Power market road map for Central and West Asia:

Promoting cross-border electricity connectivity for sustainable development

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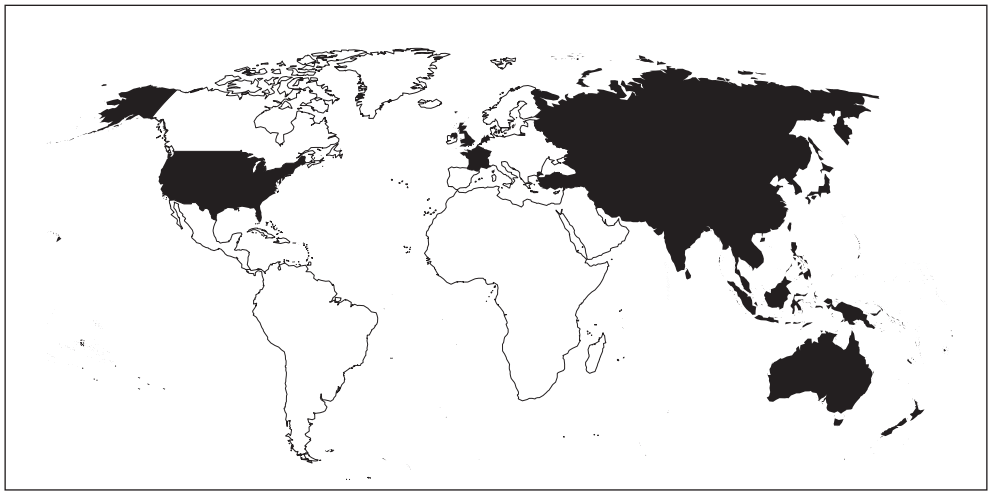

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Abbreviations

ADB	Asian Development Bank
AEDB	Alternative Energy Development Board
AERA	The Azerbaijan Energy Regulatory Agency
AR	Autonomous Republic
BAU	business as usual
BOO	building, operation and ownership contract type
BOT	building, operation and transfer contract type
BP	British Petroleum
CAPS	Central Asia Power System
CAREC	Central Asia Regional Economic Cooperation
CAREM	Central Asia Regional Electricity Market
CASA	Central Asia-South Asia
CASA-1000	The Kyrgyzstan-Tajikistan-Afghanistan-Pakistan transmission line
CASA-REM	Central Asia-South Asia Regional Energy Markets
CATCA	Central Asia Transmission Cooperation Association
CDC	Coordination Dispatch Centre
CECP	China-ESCAP Cooperation Programme
CHP	combined heat and power
CHPP	combined heat and power plant
CIS	The Commonwealth of Independent States
CPEC	China – Pakistan Economic Corridor
CPP	capacity purchase price
CPPA-G	Central Power Purchasing Agency (Guarantee) Limited
CREM	Committee for the Regulation of Natural Monopolies and Protection of Competition
DABS	Da Afghanistan Breshna Sherkat
DFPC	Department for the Regulation of the Fuel and Power Complex
DISCOs	distribution companies
DSO	distribution system operator
EAEU	Eurasian Economic Union
EBRD	European Bank for Reconstruction and Development
ECO	Economic Cooperation Organization
ECO-REM	Economic Cooperation Organization Regional Electricity Market
EMRA	Energy Market Regulatory Authority
ENTSO-E	European Network of Transmission System Operators – Electricity
EPIAŞ	Enerji Piyasaları İşletme Anonim Şirket
EPP	energy purchase price
ESCAP	Economic and Social Commission for Asia and the Pacific
ESMAP	Energy Sector Management Assistance Program
ETS	emissions trading system
EÜAŞ	Electricity Generation Company (Elektrik Üretim Anonim Şirketi)
FY	Fiscal Year
GBAO	Gorno-Badakhshan Autonomous Region
GDP	gross domestic product
GENCOs	generation companies
GHG	greenhouse gas
HPP	hydropower plant
HVDC	high-voltage direct current
IEA	International Energy Agency
IES	integrated electricity system
IFC	International Finance Corporation
IGCEP	Indicative Generation Capacity Expansion Plan
IGMC	Iran Grid Management Company
IPPs	independent power producers
IREMA	Iran Electricity Market
IRENA	International Renewable Energy Agency

IRENEX	Iran Energy Exchange
KEGOC	Kazakhstan Electricity Grid Operating Company
KOREM	Kazakhstan operator of electricity and power market operator
kWh	kilowatt-hour
LNG	liquefied natural gas
LPNPP	low-power nuclear power plant
MW	megawatts
$MtCO_2$	metric tons of carbon dioxide
MoE	Ministry of Energy
MoEWR	Ministry of Energy and Water Resources
MTTP	Mid-Term Tariff Policy
NDP	National Development Program
NDS	National Development Strategy of the Kyrgyz Republic for 2018-2040
NEPRA	National Electric Power Regulatory Authority
NESK	National Electric Grid of Kyrgyzstan
NGO	non-governmental organization
NPCC	National Power Construction Corporation
NPM	National Mitigation Plan
NPP	nuclear power plant
NTDC	National Transmission and Dispatch Company
NVQF	National Vocational Qualification Framework
OECD	Organisation for Economic Co-operation and Development
PPP	public-private partnership
PSMP	The Power Sector Master Plan for Afghanistan
PV	photovoltaics
RE	renewable energy
RES	renewable energy sources
RFO	refined petroleum products
RRMPSC	Regional Road Map on Power System Connectivity
SATBA	Renewable Energy and Energy Efficiency Organization of Iran
SDG	Sustainable Development Goal
SHPP	small hydro power plant
SOCAR	State Oil Company of Azerbaijan Republic
TALCO	Tajik Aluminum Company
TAP	The Turkmenistan-Afghanistan-Pakistan transmission line
TEİAŞ	Turkish Electricity Transmission Corporation
TEK	Turkish Electricity Administration
TOR	Transfer-Operating-Rights contract type
TPP	thermal power plant
TSO	transmission system operator
TUTAP	The Turkmenistan-Uzbekistan-Tajikistan-Afghanistan-Pakistan transmission line
TWh	terawatt-hour
UES	Unified Energy System
UES CA	Unified Energy System of Central Asia
UNDP	United Nations Development Programme
ECE	United Nations Economic Commission for Europe
US EIA	U.S. Energy Information Administration
USAID	United States Agency for International Development
USSR	The Union of Soviet Socialist Republics
VAT	value-added tax
WAPDA	Water & Power Development Authority

Foreword

The Asia-Pacific region is not on track to achieve Sustainable Development Goal 7 (SDG 7), which aims to ensure access to affordable, reliable, sustainable and modern energy for all. While progress has been made in areas such as energy access, the region continues to rely heavily on fossil fuels and progress has been hindered by fragmented regional energy cooperation. While many tools are available to accelerate the energy transition, energy connectivity — linking national power grids and enabling cross-border electricity trade — remains underutilized, despite holding enormous potential to facilitate the integration of renewable energy, improve energy security and drive sustainable development.

The Regional Road Map on Power System Connectivity, endorsed by ESCAP member States in 2021, outlines nine strategies to enhance regional energy integration. Power system connectivity is not a silver bullet, but when implemented effectively it can be a powerful enabler of a secure and accelerated energy transition. It allows countries to share energy resources more efficiently, reduce costs and improve the flexibility needed to integrate higher shares of renewable energy, such as wind and solar, which are critical to meeting climate goals and SDG 7.

Recognizing the potential benefits of increased power system connectivity, the Economic Cooperation Organization (ECO) has had a long-standing goal of establishing an ECO Regional Electricity Market (ECO-REM). The diversity of the ECO member states presents both challenges and opportunities. Countries like Kyrgyzstan and Tajikistan have abundant hydropower resources, while others, such as Turkmenistan and Kazakhstan, are rich in fossil fuels but are increasingly exploring renewable energy options. To date, however, energy connectivity across the region remains limited and cross-border power trade is often confined to bilateral agreements rather than the multilateral frameworks necessary for unlocking broader benefits.

This report emphasizes the need to build on existing infrastructure and strengthen regional cooperation to create a unified electricity trading market. By harmonizing regulations, investing in cross-border grids and fostering regional cooperation, the ECO-REM can help overcome these challenges and enable all member states to access a wider pool of energy resources, including renewables. The road map outlines specific measures, such as the establishment of regional investment platforms and regulatory frameworks that support clean energy trade, which are essential for ensuring an inclusive and just energy transition.

Energy connectivity, when coupled with other critical interventions, can be the catalyst that propels the region toward a cleaner, more resilient energy future. Achieving this vision will require strong political will, sustained cooperation and robust investment. The ECO-REM road map provides a clear pathway forward and ESCAP stands ready to work with member States to turn this vision into reality.

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Executive Summary

Multilateral trade of energy and the establishment of competitive markets play key roles in facilitating the integration of higher shares of renewable energy by enabling the exchange of power across borders. In recent years, the quest for enhanced energy connectivity has gained momentum across the Central Asian, South-West Asian and South Asian regions, fostering discussions and initiatives aimed at leveraging the potential of cross-border power trade.

One such initiative that emerged in 2012, within the Economic Cooperation Organization (ECO), is the ECO Regional Electricity Market (ECO-REM).

Despite years of effort, the ECO-REM remains primarily at the discussion stage. To facilitate the advancement of the ECO-REM initiative and enhance energy connectivity in the region, the Energy Division, within the United Nations Economic and Social Commission for Asia and Pacific (ESCAP), with support from China-ESCAP Cooperation Programme (CECP), has initiated the project "Energy connectivity for sustainable development – Enabling renewable energy resource sharing across borders".

The project covers the 10 ECO member states, which include Afghanistan, Azerbaijan, Iran (Islamic Republic of), Kazakhstan, Kyrgyzstan, Pakistan, Tajikistan, Türkiye, Turkmenistan and Uzbekistan. Each country faces its own set of challenges related to its particular context with regard to energy production, distribution and cross-border connectivity. The ECO countries share borders and there exists cross-border power transmission infrastructure with occasional or continuous electricity exchange. But there is still relatively limited amounts of cross-border electricity trade compared to the potential. Fully unlocking the benefits of renewable energy resources to meet energy sustainability, affordability and security goals requires the ECO countries to combine their efforts to reduce regulatory, technical and economic barriers to develop and trade the diverse range of low-carbon energy resources available to them.

This road map for developing the ECO-REM contains a set of targeted, actionable recommendations for policy and regulatory reforms that would enable the establishment of multilateral, multidirectional power trading among at least three countries in each subregion where cross-border electricity transmission infrastructure exists (ECE, 2024).

ECO member states already have a degree of intra- and inter-regional transnational electricity trading arrangements in place. However, none of these arrangements extend across the entirety of the ECO region. Instead, they are either multilateral or bilateral in nature, due to limited power infrastructure across some borders or geographic locations. In other words, the ECO region itself is divided into subregional and bilateral cross-border electricity trading zones that have very weak or no interactions with each other.

Development of the ECO-REM can and should take into account and build off of existing trade arrangements and integration initiatives in the region. It is therefore important to take into account the current status of initiatives in the region that support the development of energy connectivity (CAREM, CAREC and other important initiatives); the experience of dispatch centres (for example, Central Asian Power System

Dispatch Center); and broader energy market development initiatives (for example, those supported by the Global Energy Interconnection Development and Cooperation Organization (GEIDCO)).

Taking these initiatives into consideration, the ECO-REM road map proposes beginning with the establishment of a secondary market model, which will be followed by the development of a primary market model. Furthermore, the ECO region can be divided into three zones/submarkets based on their specific regional features which could be interlinked together once developed. The anticipated development period for zones is medium term (4 to 7 years), while the development period of the ECO region market is long term (7 to 10 years). The proposed zonal division is introduced below:

- Eastern Zone: Afghanistan and Pakistan.
- Central Zone: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.
- Western Zone: Azerbaijan, Iran (Islamic Republic of) and Türkiye.

Within the proposed zonal divisions, the road map outlines nine measures that are designed to ensure structured and productive cooperation at the regional and subregional levels, eliminating existing barriers and securing investments in the field. The measures are:

- Organization of stakeholders cooperation mechanism: establishing a permanent high-level working group and 'zones' as subgroups; agreeing on decision-making principles; and financing designated activities.
- Agreements on the boundaries of energy cooperation: signing of the framework of multilateral intergovernmental agreements on energy cooperation; developing a comprehensive master plan for the advancement of cross-border electricity trade in the region.
- Development of rules and mechanisms for mutual trade and interstate electricity transmission: incorporating the rules into the national legislation of ECO member states.
- Harmonization of regulations on cross-border electricity connectivity: publishing results annually through comparative analyses of energy policies.
- Regional cross-border electricity grid master plan (with subregional segments): creating coordinated cooperation mechanisms to plan the development of the regional cross-border electricity grid.
- Promoting interaction of organizations (system operators, commercial infrastructure operators): implementing cooperation mechanisms for infrastructure organizations in the electricity transmission and trade.
- Encouraging investments: developing regional platforms that bring together interested parties to promote project financing in clean energy production and trading.

- Enabling information exchange: implementing rules for information exchange between authorized government bodies and infrastructure organizations in the region.

- Sustainability of interstate electricity trade: including sustainable development criteria in projects, with a focus on cross-border electricity trade.

This report introduces a road map with the proposed actions on how to materialize the ECO-REM and an analysis of the power sectors in each of the ECO member states, with a focus on their current and perspective cross-border connectivity activities.

I. Power market road map for Central and West Asia: Background, context and recommendations

1. Background

The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) is promoting regional energy connectivity through multilateral cooperation. Energy connectivity, with a particular focus on power grids, is important for enhancing the sustainability and security of the region's energy supply. In recent years, the request for enhanced energy connectivity has gained momentum across Central and South Asian regions, fostering discussions and initiatives aimed at leveraging the potential of cross-border power trade.

One such initiative emerged during the 2nd Economic Cooperation Organization (ECO) High Level Experts Group Meeting on Energy, that was held in September 2012 in Ankara, Türkiye, where Iran (Islamic Republic of) proposed the establishment of the ECO Regional Electricity Market (ECO-REM). The importance of establishing the ECOREM was also emphasized during the 23rd ECO Regional Planning Council Meeting, held from 6-8 May 2013, in Tehran, Iran (Islamic Republic of), where member states were requested to organize relevant events to implement this initiative (Marzayev, n.d.).[1]

To facilitate the development of the ECO-REM initiative and enhance energy connectivity in the region, ESCAP, with support from the China-ESCAP Cooperation Programme (CECP), has initiated the project "Energy connectivity for sustainable development: Enabling renewable energy resource sharing across borders".

The specific focus of this project aligns with Regional Road Map on Power System Connectivity which was collectively endorsed by ESCAP member States in

1 The most recent efforts to develop the ECO-REM kickstarted at a meeting in 2020, organized in cooperation with Energy Charter. At the 4th ECO Energy Ministerial Meeting (June 2021, virtual meeting) ECO member states adopted the ECO Energy Strategy 2030 and its Action Plan, the Charter of the Clean Energy Center and the ECO-REM Road map. During the meeting, member states emphasized the importance to enhance regional energy cooperation in clean energy, energy security and addressing SDGs. For more details see Economic Cooperation Organization (ECO), "Promoting integration of power markets in the ECO region", n.d. Available at https://eco.int/promoting-integration-of-power-markets-in-the-eco-region and Economic Cooperation Organization (ECO), "4th ECO Energy Ministerial Meeting", n.d.c. Available at https://eco.int/4th-eco-energy-ministerial-meeting

2021 (ESCAP/76/15). Specifically, Strategy 5 of the Regional Road Map on Power System Connectivity (2021) refers to a "move towards multilateral power trade and create competitive markets for cross-border electricity" (ESCAP/76/15). Multilateral, multidirectional power trading is particularly important for renewable energy resources, as flexibly balancing is a key tool in enabling their secure and cost-effective integration. Moreover, enabling multilateral, multidirectional trade of electricity generated from renewable energy resources, such as wind and solar photovoltaics, forms a significant opportunity for the Central and South Asian regions to accelerate progress on the Sustainable Development Goals (SDGs), in particular, SDG 7 (Affordable and Clean Energy) and SDG 13 (Climate Action).

