SHURA
ENERGY TRANSITION CENTER

EXECUTIVE SUMMARY

Transformation of Türkiye's Electricity Distribution Sector

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 the 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 Türkiye'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.

Authors: Alkım Bağ Güllü, Hasan Aksoy, Sena Serhadlıoğlu, R. Yağız Çalışkan (SHURA Energy Transition Center), Alper Durukan, Gökhan Tosun, Kenan Sitti, Mevlüt Akdeniz, Yıldız Durukan (MRC Turkey)

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This report and the assumptions made within the scope of the study have been drafted based on different scenarios and market conditions as of June 2025. 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 cannot 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.

MRC TÜRKİYE

KEY MESSAGES

• Distribution system operators (DSOs) have traditionally been responsible for integrating distributed energy resources into the grid, as well as overseeing the maintenance, operation, and expansion of the grid. With the ongoing energy transition, the DSOs are increasingly required to assume new responsibilities, including grid-constraint management and the provision of reactive power and voltage support to the transmission system operator (TSO). Effective fulfilment of these responsibilities will necessitate the deployment of smart meters, real-time data monitoring, aggregator frameworks, and technological and regulatory innovations that facilitate active market participation by prosumers.

• To plan the transformation of the distribution system effectively, it is essential to establish regional deployment targets for renewable and distributed energy resources, allowing DSOs to anticipate and plan the required infrastructure investments in advance. This approach enables DSOs to develop consumption forecasts through advanced data analytics, taking regional targets into account, and to more clearly identify priority areas for investment.

• To enable the effective use of advanced data analytics and real-time monitoring functions, investment plans for smart meter and smart grid infrastructure at the distribution level must be prepared. In this context, implementation efficiency could be improved by streamlining, digitalizing and expediting the permitting and approval processes through regulatory measures.

• As distributed generation grows, consumers that rely on these resources draw less electricity from the distribution grid, potentially reducing distribution revenues. Although distribution company revenues in Türkiye are regulated, the large-scale integration of distributed generation may, over time, lead to higher distribution tariffs. These increases could ultimately be passed on to other consumers through higher distribution charges. Therefore, a revised pricing mechanism and regulatory framework is needed—one that supports the expansion of distributed generation, incorporates performance-based incentives, and accounts for total system costs in a balanced way.

• Although the roles and responsibilities of TEİAŞ[1] and DSOs in Türkiye are largely distinct, certain responsibilities overlap in areas such as the distribution–transmission interface, grid planning, power quality, fault management, and renewable energy integration. In this context, clarifying these overlapping roles and responsibilities, along with enhancing inter-institutional coordination, is crucial for the effective and secure operation of the power system.

• The transformation of the distribution system can be outlined in three phases, each addressed periodically through investment, planning, and regulatory measures: In the short term, the focus is on analysing the existing system and identifying priority technical improvement areas; in the medium term, on deploying technologies that enhance grid resilience in line with rising demand and generation capacity; and in the long term, on creating market conditions that support local energy trading.

[1] Transmission system operator in Türkiye

Traditional electricity systems are centralized structures based on a unidirectional flow of energy from generation to consumption. In this structure, consumers are passive actors positioned at the end of the value chain. However, in recent years, the rapid proliferation of elements such as distributed renewable energy sources, behind-the-meter energy storage systems, and demand-side participation has made it necessary to transition to a flexible and digital grid structure that allows for bidirectional energy flow within the power system.

Countries' efforts to achieve net-zero emissions by mid-century are among the main driving forces supporting this energy transition. Integrating high-capacity distributed renewable energy sources into the grid lies at the heart of modern distribution system transformation. The proliferation of distributed energy resources (DERs) not only contributes to the decarbonization of the energy system but also offers multidimensional benefits such as reduced system losses, improved voltage and energy quality, and more efficient planning of grid investments. With the acceleration of electrification (via electric vehicles, heat pumps, etc.) in the coming period, the distribution system will need to evolve beyond being merely an energy delivery infrastructure to become an active and neutral market platform. Therefore, adopting a flexible, digital, and interactive structure in the development, management, and operation of grids is of critical importance.

