency Action Plan (NEEAP) 2017-2023 that is in force since March 2018 with a great significance to achieve Turkey's 2023 targets. The NEEAP aims to achieve a 14% reduction in energy demand in terms of primary energy by 2023 compared to the 2017 levels. The plan includes 55 actions across 6 sectors of Turkey's whole energy system. Realising the goals of the plan requires a total investment volume of 10.9 billion United States dollars (US$) with investments having a payback period of less than 7 years. 31 out of the total 55 actions are about increasing energy efficiency at different stages of the electricity sector.

The primary aim of this study is to evaluate the technical and economic potential of energy efficiency in Turkey power system to 2030 beyond NEEAP's timeline of 2017-2023, and to determine the business, policy and financing models that will be needed to in turning this potential into actual investments. The study includes the assessment of the entire value chain of Turkey's power system from the grid to the end user and outlines the potential, costs and benefits of energy efficient technologies at the sector level by distinguishing the perspectives of both the private and public sectors. In order to provide insights into how this potential can be turned to investments, the study analyses the role of non-technology systemic issues that include regulations, market-based policy mechanism instruments, business models, financial mechanisms and measures to increase overall system efficiency through distributed renewable energy resources, their investment opportunities and commercialisation roadmaps along with their costs and benefits.

This main report of the study provides detailed results of the analysis as well as the background data and the methodology developed specifically for the purpose of this study. 16 different Energy Efficiency Solutions have been assessed across 5 cross-cutting categories to operationalise the estimated potential of energy efficiency, their costs and benefits and commercialisation potential to 2030, based on a review of more than 120 international best practices. A detailed report enhancing each Energy Efficiency Solution is published along with this report that provides detailed insights.

Energy Efficiency Solutions	Regulation	Market Based Policy Mechanism Instruments	Business Models	Financing Mechanisms	System Efficiency
	• Standards and Certification • Energy Efficiency Audits • Energy Management	• Energy Efficiency Obligations • Energy Efficiency Auctions • Energy Efficiency Networks	• Demand Side Response and Aggregators • Smart Meters	• Energy Efficiency Funds • Energy Service Companies (ESCO) • Other Financial Mechanisms	• Smart Tariffs • TSO-DSO Cooperation • New Business Models for DSOs • Market and Grid Integration of Distributed Energy Systems • Distributed Generation Models

What are the opportunities after the National Energy Efficiency Action Plan?

The analysis was carried out based on two scenarios, namely the Baseline scenario and the SHURA scenario, in which the extent deployment of energy efficiency technologies differ. Baseline scenario is based on the "Turkey's Electricity Demand Projections Report" prepared by the Ministry of Energy and Natural Resources of Turkey. The SHURA scenario assesses the potential of energy efficiency across 21 electricity end use areas and accounts for an accelerated deployment of energy efficiency technologies which will be enabled by the implementation of the proposed Energy Efficiency Solutions.

According to the Baseline scenario, Turkey's total annual electricity demand in 2030 reaches 459.2 TWh. In the SHURA scenario, total demand reduces to 416.9 TWh with the deployment of energy efficiency technologies. This is equivalent to a total savings of 48.9 TWh per year in 2030. After accounting for the impact of electrification of end uses that lead to additional electricity demand of 6.6 TWh/yr, net savings in electricity demand amount to 42.3 TWh. The estimated savings potential is equivalent to the electricity demand of 18 million households or the combined electricity consumption of textiles and basic metal industries in Turkey.

Estimated total electricity savings in the industry and buildings are 19.2 TWh and 16.6 TWh per year by 2030, respectively. Thus the majority of the new total savings potential exists in buildings and with almost 50% represented by motor systems in the industry sector. LED lighting systems have a high energy savings potential with a similar contribution among all the different technology types that have been assessed. Distribution network losses can be reduced by 7.2 TWh in 2030 compared to the Baseline scenario due to savings in end users, distributed energy resource deployment and demand side response. Most of these savings will be achieved through technology and the measures taken to increase energy efficiency. Additionally, significant gains can be achieved through methods such as energy management systems and the optimisation of energy consumption on the demand side. The total amount of savings are expected to be at a higher level if these gains which have been assessed only in relatively less detail are included in the scope of this study.