The project is being implemented under the broader Program on Energy Connectivity in Central Asia and the Caucasus, which was launched in January 2024 by ESCAP and the United Nations Economic Commission for Europe (ECE) (ECO, n.d.a.). A coordination meeting on the ECO-REM was held by ESCAP and the ECO Secretariat in February 2024 (ECO, n.d.b.).

The project covers the ECO region, which includes Afghanistan, Azerbaijan, Iran (Islamic Republic of), Kazakhstan, Kyrgyzstan, Pakistan, Tajikistan, Türkiye, Turkmenistan and Uzbekistan.

Each country faces its own unique challenges and opportunities in the realm of energy production, distribution and connectivity.

Afghanistan has made a significant progress in the power sector in the expansion of electricity access. However, a significant portion of the population continues to rely on traditional energy sources such as firewood and kerosene. Political and security concerns, as well as lack of funding costly infrastructure projects, create challenges for future development.

The power sector in **Pakistan** relies on imported fuel, so the country started investing in hydropower, wind and solar energy to address energy shortages and promote sustainability.

Azerbaijan, **Kazakhstan**, **Turkmenistan** and **Uzbekistan** are dominated by fossil fuels with significant untapped potential in renewable energy. They have embarked on a mission to increase the share of renewable sources to diversify their electricity generation mix and to meet global and national climate goals.

Kyrgyzstan and **Tajikistan** heavily rely on hydropower for electricity generation, but their significant hydropower potential remains largely untapped. Financial constraints and aging infrastructure hinder the development of power infrastructure in the country. Tajikistan aims to use its abundant water resources to become a major exporter of electricity in the region.

Iran (Islamic Republic of) has a diverse energy mix, including natural gas, oil, hydro power, as well significant renewable sources under development, such as wind and solar power. But despite its vast energy resources, the country faces challenges related to infrastructure, investment and international sanctions. At the same time Iran (Islamic Republic of) has the potential to serve as a key energy transit hub between Central Asia, the Middle East and South Asia, specifically between the Central Asia and the Caucasus regions.

Türkiye also has a diversified energy mix and plays a crucial role in regional energy connectivity, serving as a bridge between Europe, the Middle East and Central Asia. The country has a fully developed liberal electricity market and has considerably increased the share of renewable energy sources in electricity generation.

The ECO countries share borders and there is existing cross-border power transmission infrastructure with occasional or continuous electricity exchange. Moreover, some of the

Table 1. Regional cross-border electricity trade (TWh) in 2023

	Kazakhstan	Uzbekistan	Kyrgyzstan	Tajikistan	Turkmenistan	Afghanistan	Pakistan	Iran (Islamic Republic of)	Azerbaijan	Türkiye
Kazakhstan		–	1.44 0.07	–	–	–	–	–	–	–
Uzbekistan	–		–	0.91	4.01	1.82	–	–	–	–
Kyrgyzstan	0.07 1.44	–		0.01 0.02	1.77	–	–	–	–	–
Tajikistan	–	0.91 0.80	0.02 0.01		–	1.53	–	–	–	–
Turkmenistan	–	4.01	1.77	–		1.42	–	1.74**	–	–
Afghanistan	–	1.82	–	1.53	1.42		–	0.71	–	–
Pakistan	–	–	–	–	–	–		0.50	–	–
Iran (Islamic Republic of)	–	–	–	–	1.00* 0.89*	0.71*	–		0.03 0.03	0.15*
Azerbaijan	–	–	–	–	–	–	–	0.03 0.03		1.58
Türkiye	–	–	–	–	–	–	–	0.15	0.151*	

Source: Kazakhstan (Bureau of National Statistics, CDC "Energia"); Uzbekistan (CDC "Energia"); Kyrgyzstan (CDC "Energia", estimated data); Tajikistan (ITC Trade Map, CDC "Energia"); Turkmenistan (CDC "Energia", National Statistical Committee of the Kyrgyz Republic, Media Turkmen (ORIENT, 2024), UN Comtrade); Afghanistan (National Statistics and Information Authority, CDC "Energia"); Pakistan (EIA, NEPRA); Iran (Islamic Republic of) (US Energy Information Administration, National Statistics and Information Authority of Afghanistan, National Electric Power Regulatory Authority of Pakistan, CDC "Energia", National Statistical Committee of the Kyrgyz Republic, State Statics Committee of the Republic of Azerbaijan, Turkish Electricity Transmission Corporation).
Note: * – data for 2022; ** – estimated; green figure = exports; red figure = imports

countries, in particular Kazakhstan, Kyrgyzstan and Uzbekistan are operating as a united power system (Central Asian Power System (CAPS)). The basis for the coordinated operation of CAPS is a multilateral agreement on parallel operation, signed by the five national power systems (Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan and Turkmenistan) in the late 1990s.[2] But, there is still relatively limited amounts of cross-border electricity trade compared to their potential.

All ECO member countries possess significant untapped potential for renewable energy, even though the share of renewables in the energy mix in these countries is only 6 per cent (ECO, 2021). If developed in coordination with increased cross-border and regional connectivity, this could contribute to regional energy security and to reductions in energy sector carbon emissions. Fully unlocking the benefits of renewable energy resources to meet energy sustainability, affordability and security goals requires the ECO countries to collaborate to reduce regulatory, technical and economic barriers to boost development and encourage trade of the diverse range of low-carbon energy resources available to them.

Several attempts to realize cross-border electricity trade potential are at various stages of development. CASA1000, the Turkmenistan-Uzbekistan-Tajikistan-Afghanistan-Pakistan (TUTAP) and Turkmenistan-Afghanistan-Paistan (TAP) projects are among key regional initiatives that

2 In 2003, Turkmenistan disconnected from the united system and, in 2009, Tajikistan was disconnected from the regional power system by Uzbekistan. In 2018, Tajikistan with reconnected and initiated bilateral electricity trade with Uzbekistan (in island mode) and full reconnection to CAPS was formally finalized in June 2024.

Table 2. Share of installed renewable energy sources capacity in ECO member states and future development plans (percentage)

GW	Status in 2022		Mid- and long-term plans	
	Renewable energy sources (excluding hydro)	Hydro (including small hydro)	Renewable energy sources (excluding hydro)	Hydro (including small hydro)
Türkiye	27	30	2035: 55	2035: 55
Pakistan	3.11	10.80 (na)	FY-2025: 40% of total generation capacity FY-2030: 60% of total generation capacity	na
Kazakhstan*	2.25	2.80 (0.20)	2035: +6.00	2035: +2.00 (na)
Iran (Islamic Republic of)*	0.97	13.23 (na)	2027: 20.00 2031: 50.00	na
Azerbaijan***	4	17	2030: 30% in the total installed capacity (including hydro)	---
Afghanistan	0.03	0.45 (na)	2032: 5.00	2032: +1.51 (na)
Uzbekistan	0.30	2.05 (na)	2030: +8.00	2030: +1.11 (na)
Tajikistan	>0.01	5 (0.027)	2030: +0.80	2030: + around 4 (na)
Turkmenistan	0.00	0.00 (0.00)	na	na
Kyrgyzstan**	0.00	3.03 (0.06)	2040: 10% in the total energy balance of the country	

Source: Kazakhstan (Energy Balance until 2035); Uzbekistan (Electricity Supply Security Concept for 2020-2030); Kyrgyzstan (National Development Strategy of the Kyrgyz Republic for 2018-2040); Tajikistan (National Development Strategy 2030 and the Green Economy Strategy); Afghanistan (Power Sector Master Plan for Afghanistan); Pakistan (National Electricity Plan 2023-27); Iran (Islamic Republic of) (Intellinews, "Iran looks to solar power to solve energy shortages", 31 October 2023. Available at https://www.intellinews.com/iran-looks-to-solar-power-to-solve-energy-shortages-298872); Azerbaijan (COP26 Glasgow statement); and Türkiye (Türkiye National Energy Plan).
Note: * — data for 2023; ** — data for 2021; *** — data for 2023; N/A — not available.

Table 3. Share of renewable energy sources (including hydro) in regional electricity generation in 2010, 2015, 2020, 2021, percentage.

Country	2010	2015	2020	2021
Afghanistan	NA	NA	NA	NA
Azerbaijan	18.4%	7.4%	5.5%	5.8%
Iran (Islamic Republic of)	4.2%	5.1%	5.1%	5.0%
Kazakhstan	14.7%	10.4%	11.0%	10.9%
Kyrgyzstan	91.8%	85.2%	90.8%	85.6%
Pakistan	33.7%	32.5%	26.8%	24.6%
Tajikistan	99.8%	99.1%	90.1%	90.0%
Türkiye	26.4%	32.0%	41.9%	35.4%
Turkmenistan	X	X	X	X
Uzbekistan	18.7%	13.5%	8.1%	7.5%

Source: International Energy Agency (IEA), "Energy Statistics Data Browser", n.d. Available at https://www.iea.org/data-and-statistics/data-tools/energy-statistics-data-browser?country=WORLD&fuel=Energy%20supply&indicator=TESbySource
Note: N/A = not available; X = not applicable

Table 4. Notable key regional infrastructure projects for cross-border electricity trade

Project	Countries	Description	Status
CASA-1000	Afghanistan, Kyrgyzstan, Pakistan, Tajikistan	CASA-1000 project consists of a 500 kV alternating current transmission line connecting Kyrgyzstan and Tajikistan, and a 500 kV direct current transmission line connecting Tajikistan, Afghanistan and Pakistan. The project was approved in 2012 by all member countries. The first three construction contracts for CASA-1000 facilities were signed in December 2017. Since then, seven contracts have been awarded, signed and activated with field construction activities having begun on all ten contracts by April 2021 (CASA-1000, 2024b). However, the CASA-1000 project in Afghanistan was paused in the wake of the political situation in August 2021, while construction activities are nearly complete in Kyrgyzstan, Tajikistan and Pakistan (World Bank Group, 2024).	Partially completed
TUTAP	Afghanistan, Pakistan, Tajikistan, Turkmenistan, Uzbekistan	The Turkmenistan-Uzbekistan-Tajikistan-Afghanistan-Pakistan (TUTAP) power interconnection project envisages Afghanistan as an energy trading hub connecting neighbour countries. The project consists of six interconnections / lines (Energy Charter, 2020): • Uzbekistan-Afghanistan (220kV; 500 km) • Tajikistan-Afghanistan (220kV; 160 km) • Turkmenistan-Afghanistan (500kV, 350 km) • Kabul-Jalalabad-Kunar (220kV) • Uzbekistan-Afghanistan (Surkhan-Pule Khumri, 500kV, 201 km) • Turkmenistan-Afghanistan-Pakistan (500kV, 750 km)	Partially completed
TAP	Afghanistan, Pakistan, Turkmenistan	The Turkmenistan-Afghanistan-Pakistan power interconnection project envisages the use of existing infrastructure under the TUTAP power interconnection project and a new one to transfer power from Turkmenistan through the border of Serhetabad (Turkmenistan) and Torghundy intoIt, Kandahar and Spin Boldak in Afghanistan and to Chaman and Quetta in Pakistan.	Partially completed

Source: Energy Charter, "Energy trade and regional connectivity: TUTAP power interconnection project", October 2020. Available at https://www.energycharter.org/fileadmin/DocumentsMedia/News/6_Asian_Development_Bank.pdf; International Energy Agency (IEA), "Establishing Multilateral Trade in ASEAN", Paris, 2019. Available at https://www.iea.org/reports/establishing-multilateral-power-trade-in-asean

enhance cross-border electricity infrastructure (table 4).

To provide a holistic understanding of the regional dynamics, this road map draws upon insights and lessons learned from relevant studies and publications focusing on energy cooperation and market integration in Central Asia and particularly examining the opportunities for market formation. There are several initiatives in the region supporting the development of energy connectivity, including:

- **United States Agency for International Development (USAID)** provides technical assistance and capacity-building to the five Central Asian countries to help create an economically viable **Central Asia Regional Electricity Market (CAREM)** (USAID, n.d.). In particular, USAID supports Central Asian Governments to create the conditions to increase cross-border flows, and closely collaborates with them to develop the structures, rules and institutions that will guide the implementation of a safe, secure and reliable regional electricity market (USAID, n.d.).
- **The Asian Development Bank (ADB)** conducted an analysis on future energy market options for **Central Asia Regional Economic Cooperation (CAREC)** programme members to help facilitate sustainable energy infrastructure investment (ADB, 2022). In 2019, ADB published "CAREC Energy Strategy 2030: Common Borders. Common Solutions. Common Energy Future", which provides the new long-term strategic framework for the program and prioritizes five operational

clusters, including "Infrastructure and Connectivity". As of December 2021, CAREC has invested nearly US$ 12.71 billion in energy projects that are mostly aimed at expanding bilateral electricity trade and improving the regional power network that aim to support growth in ongoing trade (CAREC, 2022).

- **The World Bank** explores the possibilities of developing a regional electricity market in Central and South Asia (World Bank Group, 2023a; World Bank Live, 2022). It is also providing technical assistance funding within the framework of **CASA-1000** as a part of consortium of international development institutions, including the Islamic Development Bank, the European Investment Bank and the European Bank for Reconstruction and Development etc (CASA-1000, 2024a).

Moreover, Kazakhstan and Kyrgyzstan, in collaboration with Armenia, Belarus and the Russian Federation are participating in the creation of a common electric power market within the Eurasian Economic Union (EAEU). In October 2023, the Heads of the Governments of the Eurasian Economic Union countries approved the "Rules for mutual trade in electric power", and the "Rules for determining and allocating the capacity of cross-border interconnections in the common electric power market" (EEC, 2023).

Most of the initiatives emphasize the importance of regional cooperation for improving energy security, reducing costs and promoting sustainable development. However, there are key barriers to integration, including policy and regulatory barriers, infrastructure development needs and geopolitical tensions. The ECO-REM project aims to provide specific regulatory reforms and next steps needed to establish a functioning regional electricity market and its implications for regional energy cooperation and sustainable development. Through collaborative efforts and strategic partnerships, countries within the ECO region can unlock the full potential of multilateral power trade and market integration, which will lead to wider integration of renewable energy resources and broader energy transition.

2. Goals and principles

The main objective of this project is to accelerate progress on the establishment of multilateral power trading linked to the integration of renewable energy resources. The project will focus on the potential for establishing multilateral power trade in the context of existing connectivity efforts, specifically the proposed ECO-REM.

The ultimate goal of this project is to deliver a set of targeted, actionable recommendations for policy and regulatory reforms that would enable the establishment of multilateral, multidirectional power trading among at least three countries in each subregion where cross-border electricity transmission infrastructure exists.

The project is intended to provide a reference for regional cooperation towards achieving power grid integration over the period 2025 to 2035.

Vision:

- Transnational power system connectivity can, if properly guided, enable the development of interconnected grids that are more reliable, affordable and sustainable.

- Integrating power systems across borders allows countries to leverage their diversity both in terms of supply and demand to lower the cost of power facilities development and operations while simultaneously improving reliability and decreasing carbon emissions.

- Transnational power system connectivity contributes to achieving Sustainable Development Goal 7 and the other Goals.