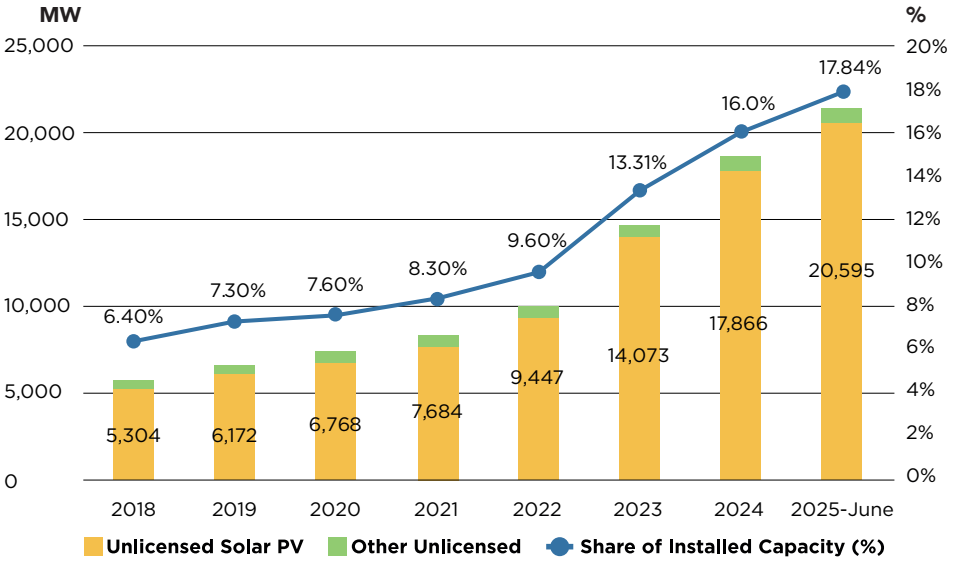
The distribution grid in Türkiye is structured to deliver electricity from transformer substations owned by TEİAŞ (Turkish Electricity Transmission Corporation) to end users. Traditionally, this system passively receives energy and operates under a structure where control is largely maintained by TEİAŞ. In conditions where DERs are limited, this configuration features a simple architecture that is relatively easy to manage. However, the rapid proliferation of distributed energy resources such as rooftop solar photovoltaic (PV) systems, electric vehicle (EV) charging stations, and heat pumps is altering consumption profiles, leading to bidirectional energy flows and fluctuations in power quality. This situation undermines the adequacy of existing operation and control mechanisms and consequently requires the enhancement of the monitoring, forecasting, control, and flexibility capabilities of the distribution system.

This transition inevitably enforces new investments in medium (MV) and low voltage (LV) grids, as well as the modernization of existing infrastructure. The process is critically important for maintaining power quality and ensuring the balance between supply and demand. In this context, modernizing and expanding the distribution system to accommodate these developments represents a fundamental cornerstone of the transformation. To ensure effective progress, developing distribution systems with a strong emphasis on digitalization and clearly defining the evolving roles and responsibilities of distribution system operators (DSOs) are key elements that will accelerate this transition.

According to SHURA's *"Net Zero 2053: A Roadmap for Türkiye's Electricity Sector"* report, achieving the targeted energy transition will require approximately 5 billion US dollars (US$) in annual investments in transmission and distribution infrastructure. The figure corresponds to nearly one-third of the electricity sector's total annual investment needs (SHURA, 2023). SHURA's *"Integration of Renewable Distributed Energy Generation into the Grid and Market"* study further highlights that DERs can deliver multidimensional benefits by enhancing overall system flexibility (SHURA, 2021). However, this study also emphasizes that the successful implementation of this transition depends on holistic planning and a robust, adaptive regulatory framework.

As of June 2025, Türkiye's total installed power capacity has reached 119,647 megawatts (MW). Of this capacity, 21,345 MW (18%) corresponds to unlicensed power plants, consisting predominantly of solar PV installations. The total installed capacity of solar PV power plants accounts for 20,595 MW, which represents 96.5% of the total unlicensed capacity. In total, there are 34,398 unlicensed solar PV power plants, with an average installed capacity of approximately 0.60 MW per plant. The evolution of installed unlicensed capacity and its share within total installed capacity is shown in Figure 1.

Figure 1. Installed Capacity Development of Unlicensed Power Plants (2018-2025)



Source: TEİAŞ Yük Tevzi Bilgi Sistemi (2025)

As part of the medium-term renewable energy objectives, the *"2024 – 2028 Strategic Plan"* published by the Republic of Türkiye Ministry of Energy and Natural Resources (MENR) envisions an annual increase of 3.5 gigawatts (GW) in solar PV installed capacity. Accordingly, the total installed solar PV installed capacity is expected to reach 33.1 GW by the end of 2028.

The MENR's strategy document *"Energy Transition – Renewable Energy 2035"* further highlights that the unlicensed solar installed capacity currently in the investment phase amounts to 23.5 GW, while licensed projects total approximately 20 GW. The same strategy document raises Türkiye's combined solar and wind installed capacity target to 120 GW by 2035 – representing nearly a 50% increase compared to the 82.5 GW projected in the *National Energy Plan (NEP)* published in 2022.