Figure 1: *Developments in electricity demand according to different scenarios, 2010-2030*

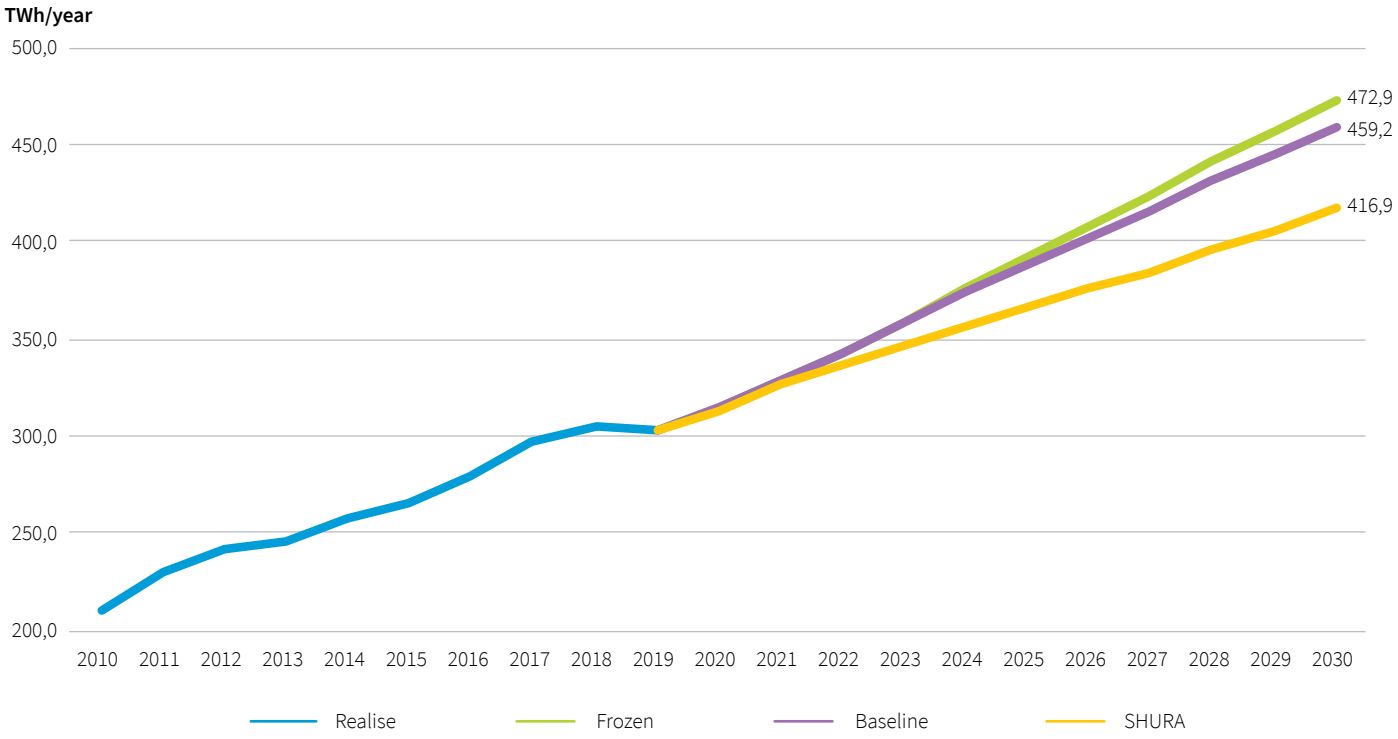
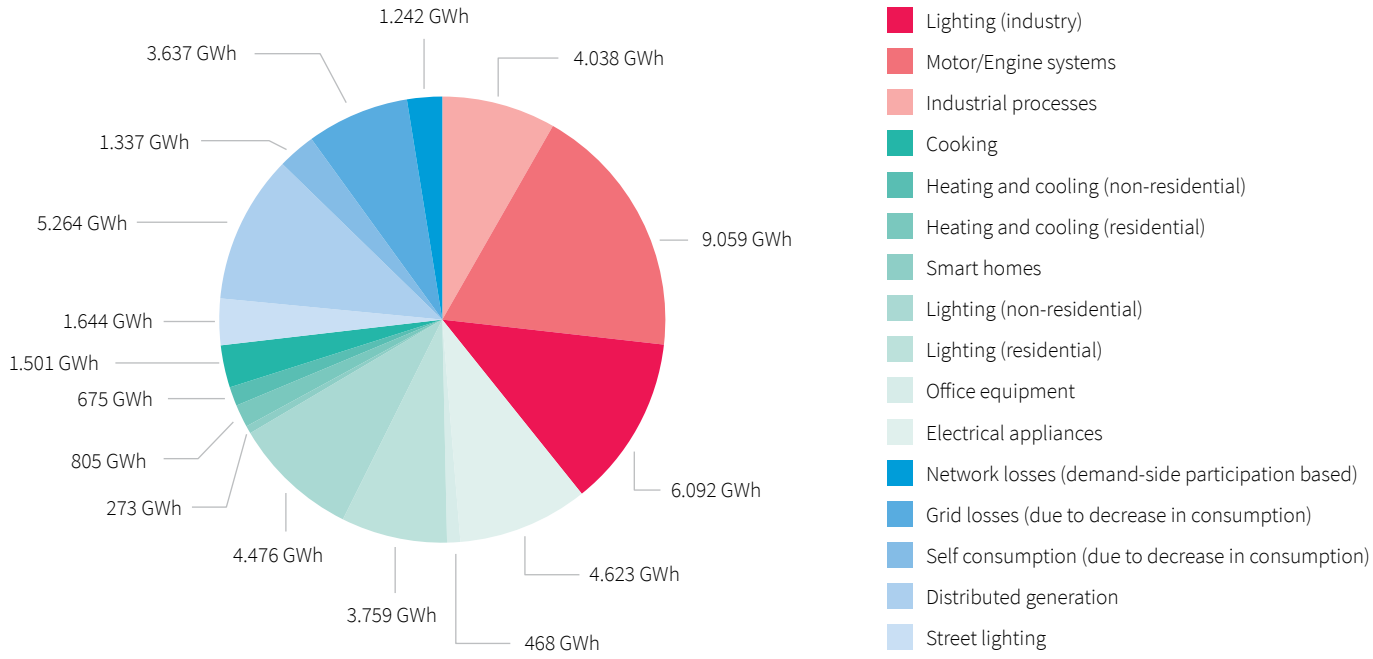