Principles:

- Focus on achieving a set of targeted, actionable recommendations for policy and regulatory reforms that would enable the establishment of multilateral, multidirectional power trading.
- Support power system connectivity through relevant policies, regulations and business models that carefully consider each country's circumstance.
- Decide nationally whether transnational connectivity is appropriate and according to country context.
- Enhance cooperation with other intergovernmental and non-governmental organizations and the business community and private sector by preparing joint studies and participating in joint events, such as surveys, seminars and workshops.
- Develop the project based on previous efforts in the region by various developing partners.

3. Challenges for the ECO region

Establishing the ECO-REM would create significant potential for enhancing renewable energy development, improving energy security, promoting economic growth and fostering regional cooperation among member countries. However, despite its potential benefits, the development of ECO-REM faces certain challenges that need be addressed to fully realize its objectives. All ECO member states face limited options for financing, particularly in attaining foreign direct investments and local private financing, and competing policy priorities. While the Governments of some ECO member states can mobilize state funds for large energy projects, mobilizing investment is a challenge for private sector participants for capital-intensive medium and small-scale projects in the power sector.

In terms of fitting into national electricity trading systems, multilateral electricity trading can have "primary" and "secondary" models. In primary models, regional, multilateral electricity trade is the default mode, whereas in secondary models regional electricity trading takes place as an additional option on top of national markets or national power system operation arrangements (IEA, 2019).

All models require some kind of prerequisites for their formulation and implementation. Such requirements fall into political, technical and institutional categories (IEA, 2019; Malaysian Energy Commission, 2021):

- Political requirements: traditional official collaboration among states, such as intergovernmental agreements. In a nutshell, political requirements comprise one critical element in inter-state collaborations; political will to commence such collaborations.
- Technical requirements: operational grounding for multilateral electricity trading. These requirements include built and operational cross-border connectivity infrastructure, harmonized grid codes of participating countries, agreed pricing mechanisms, non-discriminative third-party access to the grids for participating countries, agreements on information-sharing and agreed dispute resolution mechanisms.
- Institutional requirements: additional responsibilities for the involved electricity utility organizations/companies, from participating countries, for the institutional aspects of future cross-border trading operations, such as capacity-building for human resources of electricity utility organizations/companies on multilateral electricity trading (if needed), institutional restructuring these utilities (if needed), and the development of a multilateral electricity market among participating countries supported through the establishment of a market coordinating organization.

Table 5. Key common and specific challenges for the ECO region

Issues	Common issues across the region	Specific issues for a few countries in the region
Economic and political issues		
Long standing political issues		⊕
Territorial disputes in the region		⊕
International economic sanctions		⊕
Long-term economic sustainability issue	⊕	
High level of income inequality and poverty		⊕
Limited foreign direct investments	⊕	
Issues for power markets		
Gaps in the legal and regulatory framework for power markets		⊕
Lack of strategy planning for power markets		⊕
Lack of or limited regional and/or subregional power markets		⊕
Lack of political consensus for subregional power markets		⊕
Low level of energy infrastructure development		⊕
Issues with energy security of power supply in countries including power shortages, high share of the electricity import, issues with energy connectivity inside countries		⊕
Diverse country-specific demand-supply patterns and supply security (i.e. some countries have power abundance from own generation, while some experience power shortages)		⊕
Low availability of primary energy resources		⊕
Initial level of power market development (and different power market development status)		⊕
Inflexible energy tariff regulation and lack of cost-recovery tariffs		⊕
Insufficient development of renewable energy power		⊕
Dependence on imported energy technologies (lack of equipment for the production, transmission and distribution of electricity; lack of capacities to produce the equipment for alternative RES) and lack highly qualified specialists with international experience	⊕	
Limited data sharing opportunities	⊕	

Source: ESCAP analysis.

Depending on the maturity of electricity markets of countries, the primary and secondary models discussed above can be applied immediately or gradually. The requirements can be applied simultaneously or partially, depending on each model and for specific cases.

Institutional arrangements

The electricity sector is highly regulated and the process of integrating national power grids requires enhanced regional energy cooperation between member States, with support from regional and subregional institutions (ESCAP/CE/2021/4). Historical rivalries, territorial disputes and geopolitical instability in the region can slow down cooperation and consensus-building

efforts necessary for advancing the regional electricity market agenda. Mitigating political and geopolitical risks requires necessary diplomatic engagement and the establishment of institutional mechanisms to create trust and cooperation among ECO member states. It is important to enhance institutional arrangements to implement dispute resolution mechanisms.

Diverse regulatory frameworks and lack of regulation

The variety of regulatory frameworks among ECO member states pose a significant challenge to regional market development. Diverse legal requirements, standards and procedures create barriers to harmonization, creating difficulties for the seamless flow of electricity across borders. For example, several ECO member states do not have a RES regulatory framework even though a number of RES projects are being planned for implementation there. Also, rules for integration of new variable renewable energy to the national power systems are absent in some countries. Therefore, further development of RES will require technical coordination with traditional energy systems.

Overcoming regulatory fragmentation requires concerted efforts to align policies, streamline procedures and establish a common regulatory framework conducive to cross-border electricity trade, including harmonized technical standards (grid codes), rules of interconnector capacity calculations, rules of third-party access, trading rules and a harmonized wheeling charge methodology.

Energy security

ECO member states face a range of issues related to energy security. Some of the concerns are:

- Limited domestic grid infrastructure: this feature hugely impacts the security of power supply in countries;
- Costly power outages: these affect economic activities, and the manufacturing and exporting facilities;
- Increasing electricity deficit: due to growing demand and slow rate of commissioning new power generation facilities;
- Limited diversity of energy supply;
- Aging and inefficient network and power equipment.

Enhancing regional energy connectivity, with a focus on power grids, is an important means of enhancing the energy security of the region. In this regard, it is important to consider the circumstances of each country.

Market design

The absence of standardized market designs and pricing mechanisms slows down the establishment of efficient and competitive electricity markets within the ECO region. Various approaches to market structuring, pricing and market rules disrupt market transparency and increase investor risks. ECO member states have following issues:

- Diverse levels of renewable energy development in the regional countries;
- Lack of or limited regional and/or subregional power markets and energy connectivity: bilateral trade agreement for electricity is a basic form of agreements for current regional trade;
- Diverse electricity generation patterns associated with the availability of primary energy resources;
- Diverse power sector institutional settings: different power market development status, or some countries have auction rules on capacity allocations;
- Diverse country-specific, demand-supply patterns and supply security: some

Table 6. Structure of domestic power market and status of ECO member states

Country	Regulatory form of domestic power market	Structure
Afghanistan	Monopoly	Vertically integrated (fragmented) Limited third-party participation
Azerbaijan	Wholesale market	Functionally unbundled but is on the track for market liberalization Third-party participation is available
Iran (Islamic Republic of)	Wholesale and retail markets; Partial day-ahead market	Functionally unbundled Third-party participation is available
Kazakhstan	Wholesale and retail markets	Full legal and functional unbundling Third-party participation is available
Kyrgyzstan	Monopoly	Legally unbundled Limited third-party participation
Pakistan	Central Power Purchasing Authority as single buyer and seller	Functionally unbundled Third-party participation is available
Tajikistan	Monopoly	Legally unbundled Limited third-party participation
Türkiye	Wholesale and retail markets; Functional day-ahead market and electricity exchange	Functionally unbundled and liberalized market Third-party participation is available
Turkmenistan	Monopoly	Vertically integrated Third-party participation is not available
Uzbekistan	Energo Sotish as single buyer and seller	Legally unbundled Limited third-party participation

Source: ESCAP analysis taken from International Energy Agency (IEA), "Project on Establishment of ECO Regional Electricity Market", December 2022; International Energy Agency (IEA), "Cross-Border Electricity Trading for Tajikistan: A Road map", Paris. Available at https://www.iea.org/reports/cross-border-electricity-trading-for-tajikistan-a-road map/a-road map-for-cross-border-electricity-trading-for-tajikistan

countries enjoy power abundance from own generation, while some experience power shortages;

- In many countries of the region the main activities of generation, transmission or distribution of electricity are managed by vertically-integrated state-owned companies.

Discussing harmonized market frameworks, pricing mechanisms and regulatory structures supports fair competition for both bilateral and multilateral trade, which will help attract investments in the region.

Infrastructure development

Insufficient infrastructure, including inadequate transmission capacity, interconnection facilities and insufficient development of renewable energy power in some ECO member states constrains the effective development of the power market in the ECO region. The lack of robust transmission networks limits the exchange of electricity between countries, thereby slowing market integration.

Addressing infrastructure challenges requires substantial investments in grid expansion, modernization and interconnection projects to enhance cross-border electricity flows and promote market development.

Energy prices

Different tariff structures and pricing mechanisms among ECO member states present obstacles to the harmonization of electricity tariffs within the regional electricity market. ECO countries have different pricing policies, including subsidies

and cross-subsidies, which discourage private investments and undermine market competitiveness. Low tariffs and low payment discipline in some ECO member states negatively affect financial stability of the power sector, thus limiting progress in establishing competitive energy markets. Below-cost recovery tariffs and national fuel and energy subsidies can also disincentivize investments for renewable energy development (Alawad, 2022).

Overcoming tariff harmonization challenges and implementing transparent tariff regulation mechanisms can ensure fair competition, investment attractiveness and market efficiency.

Technical challenges

Rapid technological development creates additional challenges for the establishment of the regional electricity market. Some ECO member states face challenges, in the field of green energy, such as the lack of equipment for production, transmission and distribution of electricity (including smart grids or electricity storage to accompany development of renewables), and the lack of capacities to produce the equipment for alternative and renewable energy sources.

Investing in research, development and deployment of advanced renewable energy, grid technologies, intelligent of electric power dispatching and smart grid solutions can enhance the flexibility, reliability and quality of electricity delivery and sustainability of the energy systems in the region.

Capacity-building

Within the field of green energy and energy connectivity, some ECO member states face a lack of highly qualified specialists with international experience and insufficient levels of corporate governance in energy companies. Building human capacity is fundamental to the successful implementation and operation of the regional electricity market, where capacity-building constraints, including limited technical expertise, institutional capabilities and regulatory capacity may slow down the establishment of the regional market. Overcoming capacity-building challenges requires investing in training programs and knowledge-sharing initiatives, where exchange of best practices with neighbour countries or peers from other regions could become an effective solution.

Data-sharing

Challenges, such as data accessibility and reliability, interrupt seamless information exchange among stakeholders. ECO member states do not have a common, shared energy database, including data standards, data collection mechanisms, and rules for data transparency and accessibility to facilitate joint market operations.

Addressing data-sharing challenges requires establishing common data standards, enhancing data collection mechanisms, and promoting data transparency and accessibility to facilitate market efficiency.

4. Potential benefits of energy connectivity in the region

The ECO-REM has the potential to generate benefits for participating countries and various stakeholders, including:

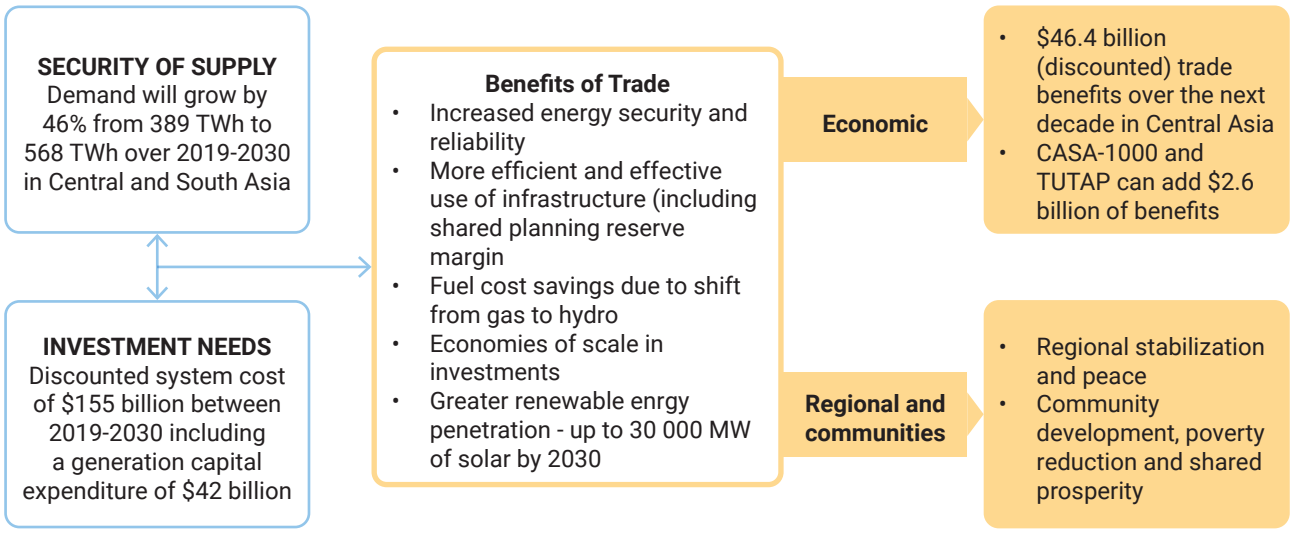
- For Governments:
  - Promoting efficiency and reliability of energy systems;
  - Improving energy security;
  - Increasing macroeconomic benefits due to increased supply and reliability of electricity supply that would facilitate economic activities;

- Accelerating transition to low-carbon energy systems through increased trade in low-carbon electricity;
- Boosting electricity exports and revenues.

- For utilities, industry and other businesses:
  - Promoting more efficient use of generation and supply infrastructure;
  - Increasing investments in electricity infrastructure;
  - Increasing clean energy production;
  - Reducing energy costs and increasing investment in modernization;
- For communities:
  - Stabilizing electricity prices (through the development of trade between countries and regions during different seasons and during the day);
  - Increasing access to electricity and reduced energy poverty (through the development of electricity grid and price stabilization);
  - Improving the welfare of the population;
  - Reducing emissions and ancillary environmental benefits through the growth of low-carbon energy and reduced reliance on fossil fuels.

While the full economic, environmental and social benefits of the ECO-REM have not been modelled as part of this project, studies that been done for ECO member states that offer relevant insights. For example, in 2020, the World Bank assessed the economic benefits of developing a regional energy system in Central Asia together with Afghanistan and Pakistan (World Bank Group, 2020). The findings of the model estimate that economic benefits of up to $6.4 billion (in discounted terms) can be realized between 2020-2030 through better exploitation of hydro potential and thermal generation in the region, shared planning reserve margin, reduction in unmet electricity demand and fuel cost savings due to the shift from gas to hydropower generation.

Figure 1. Estimated benefits of regional electricity trade in Central Asia



Source: World Bank Group, "Central Asia electricity trade brings economic growth and fosters regional cooperation", 20 October 2020. Available at https://www.worldbank.org/en/news/feature/2020/10/20/central-asia-electricity-trade-brings-economic-growth-and-fosters-regional-cooperation

Note: CASA-1000 = The Afghanistan-Kyrgyzstan-Pakistan-Tajikistan transmission line; TUTAP = The Turkmenistan-Uzbekistan-Tajikistan-Afghanistan-Pakistan transmission.

The full development of the CASA-1000 and TUTAP projects could add another $2.6 billion to these gross benefits of increasing Central Asian trade with Afghanistan and Pakistan.

Primarily, through a shift from coal generation toward hydropower, solar and wind power generation, a carbon constrained scenario estimated a reduction of around 400 $MtCO_2$ emissions in Central Asia, in cumulative terms over the next decade, or by about 20 per cent compared to a regional trade scenario with unconstrained carbon emissions.