With the anticipated increase in predominantly solar-based resources connected at the distribution level, it is essential for the demand side to take a more active role in the energy system to ensure overall system flexibility. In this context, the widespread deployment of distributed energy generation facilities located close to consumption points, along with the adoption of innovative approaches that enable bidirectional energy flow within the grid, is of critical importance. Otherwise, the likelihood and frequency of technical issues—such as voltage fluctuations, reactive power imbalances, inadequate response to sudden load and generation changes, protection system incompatibilities, and reductions in power quality—are likely to increase. Moreover, the predominance of inverter-based DERs limits the system's ability to provide frequency and voltage support. Additionally, the increasing adoption of inverter-based DERs and clean electrification practices in energy-intensive sectors—such as industry, buildings, and transportation, where energy is consumed close to its point of generation—requires DSOs to assume greater responsibilities.

In this context, it is important that new investments in the distribution system are planned with consideration for digitalization and automation needs (Eurelectric, 2024). Distribution system modernization investments can generally be categorized under the following headings:

- Renewal of aging and suboptimal distribution infrastructure,
- Digitalization and modernization of the distribution system,
- Strengthening of cybersecurity measures,
- Widespread deployment of smart meters and micro-grid installations,
- Automation of primary and secondary substations.

The integration of these investments into distribution systems also requires the development of complementary regulatory frameworks and the implementation of practices that facilitate market operations, both of which are of great importance.

Priority Technologies and Application Areas

The applications employed in the transformation of distribution grids and the expansion of DERs may vary depending on a country's technical infrastructure, regulatory framework, and system requirements. In this context, the following technologies and applications are considered to be of primary importance in the transformation of the distribution system in Türkiye:

- Dynamic Line Rating (DLR): DLR systems are based on the principle that the current-carrying capacity of transmission lines changes in response to external environmental conditions. By monitoring these conditions in real–time and utilizing them in short-term forecasting simulations, DLR enables the optimization of a line's dynamic capacity.
- Medium Voltage (MV) Level Static Synchronous Compensator (STATCOM) Applications: STATCOM technology is based on power electronics and can quickly inject or absorb variable reactive power to or from the connected busbar through high-frequency switching. In this way, STATCOM allows for rapid voltage regulation at the connection point of an electrical grid (ENTSO-E, 2025).
- On-Load Tap Changer (OLTC) Applications in Distribution Transformers: OLTC systems provide corrective action against voltage drops by adjusting the transformer winding ratio in small steps, typically up to approximately 10%. Since this adjustment is performed without interrupting the power supply, OLTC offers high flexibility and uninterrupted operation on the lines.
- Microgrids: Microgrids are systems capable of operating independently (in island mode) from the main grid. These systems can supply electricity and heat while managing the supply-demand balance internally through one or more energy sources.
- Smart Meters and Smart Grids: Smart grids are systems that manage electricity supply and demand in real-time through digital technology, sensors, and software, ensuring efficient operation of the system. One of the most important components for smart grid deployments is the use and widespread adoption of smart meters, which can simultaneously monitor various parameters such as real-time electricity consumption, power quality, active/reactive power, voltage fluctuations, and outages.
- Cybersecurity: With increasing electrification and distributed generation, the reliance on digital data for grid operation—especially at the distribution level—raises cybersecurity threats. This situation necessitates that distribution system operators develop various cybersecurity measures and strategies to ensure secure and uninterrupted operation.

- Tariff Structures Promoting the Integration of Distributed Generation: To enhance grid flexibility, solutions traditionally focused on the supply side are increasingly being complemented by battery energy storage and demand-side participation. Within this framework, the use of dynamic tariffs to influence consumption behaviour serves as a tool for balancing grid load and utilizing capacity efficiently.
- Energy Cooperatives: Energy cooperatives operate based on a cooperative business model with joint ownership by their members. These cooperatives offer significant advantages such as increasing societal participation in energy transition, supporting employment and regional development, facilitating access to renewable energy for low-income households, and providing education and awareness on renewable energy and energy efficiency.
- Regional Energy Trading Platforms and Energy Markets: These are markets that enable the digital matching of DERs and energy consumers within a specific region, allowing consumers to purchase energy directly from local producers and benefit from various energy services.
- Regional Flexibility Markets: The development of local flexibility markets provides distribution companies with a tool to more efficiently manage the impacts of distributed generation sources, such as renewable energy plants and electric vehicles, on the grid. These markets establish regional platforms where prosumers can sell excess electricity or adjust their consumption in response to grid needs.