Figure 2: *Breakdown of electricity savings according to the SHURA scenario, 2030*



Costs of energy efficiency improvements and investment needs

SHURA scenario is estimated to create an investment need of US$ 54 billion in the 2020-2030 period. This is split into US$ 30 billion for energy efficiency, US$ 11 billion for distributed energy resources and US$ 13 billion for electrification (including heat pumps). Of the total energy efficiency investments, half of the investments will be related to electrical appliances in buildings (US$ 15 billion) and the remaining half is split across US$ 5 billion in industry, US$ 3 billion in smart homes, US$ 2 billion in air conditioners and US$ 3 billion other areas. The estimated investment needs in the SHURA scenario is four times higher than in the Baseline scenario. The investment amount determined for the next 10 years is approximately by a factor three higher than the US$ 10 billion spent for energy efficiency in all sectors of Turkey between 2002-2018 and the investments of US$ 10.9 billion targeted in the NEEAP.

When these investments are discounted to their lifetime and when the costs of operation, maintenance and energy costs are accounted for, the weighted average levelised cost of energy savings for the SHURA scenario technology portfolio is estimated to be between US$ 9 and 14 cents per kWh of saved electricity. The cost of policy implementation is around 1% of these costs. Weighted average levelised cost of energy savings exclude any gains from the electricity savings.

According to the public perspective, 82% of the total energy savings of 48.9 TWh per year in 2030 is lower than the foreseen electricity tariff in the same year. In other words, these technologies provide direct benefits to investors. The remaining 18% of the savings on the other hand, will need additional support or incentives to become more attractive to investors. Energy efficiency technologies that cost less than the electricity tariff stand out as lighting, industrial process heating and cooling, variable speed drive applications, distributed production technologies, equipment and process improvements in electric arc furnaces and efficiency increasing applications in the cement sectors. Demand side participation, efficient air-conditioning in residential buildings, some efficient electrical appliances, and smart home technologies are considered as technologies that have higher costs than the electricity tariffs.