5. Policy recommendations

The ECO member states already have intra- and inter-regional transnational electricity trading arrangements in place. However, none of these arrangements extend across the entirety of the ECO region. Instead, these arrangement are either multilateral or bilateral in nature, due to limited power infrastructure across some borders or geographic locations. In other words, the ECO region itself is divided into subregional and bilateral cross-border electricity trading zones that have very weak or no interactions with each other.

The development of the ECO-REM can and should take into account and build-off of existing trade arrangements and integration initiatives in the region. It is, therefore, important to take into account the current status of initiatives in the region that support the development of energy connectivity (CAREM, CAREC and other important initiatives), the experience of dispatch centres (for example, Central Asian Power System Dispatch Center) and of broader energy market development initiatives (for example, those supported by the Global Energy Interconnection Development and Cooperation Organization, or GEIDCO).

Taking these initiatives into consideration, the ECO-REM road map proposes to start with the establishment of a secondary market model, followed eventually by development of a primary market model. Furthermore, the ECO region can be divided into three zones/ sub-markets based on their specific regional features which could be interlinked together upon their development. The anticipated development period for zones is medium term (4 to 7 years), while the development period of the ECO region market is long term (7 to 10 years). The proposed zonal division is introduced below:

- Eastern Zone: Afghanistan and Pakistan
- Central Zone: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan
- Western Zone: Azerbaijan, Iran (Islamic Republic of) and Türkiye

The proposed operational mechanism and milestones of a multilateral electricity trading market for the ECO region is described in table 7.

Table 7. The proposed operational mechanism and milestones of a multilateral electricity trading market for the Economic Cooperation Organization Regional Electricity Market (ECO-REM)

Phase I: Pathway for zonal market mechanisms		
Zone	Relevant countries	Current status and proposed activities (medium-term perspective)
Eastern Zone	Afghanistan and Pakistan	Current status: • Political: interstate agreements available but Afghanistan has security issues. • Technical: cross-border infrastructure available between the two countries. • Institutional: weak institutions in Afghanistan. • Regulatory: lack of a single pricing mechanism/clearing rules for electricity between countries; development of regulations for third-party access to grids.

Continued next page

Table 7 continued

		Proposed activities: • Completing the planned infrastructure projects (see section I.1). • Establishing an Electricity Trading Centre to manage trading transactions (technical and economic) between Afghanistan and Pakistan and to coordinate with other zones; the Centre would also serve as a hub for information exchange • Upgrading the power system control equipment to meet technical requirements of trading in the relevant countries and support integration of higher shares of variable renewables • Capacity-building for the electric utility company in electricity trading in Afghanistan. • Developing a common or harmonized pricing mechanism.
Central Zone	Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan	Current status: • Political: Strong political will among the related countries to unite efforts and resolve the common challenges. • Technical: Established and functional regional electricity trade, i.e., Unified Energy System of Central Asia (UES CA), although Turkmenistan is not fully integrated. • Institutional: All relevant countries have bilateral and multilateral agreements. • Infrastructure: The countries are interlinked with fully functional cross-border infrastructure. • Regulatory: Lack of a single pricing mechanism/clearing rules for electricity trading. Proposed activities: • Completing the planned infrastructure projects. • Establishing an Electricity Trading Centre to develop common or harmonized pricing mechanisms in addition to the existing technical arrangements among relevant countries and with other zones; the Centre would also serve as a hub for information exchange. • Upgrading the power system control equipment to meet technical requirements of trading among the relevant countries and to integrate higher shares of variable renewables.
Western Zone	Azerbaijan, Iran (Islamic Republic of) and Türkiye	Current state: • Political: strong political will among the related countries to unite efforts and address common challenges. • Technical: no single unified trading system among three countries. • Institutional: all relevant countries have bilateral agreements. • Infrastructure: the countries are interlinked with fully functional cross-border infrastructure. • Regulatory: lack of a common or harmonized pricing mechanism/clearing rules for electricity trading. Proposed activities: • Establishing an Electricity Trading Centre to handle trading transactions (technical and economic) among three countries and to coordinate with other zones; the Centre will also serve as a hub for information exchange. • Upgrading the power system control equipment to meet the technical requirements of trading among the relevant countries and to smoothly integrate variable renewables given the increasing share of renewables.
Phase II: Pathway for unified ECO-REM		
Developing a single electricity trading market for ECO region (long-term perspective)		Proposed activities: • Preparing and concluding an agreement by all ECO member countries on political, technical and institutional arrangements for electricity trading of member states within the region and outside the region. • As a part of the agreement, establishing an electronic electricity trading platform jointly by the member states and international donor agencies that would have the following features: ▸ Integrating power system control centres of ECO member states for technical operations; ▸ Pricing mechanism/clearing rules that would have spot and day-ahead market pricing.

Development strategies and milestones:

The time frames for each strategy are defined as:

- short term (1 to 3 years);
- medium term (4 to 7 years); and
- long term (7 to 15 years).

The timeline of the ECO-REM road map can be divided into three main timing options: short term (from 1 to 3 years total); medium term (from 4 to 7 years total); and long term (from 7 to 15 years total). While the parallel activities of the Eastern, Central and Western zones take from 4 to 7 years to complete (medium term), the measures provided in the road map (measures 1 to 9) are more varied in terms of timing, though the majority may take up to 15 years to complete.

1. **Organizing a Stakeholders Cooperation Mechanism for the ECO region and the three zones**

Key milestone:

- **Establishing a permanent high-level working group and subregional groups and making agreements on decision-making principles and financing of designated activities.**

Time frame: Short term

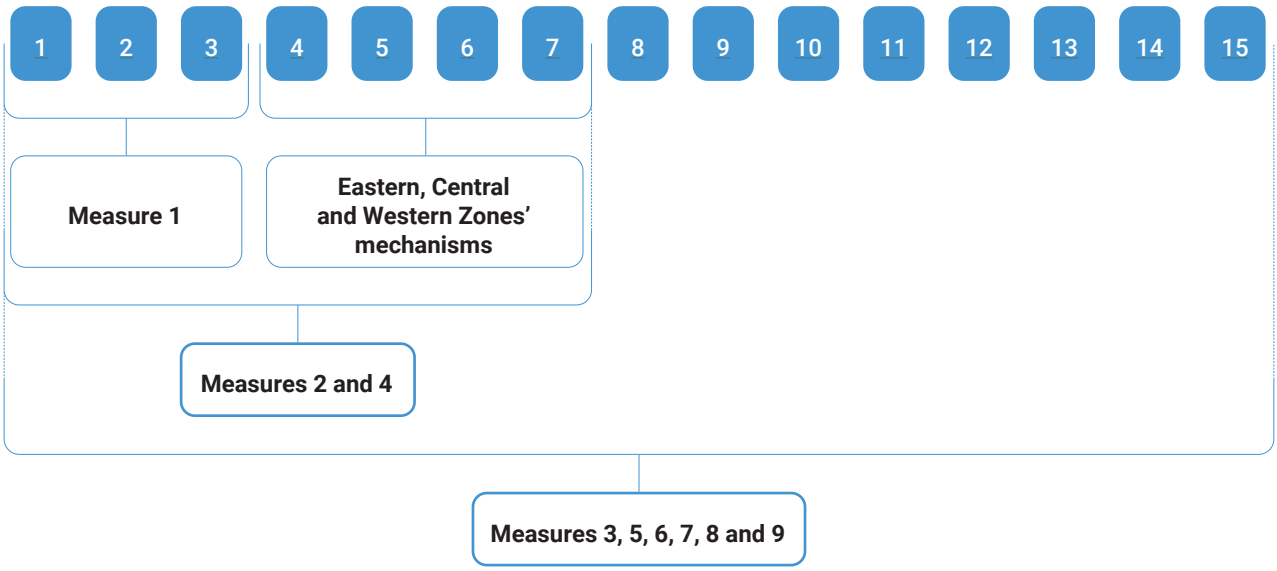
Key implementers: Member states, with support from ECO and relevant international organizations

- Conducting dialogues and discussions on the needs of cross-border electricity trade; discussing potential effects for the parties; defining tools for interaction and cooperation; and listing main participants, their rights and responsibilities, as crucial parts of the road map.

- Organizing and conducting coordination meetings with representatives of the parties (state authorities) to confirm their interest and secure their support for developing cross-border electricity trade, and to gradually form individual elements of a common electricity market.

- Establishing a permanent high-level working group on the development of cross-border electricity trade, along with expert subgroups focused on specific areas of interaction, composed of representatives from the involved parties (including the three subregional groups). These groups will promptly review and coordinate arising issues.

Figure 2. Timeline on the proposed activities



The strategy also includes determining the principles for decision-making and the financing of activities related to the development of cross-border electricity trade. This, above all, includes the involvement of international organizations and development institutions.

Furthermore, prospective studies of electricity supply and demand, with an emphasis on the feasibility of renewable energy projects, will be conducted at the regional and country level. These studies will provide conclusions and recommendations on the potential for developing cross-border electricity trade and facilitate the formation of a common electricity market.

2. **Making agreements on the boundaries of energy cooperation**

Key milestones:

- **Signing of a framework for multilateral intergovernmental agreements on energy cooperation;**
- **Developing a comprehensive master plan for the advancement of cross-border electricity trade in the region.**

Time frame: Short- and medium term

Key implementers: Member states, with support from relevant international organizations

The strategy involves defining the basic principles of cross-border electricity trade and transit in the region and addressing issues of interaction with third countries.

It includes the development and signing of a framework for multilateral intergovernmental agreements on energy cooperation covering various aspects, such as information exchange, interstate network projects, mutual electricity trade, cooperation in the field of renewable energy, the electrification of remote regions etc. There is a possibility for these agreements to be initially signed by some states with others joining later.

The strategy also encompasses the development of a concept for the evolution of multilateral energy cooperation in the region, specifying target conditions at each stage of development.

Detailed studies will be conducted to create a set of road maps for different areas of state cooperation, within the region, to achieve these target conditions. It is advisable to apply the principle of "different paces" for individual states in the region and to consider the formation of subregional unions at intermediate stages.

Finally, the strategy aims to develop a comprehensive master plan (detailed road map) for the development of cross-border electricity trade in the region.

3. **Developing rules and mechanisms for mutual trade and interstate electricity transmission**

Key milestone:

- **Incorporating the rules into the national legislation of the ECO member states**

Time frame: Short-, medium- and long term

Key implementers: Member states, with support from relevant international organizations

The strategy entails the development and agreement on rules for mutual electricity trade, specifying different types of trade: long-term agreements (free bilateral contracts); centralized trading (forward contracts, day-ahead or real-time market); balancing market and the settlement of deviations between actual and planned electricity flow balances.

It also includes the development and agreement on rules for interstate transmission of electrical energy (transit, replacement), incorporating rules for determining and distributing the capacity of interstate sections, including setting priorities for different types of generating capacities.

It is possible to develop transit fee and subregional pricing frameworks, payment security mechanisms, competitive bidding and market rules for centralized trading electricity. It is useful to analyse current experience of other power markets with mutual trade (box 1).

The final step is the implementation of these rules into the national legislation of the states in the region, potentially in phases.

Box 1. Case study on Southern African Power Pool (SAPP) pricing mechanism

The Southern African Power Pool (SAPP) is a regional organization of power utilities within the Southern African Development Community (SADC) that was created in August 1995. The main purpose for its creation was to enhance energy trading and optimize available electricity in the region.

SAPP coordinates the planning and operation of the interconnected electric power system among member utilities and the electricity trading, and provides a forum for regional solutions for problems related electric energy. The vision of SAPP is to be a fully integrated, competitive energy market and a provider of sustainable energy solutions for the SADC region and beyond. Current SAPP membership, as of August 2023, comprises of 20 members (12 national power utilities, 5 operating members and 3 market participants). The SAPP Coordination Centre (SAPP CC) was established as the SAPP Secretariat in Harare, Zimbabwe..

Tariff structures

SAPP has its own tariff structure for the management of its operations. In general, this is mainly supported by the national utilities in the countries who are the owners of SAPP itself.

The SAPP organizational structure is comprised of various committees that enable full participation by members and protect their interests at all levels. At the government level, a Council of Energy Ministers meets at least once a year to address policy issues, provide political leadership and, where necessary, establish institutions.

The market itself is funded by market participants paying a combination of a participation fee and a trading fee (based on trading activities). Each country has its own national tariff structure.

In the SADC, a regional regulatory association (RERA) has been established to align the regulatory framework. This is still an association, but there is ongoing work to make them a regulatory authority.

The SAPP established the Short-Term Energy Market in April 2001. From January 2004, the SAPP started the development of a competitive electricity market for the SADC region. This market now has four trading portfolios, namely: Forward Physical Market – Monthly; Forward Physical Market – Weekly; Day-Ahead Market; and Intra-Day Market.

Transmission pricing

Transmission pricing has gone through several steps during the operation of the power pool. The original wheeling charge applied in the SAPP was based on the postage stamp principle. This applied a scaling factor of 7.5 per cent to the value of the energy wheeled through one country, or 15 per cent if the energy was wheeled through two or more countries, and split between the two countries. The increase (or decrease) in losses was supplied by the seller of the energy and paid for by the buyer.

This method was replaced, in 2003, by a flow-based MW-km methodology where the charges were determined according to the proportion of assets used for wheeling. The use of assets for wheeling purposes was determined using load-flow studies to calculate the proportion of total available capacity on each contract path accounted for by a wheeling transaction. Wheeling charges were then levied in accordance with this proportion as a share of the total value of the assets affected by the wheeling transaction..

This approach is well suited to a situation in which the counterparties to each bilateral trade are clearly identifiable, i.e., when the ‘start’ and ‘end’ points of each transaction are known. As trading platforms

Continued next page

Box continued

within SAPP evolved to include markets other than long-term physical bilateral trades, an alternative methodology was deemed necessary to enable transmission charges that were being applied to trading parties when no specific counterparty for a trade was identified.

Work was undertaken in 2005/2006 to develop a nodal transmission pricing model. However, due to various regional factors, which resulted in a significant reduction in the amount of wheeling being undertaken with the SAPP, this was not implemented.

A project has now recently been concluded by the SAPP that has defined the implementation of an improved transmission pricing methodology for implementation; this will overcome the limitations inherent in the flow-based MW-km method. When and how this will be implemented is still under discussion.

The new methodology will focus on the calculation of transmission entry and exit charges.

The main implication of the new methodology is that charges can be allocated to generation and demand based solely on their capacity and location, and irrespective of the identity of the counterparty with whom electricity trade is being conducted. This is important for enabling transmission charges to be recovered from participants in the markets, where there are no defined counterparties for the trade.

4. **Harmonizing regulations on cross-border electricity connectivity**

Key milestone:

- **Annually publishing results from comparative analyses of energy policies**

Time frame: Short- and medium term

Key implementers: Member states, with support from relevant international organizations

The strategy includes the preparation and publication of a series of annual reports and comparative analyses of energy policies in the states of the region, providing conclusions and recommendations for eliminating barriers to the development of cross-border electricity trade.

It also involves the development of model regulatory acts aimed at harmonizing the legislation of the states in the region regarding energy cooperation.

Additionally, mechanisms for preliminary notification and/or coordination of changes in the regulatory framework in the energy policy of the states in the region will be developed. These changes may affect issues of energy cooperation within the signed framework of multilateral intergovernmental agreements.

5. **Developing a regional cross-border electricity grid master plan (with subregional segments)**

Key milestones:

- **Creating coordinated cooperation mechanisms for planning the development of the regional cross-border electricity grid**

Time frame: Short-, medium- and long term

Key implementers: Member states, with support from relevant international organizations and system operators

The strategy involves conducting studies to identify the requirements for developing the regional cross-border electricity grid in conjunction with national electricity development plans in the states of the region. Subregional segments for zones are also needed.