Phased Transformation Process

Regular review of investments, planning processes, and regulatory frameworks related to the distribution system is essential for the gradual and effective advancement of the transformation. Within this context, the transition can be structured into three main phases: in the short term, assessing the current situation, identifying priority areas for transformation, and preparing the foundational infrastructure; in the medium term, deploying and scaling technologies that will enhance grid resilience; and in the long term, establishing market conditions that will accelerate local energy trading. The key topics expected to emerge throughout these phases are presented below:

1. Short Term (2025-2030)

In this period, it is critical to develop roadmaps for the transformation of the distribution system and to establish the foundational infrastructure for grid modernization. Key priority actions include:

- Advancing digitalization at the distribution level,
- Developing real-time data monitoring and automation systems,
- Integrating advanced forecasting systems,
- Localizing and expanding the deployment of smart meters,
- Simplifying and digitizing application processes for distributed energy resource (DER) installations,
- Implementing regulatory measures to strengthen coordination between transmission and distribution system operators,
- Designing market and tariff mechanisms that enable the use of DER flexibility potential
- Restructuring distribution tariffs to reflect actual grid costs, considering regional characteristics and time-of-use variability,

- Resolving regulatory inconsistencies to accelerate the implementation of aggregation practices that contribute to grid flexibility, and
- As grid digitalization accelerates, establishing technical specifications and regulatory frameworks to ensure cybersecurity at the distribution level.

2. Medium Term (2030-2040)

During this period, the goal is to ensure the full deployment of smart grid infrastructure. Within this scope, the following actions are prioritized:

- Integrating technologies such as DLR, STATCOM, and OLTC transformers into regional distribution networks,
- Developing regulatory frameworks that enable DERs to provide services such as reactive power support, dynamic voltage control, constraint management, and black-start capabilities,
- Aligning aggregator activities with evolving system structures and preparing secondary legislation that clearly defines settlement rules, market participation criteria, performance tests, certification processes, and technical requirements,
- Preparing roadmaps for microgrid and mini-grid deployment to meet local energy needs—especially in industrial zones with high energy outage costs and in critical infrastructures such as hospitals, rural areas and remote regions.

The regulatory developments implemented in this phase will help reveal the systemic value of distributed generation, strengthen grid reliability, and lay the groundwork for the establishment of flexibility markets.

3. Long Term (2040-2053)

In the long term, the primary objective is to establish local energy markets to facilitate the trade of DERs and to increase transparency, security, and transaction efficiency within these markets. Within this framework, primary objective:

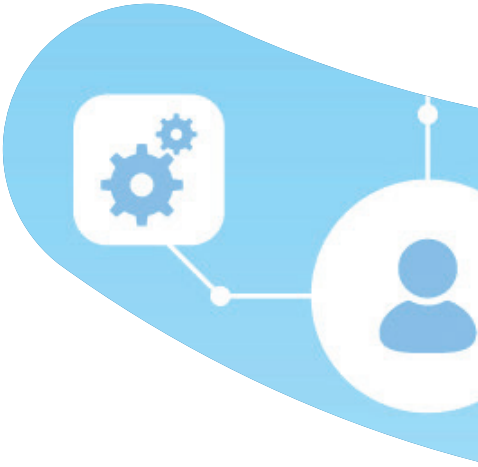
- Deploying blockchain-based solutions to enhance transparency and facilitate transaction processes in energy trading,
- Integrating Internet of Things (IoT) and blockchain-based systems for monitoring and managing greenhouse gas emissions and establishing emission tracking systems,
- Strengthening the legal, technical, and market foundations necessary for transforming the distribution system into a carbon-neutral, digital-driven structure.

Policy and Planning Perspective

An effective transformation of the distribution system requires a clear policy and planning framework. A key step in this process is defining regional deployment targets for renewable and distributed energy resources. Establishing such targets enables distribution system operators (DSOs) to anticipate future infrastructure needs, conduct more accurate consumption and generation forecasts using advanced data analytics, and clearly identify priority investment areas.

To fully leverage capabilities such as advanced data analytics and real-time monitoring, it is essential to develop comprehensive investment plans for the deployment of smart meters and smart grid infrastructure at the distribution level. In this process, streamlining, expediting, and digitalizing permit and approval mechanisms through regulatory adjustments can further enhance implementation effectiveness. In addition, the use of innovative financing instruments should be considered to ensure that planned investments can be commissioned within the projected timelines. When these measures are implemented, the distribution grid can be operated more efficiently and resiliently, while DSOs will be better equipped to respond promptly to faults and regional constraints.

In summary, enhanced integration of distributed generation into grids and markets is expected to yield multiple benefits, including accelerated decarbonization of the energy system, improved voltage and energy quality, reduced investment needs for high-cost fossil-fuel power plant deployments as well as transmission/distribution infrastructure, lower grid losses, and decreased imported fuel costs. In this context, regulatory frameworks, financial mechanisms, and business models should be designed to align with innovative approaches that maximize the utilization of distributed energy resources.



SHURA
ENERGY TRANSITION CENTER

Bankalar Caddesi, No:2, Minerva Han,
Kat:3, 34420 Karaköy/İstanbul
T: 0 (212) 292 49 39
E-posta: info@shura.org.tr
www.shura.org.tr

SHURA is founded by

İPM | IPC İSTANBUL POLİTİKALAR MERKEZİ
SABANCI ÜNİVERSİTESİ KAMPÜSÜ
İSTANBUL POLICY CENTER
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