Benefits of increasing the energy efficiency for Turkey's economy and the environment

For each US$ 1 spent for the deployment of the technology portfolio according to the SHURA scenario, there are net benefits of $ 1.2-1.5.

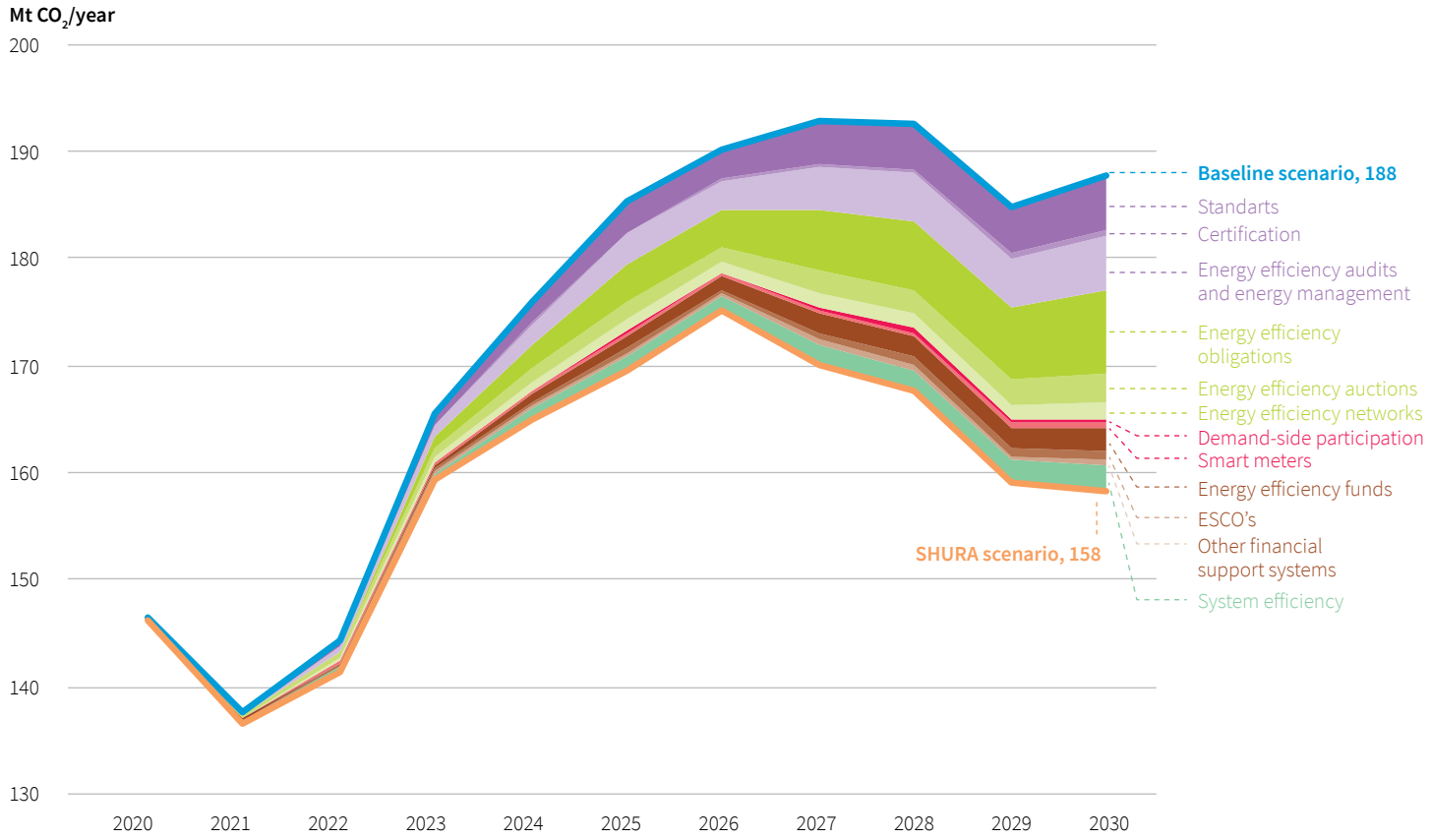
While the electricity demand per person in the Baseline scenario is estimated to be 4,920 kWh in 2030, in the SHURA scenario per capita demand reduces to 4,467 kWh. Compared to the level in 2019 (3,652 kWh/capita) in the Baseline and SHURA scenarios, the per capita electricity demand is estimated to increase by 35% and 22% in 2030, respectively.