It includes developing a regulation for planning the development of the regional cross-border electricity grid, and aligning with principles of

energy security, supply stability and economic feasibility for each state. This regulation should define the procedures for preparing and agreeing on the timelines and parameters for constructing interstate transmission lines which are included in the master plan for the regional cross-border electricity grid.

The strategy also involves developing the master plan for the regional cross-border electricity grid and a mechanism for its updating. The master plan will not be a legally binding document, but the information on projects included in it will facilitate mutual coordination of national energy system development plans and attract investors.

6. **Promoting interaction of organizations (system operators, commercial infrastructure operators)**

Key milestone:

- **Implementing cooperation mechanisms for infrastructure organizations in electricity transmission and trade**

Time frame: Short-, medium- and long term

Key implementers: Member states, with support from relevant international organizations and system operators

The strategy involves organizing the interaction of infrastructure organizations that are active in energy systems and within the electricity markets of the countries in the region (system operators and commercial infrastructure operators).

It includes agreeing on the principles of dispatch control of the energy systems in the region's states in the context of developing cross-border electricity trade. This may involve activities related to the synchronization of energy systems if relevant decisions are made. The strategy also entails developing mechanisms for coordinating national transmission plans and cross-border electricity transmission plans.

Additionally, the strategy involves developing approaches to foster competitive centralized trading within the common electricity market of the region. The latter includes developing payment mechanisms within centralized trading (security, guarantees, etc.,) and implementing pilot projects for centralized trading at the subregional level.

7. **Encouraging investments**

Key milestone:

- **Developing regional platforms that bring together interested parties to promote project financing in clean energy production and trading**

Time frame: Short-, medium- and long term

Key implementers: Member states, with support from relevant international organizations, multilateral development banks and specialized institutions

The strategy involves identifying and analysing best global practices for attracting investments in the electricity sector, with an emphasis on cross-border grid infrastructure and renewable energy sources, including those used in the region's states.

It includes conducting a comparative analysis of the investment policies in the electricity sector of the region's states, considering favourable investment climate and assessing the risks of investing in electricity projects in the region.

Based on best practices, the strategy involves developing guidelines to stimulate investments in the electricity sector. This includes implementing and adapting new innovative financial instruments (such as green bonds, renewable energy certificates, etc.,) and making recommendations for changing the investment policy for specific states in the region.

The strategy also includes developing mechanisms for dispute resolution in multilateral electricity trade in the region.

Additionally, the strategy implies organizing the interaction of interested parties (investors, including financial institutions, electricity market entities and authorities) to enhance transparency in investment policies and stimulate investments.

8. **Enabling information exchange**

Key milestone:

- **Implementing rules for information exchange between authorized government bodies and infrastructure organizations in the region**

Time frame: Short-, medium- and long term

Key implementers: Member states, with support from relevant international organizations, system operators and commercial infrastructure operators

The strategy involves developing and adopting harmonized standards for information disclosure in the electricity sector.

It includes developing and implementing rules for information exchange between authorized government bodies and infrastructure organizations in the region.

The strategy also explores the possibility of creating a unified information and analytical centre for energy information for the region's states.

Additionally, the strategy involves organizing and conducting training sessions and seminars on issues related to energy cooperation among the region's states.

Lastly, it includes concluding agreements on information exchange with other states and international organizations.

It is necessary to take steps to improve the quality of energy statistics within the region's states, including the use of common methodological approaches.

9. **Fostering sustainability of interstate electricity trade**

Key milestone:

- **Including sustainable development criteria in projects focused on cross-border electricity trade**

Time frame: Short-, medium- and long term

Key implementers: Member states, with support from relevant international organizations, system operators and commercial infrastructure operators

The strategy implies conducting research and analysis of the interconnections between the energy sector and sustainable development (environment and climate change, energy accessibility, job creation) in the states of the region. In addition, it includes assessing the impact of potential projects for the development of interstate electricity trade on indicators of sustainable development.

The strategy involves developing guiding principles for integrating sustainable development criteria into projects aimed at advancing interstate electricity trade.

It also includes creating a set of measures for the region's states to enhance resilience and readiness for emergencies in energy infrastructure (at energy facilities) to mitigate the consequences of climate change and natural disasters.

6. Outcomes

- Encouraging active and continuous regional dialogue on cross-border electricity trade and tools for interaction and cooperation

The dialogue will serve as an information and coordination platform with the participation of a wide range of stakeholders who are interested in a common electricity market. It will create a space for exchange of opinions

and experiences, overcoming barriers and fostering the development and adoption of the documents for cross-border electricity trade and cooperation.

- Creating interaction models and harmonized institutional frameworks to minimize transaction costs

Interaction models for electricity markets participants and harmonized institutional frameworks for data exchange, payments, dispatching etc., will minimize transaction costs and enhance the possibility for either bilateral or multilateral trade.

- Creating a basis for the regional electricity trade

Cross-border trade and transit principles, dispute resolution mechanisms and minimal technical requirements, including harmonized standards and third party assessments, will create a foundation for regional electricity trade. This can be piloted in bilateral trade and then finalized and scaled up.

- Promoting the most prospective investment projects

Exploring the possibilities of investments projects in the light of their contribution to regional infrastructure and electricity trade will allow the identification of the most promising and profitable projects for interested parties. Clear project definitions will in turn help to attract investment.

- Prioritizing projects aligned with sustainable development goals

Stressing the positive role of renewable energy resources and creating favourable conditions for their deployment will enhance the positive impacts of these resources.

Such outcomes will facilitate the establishment of robust multilateral, multidirectional power trading mechanisms where the infrastructure is already in place and will help to define the most prospective, sustainable and economically feasible infrastructure projects for further development of the regional electricity market.

7. Recommendations for the project development

Creating an ECO-REM requires coherent efforts from various stakeholders, including governments, international organizations, renewable energy developers, financial institutions and local communities.

The recommendations for further development include:

- Developing a working group and choosing an initiator to establish a permanent high-level working group for implementing the ECO-REM road map is a crucial step for project development. Collaboration among governments, utilities, renewable energy developers, civil society organizations and local communities is essential for garnering support and building consensus for the ECO-REM. Emphasizing renewable energy initiatives within this collaborative framework can foster sharing of goals and objectives, and promoting sustainable development across the region.

- Identifying financial aspects of implementing the road map, including leveraging private investments and funding from international institutions.

- Fostering regular dialogue among energy regulators can build a sense of community and facilitate knowledge-sharing. Including other relevant stakeholders, such as ministries, utilities and consumers, in these dialogues can enhance collaboration and address capacity gaps effectively.

- Taking a step-by-step approach is crucial for regulatory harmonization, considering the varying levels of progress across different countries. Tailoring agreements on power system connectivity models to the specific circumstances and ambitions of

the involved countries can ensure inclusivity and sustainability.

- Recognizing the value of voluntary regional cooperation, a gradual approach, starting with pilot projects, can pave the way for broader regulatory collaboration. Establishing forums and associations dedicated to knowledge-sharing, harmonization and capacity-building can facilitate this process.

- Coordinating among international donor organizations is important during the implementation of regional projects. There are several initiatives in the region which include different stakeholders and these stakeholders sometimes duplicate similar initiatives due to lack of coordination. Enhancing coordination between international organizations and development banks can ensure the delivery of more effective projects and promote complementary efforts.

Learning from the experiences of other regions is crucial for avoiding mistakes and promoting knowledge-sharing, including detailed studies about specific interconnectors and more detailed country analysis. Implementing best practices from around the world can inform decision-making and guide the successful implementation of ECO-REM development.

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II. Existing cross-border power connectivity initiatives in the ECO region

1. Existing projects supported by international donor organizations and international financial institutions

ECO member states across the South, Central and South-West Asia regions (ESCAP, n.d.),[3] have always prioritized cross-border electricity trade by incorporating it into their national development plans. Given the importance of electricity connectivity within the national and regional context, international development organizations have been providing assistance to ECO member states to achieve cross-border energy connectivity and low-carbon development. Existing projects, across ECO member states, that are being supported by international donor organizations and financial institutions are listed in table 8. The World Bank Group (table 8) and the Asian Development Bank (table 9) are the most active organizations that support the energy sectors in ECO member states, together with European Bank of Reconstruction and Development (EBRD) (table 10) and the United States Agency for International Development (USAID) (table 11).

Table 8. Key projects supported by the World Bank Group in ECO member states

Country	Project description	Status
Several countries (Afghanistan, Kyrgyzstan, Pakistan and Tajikistan)	The Central Asia-South Asia power project, commonly known as CASA-1000. The $1.2 billion project will bring 1300 MW of seasonal renewable hydropower from Tajikistan and Kyrgyzstan to Afghanistan and Pakistan. The main objective is to enable electricity trade between Central Asia and South Asia to increase the economic benefits of and reliable access to energy supply. Funding is provided by a consortium of international development institutions including the World Bank Group, Islamic Development Bank, European Investment Bank, European Bank for Reconstruction and Development, Foreign and Commonwealth Development Office (UK) and USAID (CASA-1000, 2024).	Ongoing
Tajikistan	Construction of 3780 MW Rogun hydro power plant (The World Bank, 2023b). The first unit was commissioned in July 2018. The dam will be the highest in the world upon completion in 2029, while the hydro power plant itself will be the largest in Central Asia.	Ongoing

Continued next page

3 ESCAP geographical divisions.

Table 8 continued

Country	Project description	Status
	Construction of a 200 MW private solar power plant in the Sughd region (CABAR, 2024).	Ongoing
Pakistan	Balochistan Renewable Energy Development Study. The objective is to develop utility-scale solar and wind power in Balochistan to help meet Pakistan's renewable energy targets for the power sector (NEPRA, 2023).	Ongoing

Source: National Electric Power Regulatory Authority (NEPRA), "State of Industry Report 2023", 2023. Available at https://nepra.org.pk/publications/State%20of%20Industry%20Reports/State%20of%20Industry%20Report%202023.pdf; Central Asian Bureau for Analytical Reporting (CABAR), "Tajikistan: Solar energy in support for hydropower plants", 20 March 2024. Available at https://cabar.asia/en/tajikistan-solar-energy-in-support-of-hydropower-plants; Central Asia-South Asia (CASA)-1000, "CASA-1000: Increasing clean energy availability and access in Central and South Asia", 2024. Available at https://www.casa-1000.org/; and Eurasian Research Institute.

Table 9. Key projects supported by the Asian Development Bank in ECO member states

Country	Project description	Status
Several countries (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan)	Establishment of the Central Asia Transmission Cooperation Association (CATCA). CATCA will function as a regional association responsible for strategic regional network development, including long-term network expansion planning and centralized implementation of identified new cross-border projects in the Central Asia region (Chown, 2022).	Ongoing
Several countries (Afghanistan, Pakistan, Tajikistan, Turkmenistan, Uzbekistan)	TUTAP: Turkmenistan-Uzbekistan-Tajikistan-Afghanistan-Pakistan Power Interconnection Project (Energy Charter, 2020). Phase 1: • 220 kV Uzbekistan-Afghanistan interconnection is operational • 220 kV Tajikistan-Afghanistan interconnection is operational Phase 2: • 500 kV Turkmenistan-Afghanistan interconnection is under development Phase 3: • 220 kV Kabul-Jalalabad-Kunar transmission line is under development • Upgrade of Dashte Alwan substation is under development Phase 4: • 500 kV Uzbekistan-Afghanistan interconnection (Surkhan-Pule Khumri) is planned Phase 5: • 500 kV Turkmenistan-Afghanistan-Pakistan (TAP) interconnection is planned	Partially completed
Several countries (Afghanistan, Pakistan, Turkmenistan)	Turkmenistan – Afghanistan – Pakistan Power Interconnection Project (TAP). The project will include the construction of around 500 kilometres of 500 kilovolt transmission line between Turkmenistan, Afghanistan, and Pakistan. Once completed, the project will ensure the possibility to transfer up to 4,000 megawatts of power from Turkmenistan to Afghanistan and Pakistan (ADB, 2018). Phase 1: existing infrastructure under TUTAP project is completed. Phase 2: transfer of power from Turkmenistan through the border of Serhetabad in Turkmenistan and Torghundyl Herat, Kandahar and Spin Boldak in Afghanistan, and export to Chaman and Quetta in Pakistan, is under development.	Partially completed
CAREC countries that are ECO member states (Afghanistan, Azerbaijan, Kazakhstan, Kyrgyzstan, Pakistan, Tajikistan, Turkmenistan, Uzbekistan)	Asian Development Bank (ADB) study on future energy market options for Central Asia Regional Economic Cooperation (CAREC) program members to help facilitate sustainable energy infrastructure investment (ADB, 2022). In 2019, ADB published CAREC Energy Strategy 2030: Common Borders. Common Solutions. Common Energy Future which provides the new long-term strategic framework for the program and prioritizes five operational clusters, including "Infrastructure and Connectivity".	Completed
Turkmenistan	Building ring trunk power lines throughout Turkmenistan (National Power Grid Strengthening Project) (ADB, 2024c).	Ongoing

Continued next page

Table 9 continued

Country	Project description	Status
Kazakhstan	KEGOC Renewable Energy Supporting Grid Expansion Project (ADB, 2024b).	Proposed
Uzbekistan	457 MW Sherabad Solar Power Project (ADB, 2024e).	Ongoing
Uzbekistan	220 MW Jizzakh Solar Power Plant (ADB, 2024d).	Ongoing
Uzbekistan	500 MW Dzhankeldy Wind Power Plant (ADB, 2023).	Proposed
Azerbaijan	Construction of 230 MW Garadagh Solar Power Plant (ADB partially funded the project via loan financing) (ADB, 2024a).	Completed

Source: Asian Development Bank (ADB), "CAREC Energy Outlook 2030", Manila, 2022. Available at https://www.adb.org/publications/carec-energy-outlook-2030

Table 10. Key projects supported by the European Bank of Reconstruction and Development (EBRD) in ECO member states

Country	Project description	Status
Kazakhstan	14 wind and solar power plants projects with the total capacity of 788 MW (Zankina, 2022).	Ongoing
Azerbaijan	Construction of 240 MW Wind Power Plant. EBRD funded the project via loan financing (Bitsadze, 2023).	Ongoing
Uzbekistan	Loan financing for Sherabad, Samarkand and Jizzakh Solar Power Plants.	Ongoing

Source: Indira Zankina, "EBRD Energy in Kazakhstan", presentation, European Bank for Reconstruction and Development (EBRD), 2022. Available at https://www.unescap.org/sites/default/d8files/event-documents/Session%20IV_Indira%20Zankina.pdf

Table 11. Key projects supported by USAID in ECO member states

Country	Project description	Status
Azerbaijan, Türkiye	Azerbaijan-Georgia-Türkiye Power Bridge Project. The objective is to ensure the infrastructure and study support of power flow from Azerbaijan and Georgia to Türkiye. Technical studies of the project were supported and funded by USAID. Infrastructure construction under this project is mostly completed. Azerbaijan and Georgia are already using the infrastructure to export electricity to Türkiye (USEA, 2023).	Completed
Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, (participating countries of the 'Energy' Coordination Dispatch Center (CDC))	Development of a Concept on Regional Automatic Metering and Control System of Electricity for CDC.	Ongoing
Tajikistan	Installation of 800 kW in Murghab (USAID, 2023).	Completed
Central Asian countries	Technical assistance and capacity-building to the five Central Asian countries to help create an economically viable Central Asia Regional Electricity Market (CAREM) (USAID, n.d.). In particular, USAID supports Central Asian Governments to create the conditions for increasing cross-border flows and closely collaborates with them to develop the structures, rules and institutions that will guide the implementation of a safe, secure and reliable regional electricity market.	Ongoing

Source: United States Energy Association (USEA), "Azerbaijan-Georgia-Turkey Power Bridge Project (AGT)", 2023. Available at https://usea.org/content/azerbaijan-georgia-turkey-power-bridge-project-agt and United States Agency for International Development (USAID), "United States Government and Pamir Energy Company are electrifying remote villages in Tajikistan", 13 August 2023. Available at https://www.usaid.gov/tajikistan/press-releases/aug-13-2023-united-states-government-and-pamir-energy-company-are-electrifying-remote-villages-tajikistan

2. Bilateral and multilateral electricity connectivity collaboration among ECO member states

International development organizations are supporting the cross-border electricity connectivity initiatives of ECO member states either in the regional or in the multilateral context. There are, however, bilateral and multilateral collaborations among ECO member states in the field of cross-border electricity trading. To analyse existing and future electricity trading collaborations, it is important to examine the power systems of member states in the subregions (i.e., North and Central Asia; and South and South-West Asia),[4] and review the history of their collaborations, as detailed below. Some collaboration initiatives pertain to certain regions specifically, while others are inter-regional in nature.

North and Central Asia

The ECO member states in the North and Central Asia are Azerbaijan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and the Republic of Uzbekistan, which were part of the former Soviet Union.

The power systems of Southern Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan were integrated into the Unified Energy System of Central Asia (UES CA), that had the Unified Dispatch Center in Tashkent, Uzbekistan. It was operating independently from the Unified Electricity System of the former Soviet Union. The latter system included the Unified Energy System of Northern Kazakhstan and had the Unified Dispatch Center in Almaty (ECE, 2023).

In the 1970s, these former Soviet Union republics were merged into a single ring using 500 kilovolt (kV) lines. Such integration considerably increased the operational reliability of all parallel operation participants. Working in a ring can assure parallel operation of power systems even if there is a disconnection of any link within the ring.

The UES CA was created without the consideration of national borders of the republics in the former Soviet Union. The optimal solution for frequency and capacity control, water and energy challenges at the time was a UES structure made up of 30 per cent hydro power plants and 70 per cent thermal power plants. The long-term planning of UES regimes was based on the structure of generation sources in each of the UES-included energy systems and, subsequently, the challenges of centralized fuel supply for the power plants. Optimizing the regime included the minimization of fuel prices and power losses in the grids across the entire UES, as opposed to a single energy system. The operational and technical maintenance schedules were synchronized and centrally supplied with spare parts.

Following the collapse of the Soviet Union, the centralized distribution of energy materials and resources was suspended. All countries started making efforts to become self-sufficient in energy and fuel supply, but the starting positions of the countries varied considerably. Due to the absence of local generation sources in the countries where hydropower was predominant, reservoirs began releasing more water in winter, resulting in disruptions to established water and energy regimes, and creating environmental issues.

These challenges forced the countries of North and Central Asia to collaborate. In 1991, the heads of the energy systems signed an agreement on parallel operation of the energy systems of the Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. In addition, the agreement established an administrative body to coordinate dispatch control (now 'Energiya' Coordination Dispatch Center (CDC) in Tashkent). Currently, the parallel operation includes the grids of South Kazakhstan, Kyrgyzstan and Uzbekistan.

4 ESCAP geographical divisions.

Turkmenistan voluntarily exited the UES CA in 2003 due to large opportunities for electricity export to Iran (Islamic Republic of). Turkmenistan therefore operates in parallel with the Iranian power grid. However, it also operates in "island" mode with the UES CA and has allocated separate generators for electricity export to Uzbekistan.

Tajikistan was excluded from parallel operation due to frequent violations of its conditions. This decision was made jointly by the other UES CA participants. The reconnection of Tajikistan's power to the UES CA was completed in June 2024 (Daryo, 2024). In general, Tajikistan's power system managed to regulate frequency since its exemption from the UES CA given the large reserves available at its hydropower plants.

Being one of the republics in South Caucasus, Azerbaijan had a similar experience as other Central Asian countries in terms of power system management during the Soviet Union. The unification of the power systems of the three republics of South Caucasus (Armenia, Azerbaijan, Georgia) was conducted in 1960s, and the joint system was called "Unified Energy System of Transcaucasia". Due to its significant generation capacities and availability of primary energy resources, Azerbaijan served the role of a "baseload" system. The Unified Energy System of Transcaucasia was operating in parallel with the Common Energy System of the European part of the former Union of Soviet Socialist Republics (USSR). Following the dissolution of the USSR, each country tried to ensure its energy security using the available domestic resources and cross-border trading opportunities.

The existing and planned bilateral and multilateral collaborations for connectivity of electricity in the North and Central Asia region are summarized in table 12.

Table 12. The existing and planned bilateral and multilateral electricity connectivity collaborations in Central Asia

Country	Project description	Status
Tajikistan	HVDC line from the Convertornaya CS to Nausher CS in Pakistan (for CASA-1000 project).	Ongoing
Tajikistan	50– kV Regar - Sangtuda HPP-1 line (for CASA-1000 project).	Ongoing
Tajikistan	Convertornaya convertor substation (CS) with a capacity of 1300MW near Sangtuda HPP-1 with construction of 500-220kV switchgear and its connection by 500kV line to 500kV switchgear of Sangtuda HPP-1. Rewiring of two 220kV overhead li–es: Geran - Sungtuda HPP-1 to the Sung–uda-HPP-1 - Convertornaya–and Geran - Kunduz to Kunduz – Convertornaya (for CASA-1000 project).	Ongoing
Tajikistan	500 kV Yuzhnaya – Khadzhi-Alvan overhead line to Afghanistan.	Ongoing
Tajikistan and Uzbekistan	500 kV line between New Syrdarya TPP (Uzbekistan) and Sugd substation (Tajikistan), and retrofitting the Sugd substation with its existing 500 kV line for "input-output" scheme in Uzbekistan.	Ongoing
Kazakhstan, Kyrgyzstan, and Uzbekistan	Joint construction of 1860 MW Kambarata-1 Hydro Power Plant.	Proposed
Tajikistan and Uzbekistan	Joint construction of two hydro power plants in Tajikistan with the total capacity of 320 MW.	Proposed
Turkmenistan	Construction of 500 kV line Kerky (Turkmenistan) – Andkhoi (Afghanistan).	Proposed
Turkmenistan	Construction of 500 kV Dashkhovuz - Sarymay overhead line.	Proposed
Turkmenistan	Construction of 500 kV overhead line to Iran (Islamic Republic of) with HVDC back-to-back substation.	Proposed

Continued next page

Table 12 ccontinued

Country	Project description	Status
Kazakhstan, Kyrgyzstan, Tajikistan and Uzbekistan	Assessment of the reliability in parallel operation of UES CA with UES (Unified Energy System) Kazakhstan.	Proposed
Kazakhstan and the Russian Federation	Agreements with the Russian Federation: • Agreement on parallel operation of energy systems of Kazakhstan and the Russian Federation. • Agreement with the Russian Federation on rendering services for transmission of electric energy through the power grid of Kazakhstan.	Ongoing
Afghanistan and Uzbekistan	500 kV Surkhan-Khadzhi-Alvan line.	Proposed
Afghanistan and Turkmenistan	500 kV line to Kabul.	Proposed
Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan	Establishment of the Central Asia Transmission Cooperation Association (CATCA). CATCA will function as a regional association responsible for strategic regional network development, including long-term network expansion planning and centralized implementation of identified new cross-border projects in the Central Asia region (Chown, 2020).	Ongoing
Azerbaijan and Türkiye	Azerbaijan – Türkiye – Europe Energy Hub (envisaged in the Socio-Economic Development Strategy of the Republic of Azerbaijan for 2022-2026). The project route consists of Azerbaijan, Zangazur Corridor (Armenian territory between the mainland Azerbaijan and Nakchhivan Autonomous Republic (AR) of Azerbaijan), Nakchhivan AR and Türkiye. Its objective is to ensure an alternate power supply from Azerbaijan to Türkiye via Armenia and Nakhchivan AR, in addition to the current route via Georgia. The infrastructure developments in the mainland Azerbaijan and Nakhchivan AR are almost complete, while the infrastructure development in the territory of Armenia are subject to negotiations (The President of the Republic of Azerbaijan, 2022).	Ongoing
Azerbaijan, Georgia, Hungary and Romania	Caspian – Black Sea – Europe Green Energy Corridor Project. On 17 December 2022, the Governments of Azerbaijan, Georgia, Romania and Hungary signed the "Agreement between Governments of the Republic of Azerbaijan, Georgia, Romania and Hungary on strategic partnership in the field of development and transfer of green energy". This initiative envisages the export of Azerbaijan's renewable electricity to Europe via Georgia and Black Sea. About 2.5 GW of renewable electricity capacity (wind and solar) is planned to be exported from Azerbaijan during the first phase (Trend News Agency, 2022). In general, Azerbaijan is planning to export 5 GW of electricity to Europe by 2030. A total of 4 GW will be exported via the subsea cable (i.e., Black Sea) from Georgia, and 1 GW will be exported from Nakhchivan via Türkiye (Ashirov, 2023).	Ongoing
Azerbaijan, Iran (Islamic Republic of) and the Russian Federation	Synchronization of Azerbaijan, Iranian and Russian Power Grid (North-South Project). The negotiations on synchronization of power grids these three countries started several years ago. The Iranian consulting company recently completed the relevant feasibility study on the project last year. Up to 1000 MW capacity can be transmitted via the Project, subject to the installation of necessary equipment (Ganbay, 2024). The current connection scheme among three countries allows for the transmission of only 300 MW capacity (either by asynchronous mode or island mode). Azerbaijan and the Russian Federation will build the second 330 kV transmission line between their grids, in addition to the existing one, to ensure stable power flows.	Ongoing
Azerbaijan, Kazakhstan, and Uzbekistan	Azerbaijan is conducting negotiations with the Central Asian countries to expand electricity trading and involve them in the initiatives on exporting electricity to Europe. A Memorandum of Cooperation has been recently signed among Azerbaijan, Kazakhstan and Uzbekistan to integrate the power systems of these countries (Yevgrashina, 2024).	Proposed

Source: United Nations Economic Commission for Europe (ECE), "Energy Connectivity in Central Asia: An inventory of existing national energy systems", 2024. Available at https://unece.org/sites/default/files/2024-02/EN_Energy%20Connectivity%20in%20Central%20Asia_V2.pdf; and presentation delivered by Khamidilla Shamsiev, Director of the Central Dispatch Center 'Energia' at the Consultation Workshop on the "Energy connectivity for sustainable development – Enabling renewable energy resource sharing across borders" project held in April 2024.

Table 13. The existing and planned bilateral and multilateral electricity connectivity collaborations in South and South-West Asia

Country	Project description	Status
Iran (Islamic Republic of) and Türkiye	Expansion of the electricity trading between Iran (Islamic Republic of) and Türkiye. On January 2024, Iranian Electricity Transmission Operator IGMC and TEIAŞ of Türkiye signed the Operation Agreement on 400-kV Van Back-to-Back – Khoy Transmission Line Turkish (TEIAŞ, 2024).	Proposed
Armenia and Iran (Islamic Republic of)	Extension of the "gas for electricity" program between Iran (Islamic Republic of) and Armenia until 2030 (Zafar, 2023).	Ongoing
Afghanistan, Pakistan, Tajikistan, Turkmenistan, and Uzbekistan	TUTAP: Turkmenistan-Uzbekistan-Turkmenistan-Afghanistan-Pakistan Power Interconnection Project (Energy Charter, 2020). Detailed information provided in Table 9.	Partially completed
Afghanistan, Pakistan, Turkmenistan	Turkmenistan-Afghanistan-Pakistan Power Interconnection Project (TAP). The project will include the construction of around 500 kilometres of 500 kilovolt transmission line between Turkmenistan, Afghanistan and Pakistan (ADB, 2018). Detailed information provided in Table 9.	Partially completed

Source: Asian Development Bank (ADB), "Power interconnection project to strengthen power trade between Afghanistan, Turkmenistan, Pakistan, 28 February 2018. Available at https://www.adb.org/news/power-interconnection-project-strengthen-power-trade-between-afghanistan-turkmenistan-pakistan; Qabil Ashirov, "Azerbaijan positioning itself as trans-regional energy hub through expanding green projects, AZERNEWS, 28 December 2023. Available at https://www.azernews.az/business/219646.html; Abbas Ganbay, "Talks on unification of electric systems of Russia, Azerbaijan and Iran continue", AZERNEWS, 27 February 2024. Available at https://azernews.az/business/222473.html; Lada Yevgrashina, "Azerbaijan signs cooperation memo to integrate Kazakhstan and Uzbekistan's energy networks (PHOTO)", Trend News Agency, 1 May 2024. Available at https://en.trend.az/business/green-economy/3893516.html; Turkish Electricity Transmission Company (TEIAŞ), "400 kV Van Back to Back-Khoy Interconnection Line Operation Agreement Signed", 25 January 2024. Available at https://www.TEIAŞ.gov.tr/haberler/400-kv-van-back-to-back-khoy-enterkonneksiyon-hatti-isletme-anlasmasi-imzalandi; and Syed Zafar Mehdi, "Iran, Armenia extend, expand energy swap deal until 2030. Anadolu Ajansi, 14 August 2023. Available at https://www.aa.com.tr/en/asia-pacific/iran-armenia-extend-expand-energy-swap-deal-until-2030/2966020

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III. Electricity markets of ECO members: Current situation and plans for development

1 The Islamic Republic of Afghanistan

1.1 Summary

The power system in Afghanistan is divided into 4 segments and is characterized by electricity shortages. The separate segments operate at different frequencies to ensure interconnection with the power grids of countries from which electricity is imported and which are not synchronized to each other.

Electricity is mostly generated from hydropower plants. Despite the high potential of solar and wind generation, such alternative renewable energy sources (excluding hydropower) have not yet been fully tapped into. The country is 31 per cent grid electrified and, in 2017, 98 per cent of households had access to electricity via distributed energy resources (mainly solar panels).

The electric power sector is under state ownership, which controls all the main activities such as generation, import, transmission and distribution. Afghanistan does not have a liberalized electricity market, domestic electricity prices are regulated and import prices are subject to bilateral agreements.

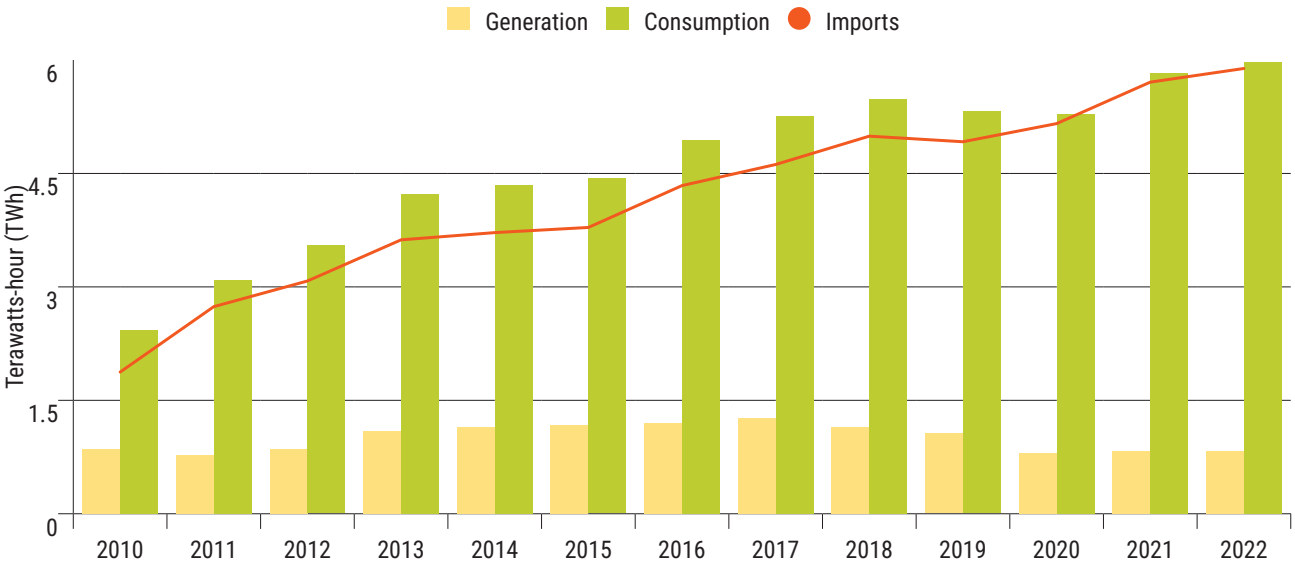
Afghanistan is interested in projects to build its own generation capacities (especially renewable energy sources), as well as expand the import and transit of electricity to other countries. However, a significant number of obstacles remain, primarily with financing such projects.