The savings potential determined in the SHURA scenario reduces the demand for electricity generated from natural gas by almost half as well as reducing the dependence on imported coal by 10% compared to the Baseline scenario by 2030. While the natural gas consumption of power plants in the Baseline scenario is estimated to be 19.7 billion m^3 in 2030, this amount declines to 8.7 billion m3 with the decrease in electricity demand in the SHURA scenario. As the SHURA scenario

also accounts for the deployment of technologies such as combined heat and power capacity (to around 5 GW by 2030), electrical cooking and heat pumps, natural gas consumption is estimated to increase by an additional 2.3 billion m^3 per year by 2030. The benefit of reducing the natural gas consumption by 8.7 billion m3 is estimated to be approximately US$ 2.4 billion in 2030. In the Baseline scenario, the coal consumption of power plants in 2030 is expected to be 111.8 million tonnes, while this value decreases by 3% in the SHURA scenario to 108.2 million tonnes. When savings from imported coal are also accounted for, the total benefit in terms of energy dependency is equivalent to US$ 2.7 billion per year.

In the SHURA scenario, the annual CO_2 emissions related to the electricity sector are reduced by 25.1 million tonnes compared to the Baseline scenario in 2030. This translates to limiting the growth in CO_2 emissions of the electricity sector to 5%, compared to its current level. Decrease in the use of coal for centralised electricity generation has a large impact on CO_2 emissions. In 2020, the generation of 1 kWh electricity results in around 465 g CO_2 emission. Emissions are expected to decrease to 409 g and 380 g levels in Baseline and SHURA scenarios in 2030, respectively.

Figure 3: *Change in CO_2 emissions from power plants, (2020-2030)*



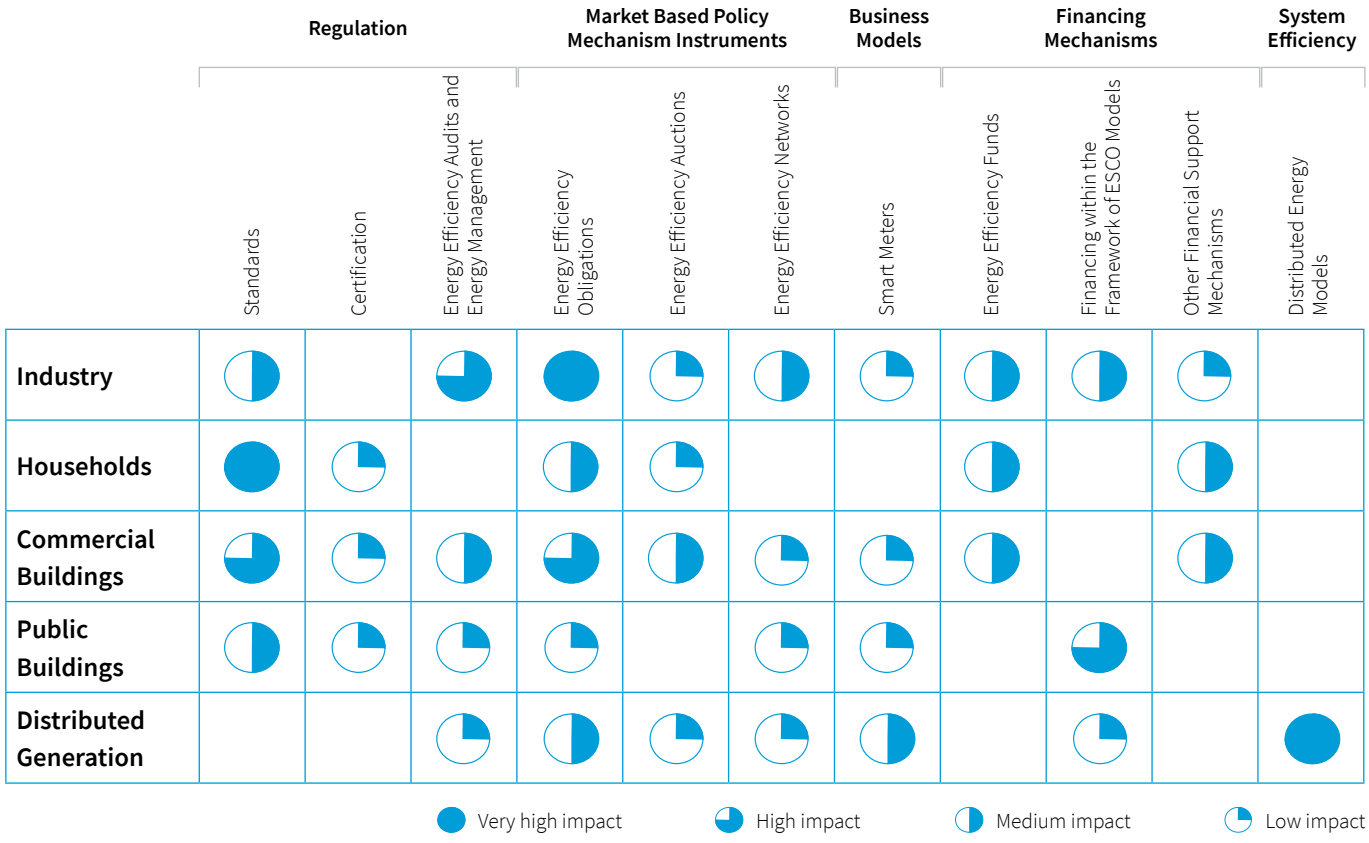
Improving energy efficiency has not only economic benefits, but also additional benefits such as contributing to increasing the share of renewable energy, reducing CO_2 emissions and new job creation, which are also assessed within the scope of the study. Energy efficiency also allows for more efficient use of local resources such as natural gas that Turkey is in search of, supporting these resources in meeting Turkey's