1.2 Current situation in the electricity sector

1.2.1 Supply and demand balance

Afghanistan has been characterized by high demand for electricity mainly due to population growth. The increase in electricity demand was met by an increase in imports. The country does not export electricity.

Figure 3. Electricity supply, demand and trade in Afghanistan, 2010-2022 (TWh)



Source: United States Energy Information Administration (EIA), "Afghanistan", n.d.a. Available at https://www.eia.gov/international/overview/country/AFG

In 2021, electricity consumption per capita in Afghanistan was about 146 kWh/person, which is 23 times lower than the global average (about 3,400 kWh/person) (IEA, 2023). Current average household consumption levels differ substantially between various provinces and grid systems. The average residential consumption is comparatively high in the main load centres, such as Kabul and Herat (ADB, 2013).

1.2.2 Capacity and generation

In 2022, the capacity of electric power plants in Afghanistan amounted to 0.6 GW, which is 1.8 times higher compared to 2010. The increase in energy capacity, between 2010-2022, occurred mainly from hydropower plants.

Hydropower plants dominate in the structure of energy capacity in Afghanistan with a share of 73 per cent in 2022. Alternative renewable energy sources (excluding hydropower) have received limited development in Afghanistan. In 2022, the share of renewable energy sources in energy capacity was only 5 per cent (10 per cent in generation) and was mainly represented by solar power plants.

Oil dominates in electricity generation at thermal power plants (TPP) and its share has grown between the period 2010-2022. Natural gas is not included in the energy mix (the fertilizer plant in Mazar-i-Sharif has gas-fired power plant and there is gas-fired mobile power plant in Sheberghan).

The generation, import, transmission and distribution of electricity is managed by a state-owned vertically-integrated company, Da Afghanistan Breshna Sherkat (DABS). The private sector is involved only in fossil fuel and renewable energy (except hydropower) generation. All independent power producers that generate more than 1 MW of power are required to sell electricity to DABS through a power purchase agreement (ADB, n.d.). Given that power supply reliability is low, with no reserve capacity and grids that require technical modernization, Afghanistan aims to increase its generation capacities and has launched campaigns to attract investments for constructing hydro and renewable power plants (Invest in Afghanistan, n.d.).

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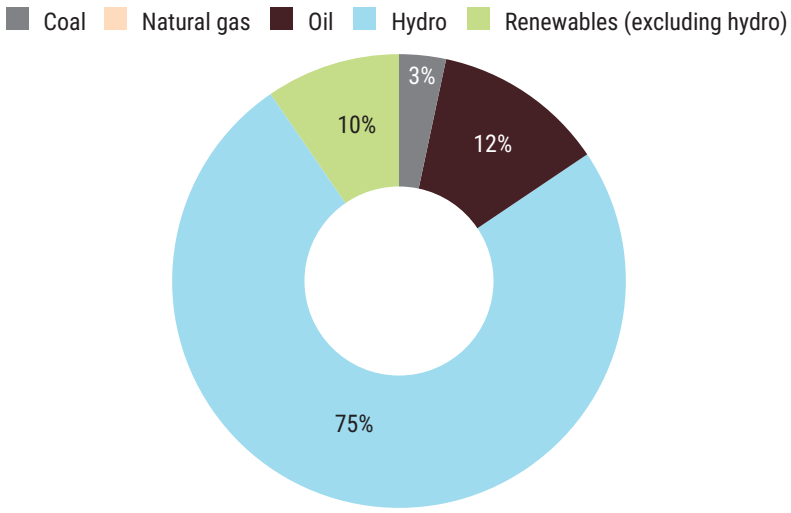
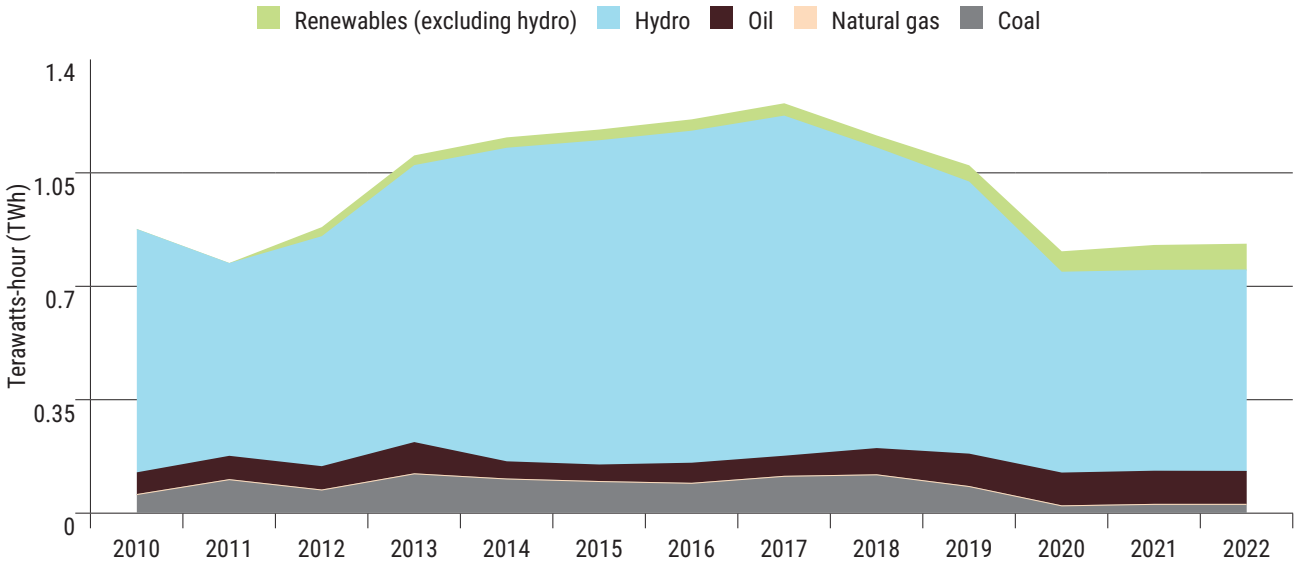
Figure 4. Electricity generation by source in Afghanistan, 2022



Source: United States Energy Information Administration (EIA), "Afghanistan: Electricity", n.d.b. Available at https://www.eia.gov/international/data/country/AFG/electricity/electricity-generation?pd=2&p=0000000000000000000000000000fvu0000000000000000000000000000000000u&u=0&f=A&v=mapbubble&a=-&i=none&vo=value&t=C&g=none&l=249--1&s=315532800000&e=1640995200000&

Figure 5. Electricity generation by source in Afghanistan, 2010-2022



Source: United States Energy Information Administration (EIA), "Afghanistan: Electricity", n.d.b. Available at https://www.eia.gov/international/data/country/AFG/electricity/electricity-generation?pd=2&p=0000000000000000000000000000fvu0000000000000000000000000000000000u&u=0&f=A&v=mapbubble&a=-&i=none&vo=value&t=C&g=none&l=249--1&s=315532800000&e=1640995200000&

1.2.3 Imports and exports

The electric power system of Afghanistan is connected with Iran (Islamic Republic of) (132 kV and 20 kV), Tajikistan (220 kV and 110 kV), Turkmenistan (500 kV (used as 220 kV and 110 kV)) and Uzbekistan (220 kV).

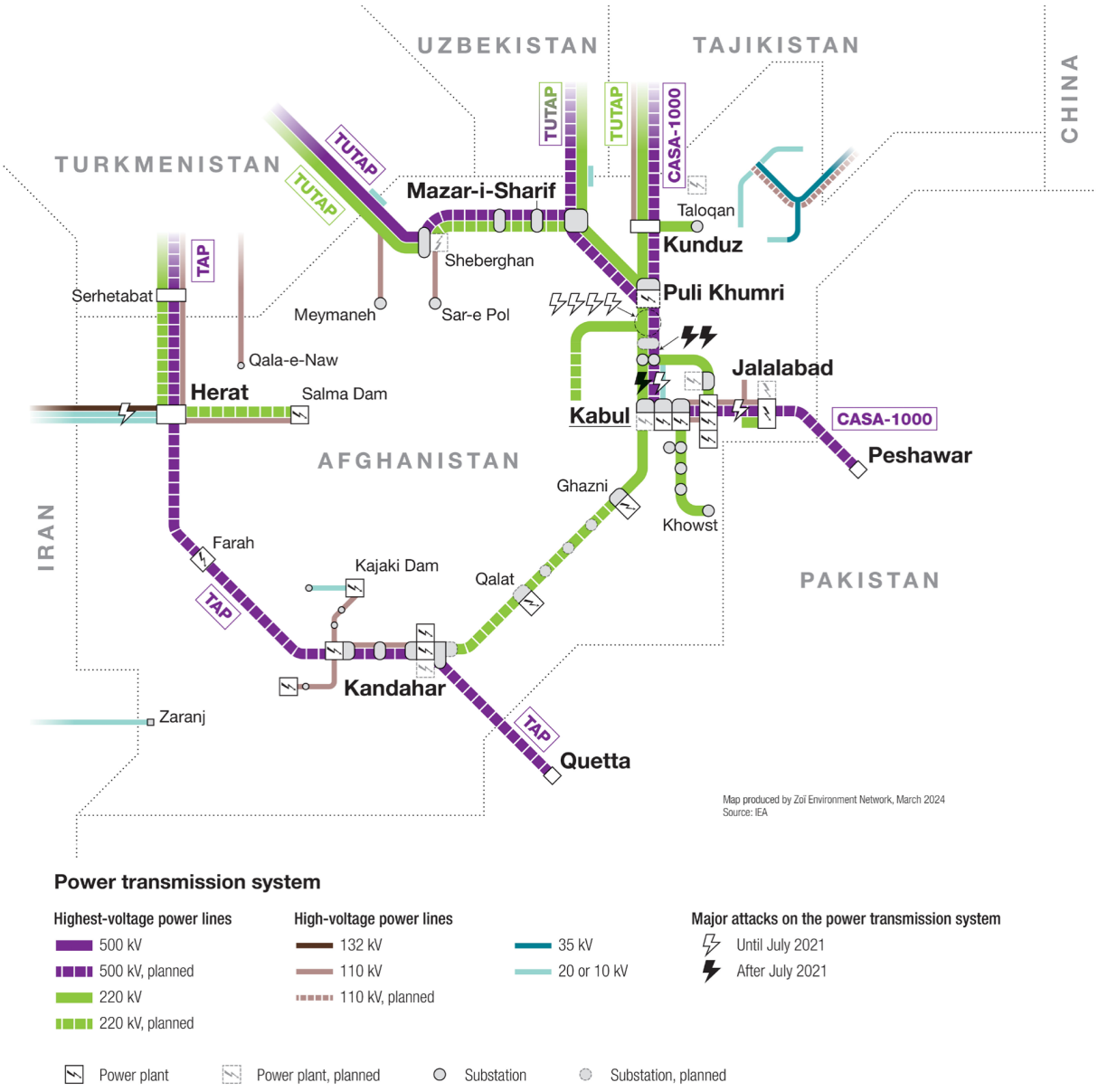
The country's cross-border transmission capacity is 2033 MW: with 380 MW with Iran (Islamic Republic of); 539 MW with Tajikistan; 216 MW with Turkmenistan (Moore Afghanistan, 2017); and 898 MW with Uzbekistan (ECE, 2023).

Table 14. Cross-border electricity trade of Afghanistan (billion kWh), 2016-2023*

Country	2016 / 2017	2017 / 2018	2018 / 2019	2019 / 2020	2020 / 2021	2021 / 2022	2022 / 2023
Imports							
Iran (Islamic Republic of)	0.78	0.72	0.74	0.76	0.87	0.81	0.71
Tajikistan	1.26	1.22	0.91	1.46	0.93	1.28	1.74
Turkmenistan	0.63	0.66	0.74	0.69	0.73	1.08	1.50
Uzbekistan	1.65	2.01	2.59	2.02	2.65	2.15	1.43

Source: National Statistics and Information Authority (NSIA), "Statistics", n.d. Available at http://nsia.gov.af/services
Note: * fiscal year

Figure 6. Electricity transmission network in Afghanistan



Source: Organization for Security and Cooperation in Europe (OSCE), "The effects of the crisis in Afghanistan on Central Asia's energy sector: A risk assessment", 2024. Available at https://www.osce.org/files/f/documents/5/e/564931.pdf

Electricity imports in Afghanistan amounted to 5.4 billion kWh in the 2022/2023 fiscal year.

1.2.4 Demand

Electricity demand amounted to 6 billion kWh on the domestic market in 2022, which is 2.5 times higher compared to 2010. The current level of losses is estimated to be about 22 per cent. The structure of final electricity consumption is dominated by residential sector (64 per cent) in the 2022/2023 fiscal year.

1.3 Electricity market regulation

Electricity prices (tariffs) in Afghanistan are set by DABS. Local (regional) tariffs are set for consumers from different categories and according to the level of usage (DABS, 2023a).

In October 2023, the Ministry of Energy and Water stated that the electricity tariffs will be equal across the country (Qooyash, 2023), however exact dates were not announced.

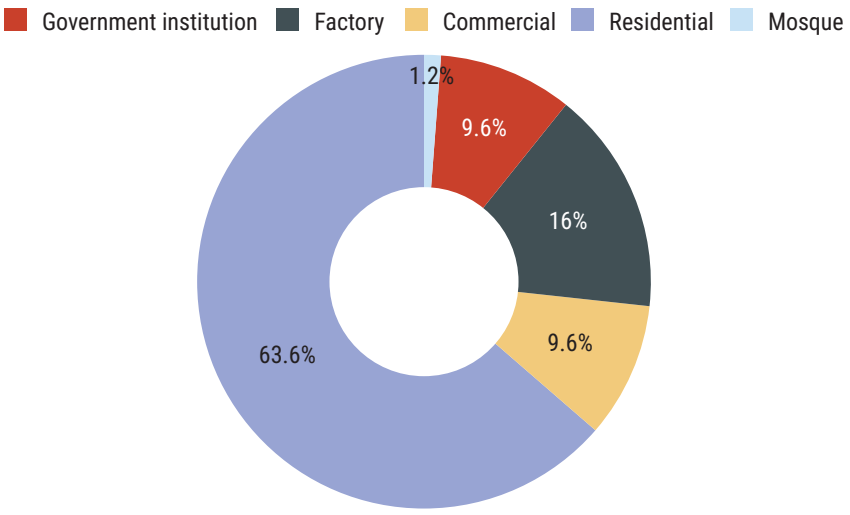
Prices for imported power are below the level of the domestic market, but taking into account transmission and distribution costs, imported electricity need to be subsidized.