energy need for many years to come. It should be taken into account that the social and economic benefits that are excluded from the scope of the study such as creating new employment areas, increasing research and development capacity, improving air quality and human health, increasing raw material efficiency and other non-energy benefits are expected to be much higher than the economic benefits. The costs of SHURA scenario technology portfolio should be assessed with the non-energy related benefits it might create.

What are the pathways to achieve SHURA scenario's energy efficiency potential?

SHURA scenario shows potential total savings in electricity demand of 48.9 TWh/year and an additional electricity demand of 6.6 TWh/year in 2030 due to electrification. Compared to the Baseline scenario, net annual savings in the same year are estimated at 42,3 TWh. In order to understand how this potential can be operationalised, the study assesses 16 Energy Efficiency Solutions across 5 cross-cutting categories of regulation, market-based policy mechanism instruments, business models, financing mechanisms and measures to increase system efficiency.

Figure 4: *Impact of Energy Efficiency Solutions on the Sectors*



Detailed recommendations for policy makers and other actors of the power system are provided in the 5 supporting reports prepared for each Energy Efficiency Solution category. General policy recommendations, developed taking into account that energy efficiency is at the top of accelerating the energy transformation of Turkey, are as follows:

- As the results of this study show, for accelerating energy efficiency in Turkey, it will be important to determine long-term strategies and targets in line with sectoral targets. Energy sector-wide targets should be determined in the first place and

sectoral targets should be defined within this general framework. To achieve these, it will be necessary to review and re-define the duties and responsibilities of actors to implement and manage the proposed Energy Efficiency Solutions. In parallel with the technological developments, to accelerate the improvements in energy efficiency in all sectors, the current Energy Efficiency Solutions that are in place should be constantly reviewed and should be redefined and improved if necessary.

- Technical and administrative competencies should be increased and existing practices should be developed in order to achieve the potentials and to effectively implement and manage energy efficiency. Technical and administrative competencies of stakeholders that deal with the different Energy Efficiency Solutions should be increased and processes should be improved by monitoring the benefits obtained as a result of their implementation. It is essential to develop appropriate measurement, reporting and verification systems to monitor and manage the implementation of the Energy Efficiency Solutions.
- Sector stakeholders should be informed about the transforming role of energy efficiency, their awareness about the economic and other benefits of energy efficiency should be increased and they should be made conscious about the potential of energy efficiency investments.

General and detailed recommendations for policy makers and other actors of the power system are provided in the 5 supporting reports prepared for each Energy Efficiency Solution category: Regulation, market based policy mechanism instruments, business models, financing mechanisms, system efficiency.

Beyond these recommendations, the detailed and inclusive energy efficiency regulations that are already in place in Turkey should be continued and strengthened so as to realise higher energy savings to 2023 and beyond the NEEAP. To support the regulations, market-based policy mechanism instruments should be implemented as soon as possible to increase energy efficiency at low cost and effectively. Within the scope of these mechanisms, investments with low implementation costs and high contribution to energy efficiency should be put into practice through energy efficiency obligations and energy efficiency auctions, and these activities should be supported by energy efficiency networks.

Financing mechanisms and models should be developed and implemented to ensure that regulation, market-based policy mechanism instruments and other efficiency enhancing actions are implemented in a less costly and faster manner. Energy transition and its sub topics should be defined as a separate item under financing mechanisms.

Business models that can further integrate the demand side and distribution grids should be developed and implemented to increase energy efficiency. In this context, the use of smart meters should be increased in parallel with Turkey's existing smart grid roadmap, and the demand side response for increasing system flexibility should be utilised through the creation of various markets. System efficiency mechanisms and models that will empower the consumer, enable the whole system to operate in a more integrated and efficient fashion, and enable opportunities arising from distributed energy resources should be assessed and implemented.
The results of this comprehensive study, which consists of six reports published by the SHURA Energy Transition Center in 2020, could be an important starting point for the development of the new energy efficiency strategies and targets to 2030 and beyond, as well as supporting the realisation of the NEEAP targets until 2023.

What are the benefits of energy efficiency for the Turkish economy and society?

The decisions that will be taken by the Turkish energy sector today is of key importance for transforming the energy system into a cleaner, cheaper and more secure supply in the next 10 years in terms of renewable energy, electrification, and especially from the perspective of energy efficiency as shown in this study.
The energy efficiency measures that allow for the strengthening of the energy system brings about solutions to the ongoing energy import dependency of Turkey as shown in this study, also playing an important role in reducing the adverse impacts of climate change by reducing electricity sector's CO_2 emissions, which is responsible for the largest share of greenhouse gas emissions in Turkey.

Energy efficiency, electrification and distributed energy resources required for this transformation in Turkey are leading the way to increase economic activity by providing an investment opportunity of US$ 54 billion dollars in the next 10 years. These investments in particular will certainly play a big role in reducing dependence on foreign trade of manufactured technologies and equipment, enabling these to be produced in Turkey. The increase in investments and domestic production will be reflected as new opportunities for employment. Procuring the necessary technologies and services for an industry with more renewable energy shares and increasing energy efficiency will carry the current employment levels up. Turkey's industry providing a much cleaner source of energy, providing lower costs and less emissions in the value chain of products on the market, will also support the country's export potential. In addition to economic benefits, energy efficiency will also contribute greatly to the reduction of air pollutant emissions to which a high proportion Turkey's population is exposed to.

There are enormous opportunities ahead of Turkey in accelerating the energy sector transformation in the next decade and all stakeholders, especially the public sector, have come a long way in recent years in order to take advantage of these opportunities. These efforts will need to be continued to realise the cost-effective potential evaluated in this study. Energy efficiency investments can be considered as losing their priority in different sectors for a short time, along with the decreasing energy prices since the beginning of the COVID-19 pandemic. However many strides made by the National Energy Efficiency Action Plan's long-term positive effects should be considered in order to accelerate the implementation of Turkey, in particular at the beginning of 2020. Preventing a delay that may occur due to a decrease in demand and energy prices in the implementation of such a comprehensive and detailed plan will primarily provide commencement of the implementation of the solution for the problems of Turkey's dependence on imported fuels without postponement, and maximise the social and economic benefits of the energy transition.

In this context, the energy sector will overcome the difficulties associated with the changes in investment, financing and energy prices, which the energy sector has increasingly felt since the beginning of 2020 due to different reasons including the developments in the global economy alongside with the COVID-19 pandemic. Meanwhile, Turkey will also be able to go a long way in increasing the welfare of the society by having a cheaper, cleaner and more secure energy system. As in this study, it is of great importance to start exploring all these opportunities now and to include the results in medium- and long-term plans.

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 notbeholden to narrow corporate or political interests, but rather to its commitment to confronting climate change.

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