Table 15. Electricity consumption by sector in Afghanistan, billion kWh, 2020-2023*

Sector	2020 / 2021	2021 / 2022	2022 / 2023
Mosque	0.05	0.06	0.06
Government institution	0.26	0.40	0.44
Factory	0.40	0.59	0.74
Commercial	0.26	0.39	0.45
Residential	1.93	2.67	2.96

Source: National Statistics and Information Authority (NSIA), "Statistical Yearbook 2023-24", 2024. Available at http://nsia.gov.af/library
Note: * fiscal year

Figure 7. Electricity consumption by sector (percentage) in the fiscal year 2022/2023, in Afghanistan



Source: National Statistics and Information Authority (NSIA), "Statistical Yearbook 2023-24", 2024. Available at http://nsia.gov.af/library

Table 16. Kabul Breshna tariffs (from 2016 to present)

Consumer's category	The level (kWh)	Tariff in US dollars (cents/kWh)
Apartments	0-200	3.47
	201-400	5.21
	401-700	8.68
	701-2000	12.15
	>2000	13.89
Holy places	-	According to the release
Commercial	-	17.36
Government	-	19.10
Non-governmental organizations	-	17.36
Registered factories	-	9.38
Unregistered factories	-	17.36

Source: Da Afghanistan Breshna Sherkat (DABS), "Kabul Electricity Tariff", 2023b. Available at https://main.dabs.af/static/16
Note: *calculated at the exchange rate USD/AFN in April 2024.

Table 17. Average wholesale prices for imported power, based on trade data in US dollars (cents/kWh), 2018-2021

Country	2018 (cents/kWh)	2019 (cents/kWh)	2020 (cents/kWh)	2021 (cents/kWh)
Iran (Islamic Republic of)	6.2	5.6	5.5	5.9
Tajikistan	3.4	3.7	3.7	4.4
Turkmenistan	3.3	3.5	3.5	3.7
Uzbekistan	5.2	4.4	4.4	5.0

Source: Organization for Security and Cooperation in Europe (OSCE), "The effects of the crisis in Afghanistan on Central Asia's energy sector: A risk assessment", 2024. Available at https://www.osce.org/files/f/documents/5/e/564931.pdf

1.4 Plans and measures for the electricity sector development

1.4.1 National goals and plans

The Power Sector Master Plan for Afghanistan (PSMP) was developed in April 2013 and amended in November 2014 (ADB, 2013). According to the PSMP, the gross demand of electricity is expected to increase, in the base case scenario, between 5.7 to 8.7 per cent per annum on average from its current level to 18,409 GWh in 2032. In addition, high and low demand scenarios were developed which show a total gross demand of about 22,534 GWh and 13,701 GWh in 2032, respectively.

According to the PSMP, the base case scenario calls for the generation of 1,200 MW through new coal-fired plants, 200 MW through new gas-fired thermal power plants (TPP) and the construction of 5 hydropower plants (with a total generation of 1508 MW). The 2015 National Renewable Energy Policy has set a target to increase in renewable generation capacity of 4,500-5,000 MW by 2032, which is equivalent to 95 per cent of the total energy mix of 5000-6000 MW as per the targets of PSMP (Afghanistan, Ministry of Energy and Water, 2015).

To meet the increase in demand in the most economical way, the PSMP includes targets for energy saving and import expansion (imports are especially necessary to compensate for the

winter shortage of hydroelectric generation). To achieve this, the PSMP aims to expand the capacity of interstate and internal power transmission lines including the Turkmenistan-Uzbekistan-Tajikistan-Afghanistan-Pakistan (TUTAP), Turkmenistan-Afghanistan-Pakistan (TAP), and the Kyrgyzstan-Tajikistan-Afghanistan-Pakistan (CASA-1000) high voltage transmission lines.

However, when the Taliban took control in 2021 these plans were disrupted, which lead to the freezing of major infrastructure projects (Daryo, 2024). Many international investment donors withdrew their funding and limited work has only resumed in recent months. In 2024, the World Bank renewed its support for CASA-1000 Project in Afghanistan (The World Bank, 2014).

With respect to SDG 7 (Affordable and Clean Energy), the National Development Strategy set out goals for increasing access to electricity in major urban and rural areas (Afghanistan, Ministry of Finance, 2021). The objective of this strategy is to ensure that over 65 per cent of households and more than 90 per cent of commercial and non-residential establishments have access to sustainable electricity supply.

In 2017, 97.7 per cent of the population had access to electricity, as compared to 42.2 per cent in 2008, as reported by a survey. The rapid progress in access to electricity was due to the increased use of solar energy (individual for households). Access to electricity grids, however, is only about 30.9 per cent (38 per cent in 2022, according to DABS) (Salam Watandar, 2022).

1.4.2 Current measures for the development of lower-carbon energy

The Nationally Determined Contribution of Afghanistan (2015) aims to achieve a 13.6 per cent reduction in GHG emissions by 2030 compared to the business as usual (BAU) 2030 scenario, conditional on external support.

Greenhouse gas emissions and mitigation measures include the development of hydropower, solar systems, wind and biomass in energy production, the transition from fossil fuel (coal-fired power plants) to natural gas and renewable energy sources. Investing in renewable energy is a potential solution to the energy security problem that the country faces.

Table 18. Access to different sources of electricity in Afghanistan, 2017

Source	Percentage of population with access
Any source	97.7
Electric grid	30.9
Government generator	0.2
Private generator	1.4
Private dynamo	1
Community generator	0.5
Community dynamo	6.7
Solar	59.4
Wind	0.5
Battery	10.8

Source: Afghanistan, Central Statistics Organization, "Afghanistan Living Conditions Survey 2016-17", 2018. Available at https://www.ilo.org/surveyLib/index.php/catalog/7920/download/48976

The National Renewable Energy Policy identifies high priority sectors where deployment of renewable energy projects will be taken up, de-licenses projects of up to 100 kW, and specifies guidelines for setting tariffs for different categories of renewable energy projects.

1.4.3 Key challenges and issues in lower-carbon energy development

Barriers to lower-carbon energy development that remain relevant after the Taliban returned to power in 2021 include (The World Bank, 2018):

- Security and political risks (for investors);
- Technical barriers: limited capacity of the grid to accommodate renewable energy. The existing grid is fragmented into smaller sub-grids and in many cases has limited capacity to accommodate the addition of large solar or wind plants;
- Commercial risks: the credit worthiness of the off-taker and exchange rate volatility;
- Financing barriers: lack of commercial finance, highly centralized banking, lack of private commercial risk insurance/ guarantees and limited availability of flexible microcredit facilities for off-grid projects;
- Gaps in the legal and regulatory framework: no regulatory framework to secure obligations to consume renewable energy and provide tariffs, lack of clarity over the permitting process, lack of framework for mini-grid and standalone (off-grid) systems.

Moreover, a number of strategies and plans related to lower-carbon energy development have not been revised and updated since 2021.

1.4.4 Plans for cross-border power trade development

Afghanistan plans to increase electricity imports and also become a transit country. In this regard, it provides the expansion of cross-border power transmission lines and the construction of internal lines (including the above mentioned TUTAP, TAP and CASA-1000 transmission lines).

Existing energy agreements, that were signed by the Government until 2021, form the basis of most cross-border electricity trade initiatives and the current Government seeks to extend such agreements and sign new ones (OSCE, 2024).

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2 The Republic of Azerbaijan

2.1 Summary

Having an abundant supply of primary energy resources and significant electricity infrastructure, Azerbaijan is self-sufficient in meeting its domestic demand for electricity with domestic energy generation. The Government has the largest ownership in electricity generation, transmission and distribution assets, and has been implementing reforms to further develop unbundling, encourage a competitive electricity market, as well as increase efficiency.

The country also possesses notable renewable energy sources. However, they amount to only 21 per cent (comprising of hydro, wind, solar and bioenergy) of the total installed capacity (Azerbaijan, Ministry of Energy, 2024f). Natural gas still accounts for 90 per cent of total electricity generation in the country. Nevertheless, the Government's agenda for the development of the electricity sector is to achieve a significant share of renewables in the structure of electricity generation, increase operation efficiency, reduce losses, and shift to a fully developed liberal electricity market by the end of 2028.

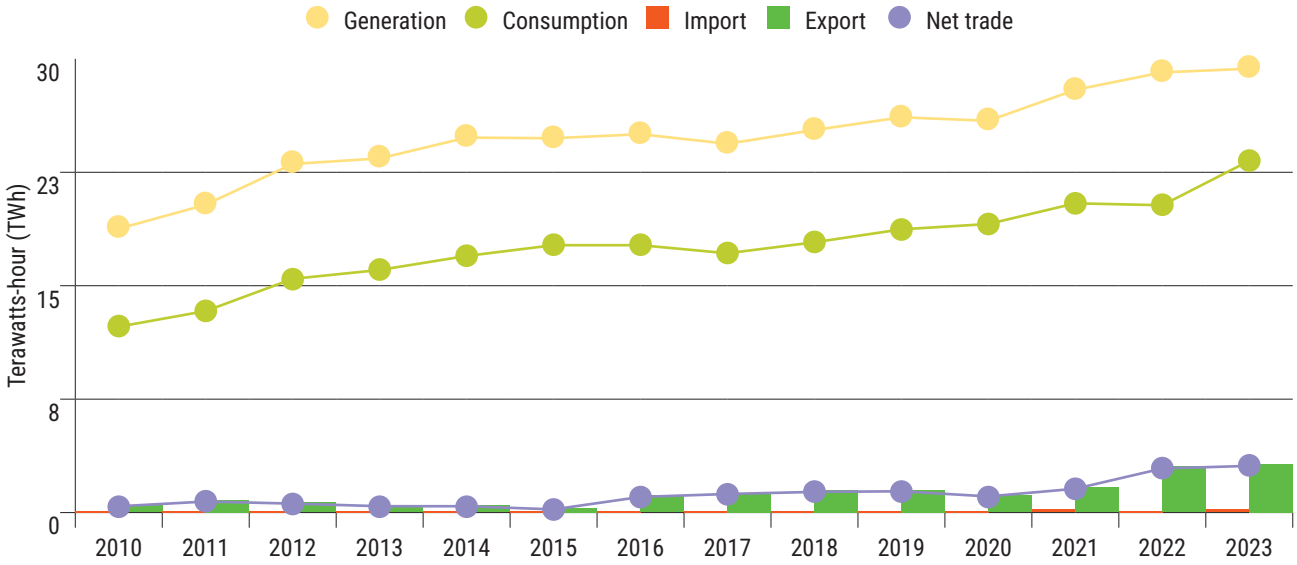
Azerbaijan has a solid transmission grid which is interconnected with its neighbouring countries: Iran (Islamic Republic of), Georgia, the Russian Federation and Türkiye. Being a net electricity exporter, Azerbaijan is striving to further increase its electricity exports, while also functioning as a transit country.

2.2 Current situation in the electricity sector

2.2.1 Supply and demand balance

Azerbaijan has a well-developed electricity infrastructure and electricity generation potential given its largely rehabilitated power plants and grids, and its abundant primary energy resources, such as oil and natural gas. The country is self-sufficient in terms of

Figure 8. Electricity supply, demand and trade in Azerbaijan, 2010-2023 (TWh)



Source: The State Statistical Committee of the Republic of Azerbaijan, "Energy" page, 2024. Available at https://stat.gov.az/source/balance_fuel/?lang=en; Azerbaijan, Ministry of Energy, "Annual Reports" page, 2020. Available at https://minenergy.gov.az/az/hesabatlar/illik-hesabatlar

its own electricity generation and the entire population (100 per cent) of the country has access to electricity.

Electricity generation increased by 93 per cent in 2023 as compared to 2010. The supply balance had a positive trend during the 2010-2023 period. Overall, the electricity generation and consumption per capita in 2023 were 2.8 and 2.3 MWh respectively, which was below the global average (IEA, 2023).

2.2.2 Capacity and generation

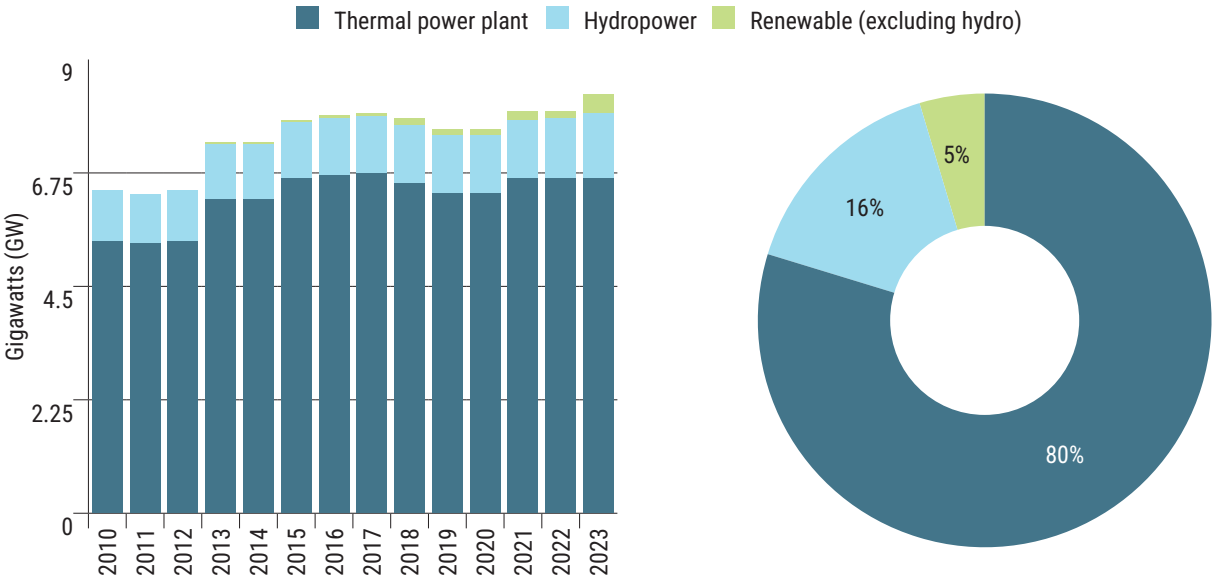
As of 2024, Azerbaijan had a total installed capacity of over 8.37 GW: 6.63 GW of thermal, and 1.74 GW of hydro and renewable energy power plants (wind, solar, bioenergy) (The State Statistical Committee of the Republic of Azerbaijan, 2024a; Azerbaijan, Ministry of Energy, 2020). The total generation capacity has increased by 30 per cent between 2010-2024. There are 94 power plants in Azerbaijan, including 22 thermal, 54 hydro, 5 wind, 9 solar, 1 bioenergy and 3 hybrid power plants (The State Statistical Committee of the Republic of Azerbaijan, 2024a; Azerbaijan, Ministry of Energy, 2020).

In 2023, approximately 93 per cent of electricity was produced by thermal power plants and about 7 per cent from hydropower and renewable energy plants. Natural gas dominates electricity generation and is used as the main fuel at all thermal power plants.

As part of various government development programs, all power plants that were built prior to and during the time that Azerbaijan was part of the Union of Soviet Socialist Republic (USSR) (1991) have been rehabilitated in the last 20 years. The conventional steam cycle generation technology has been replaced with combined cycle and gas-engine based technologies to increase efficiency (Azerenerji, 2013).

Hydropower is the second main generation source in the country. Although the hydropower generation capacity increased by 15 per cent between 2010-2023, the hydropower electricity generation declined by 49 per cent in 2023 as compared to 2010. This was due to several

Figure 9. Trend of electricity generation capacities in 2010-2023 (left), and breakdown by type of energy in 2023 (right), in Azerbaijan

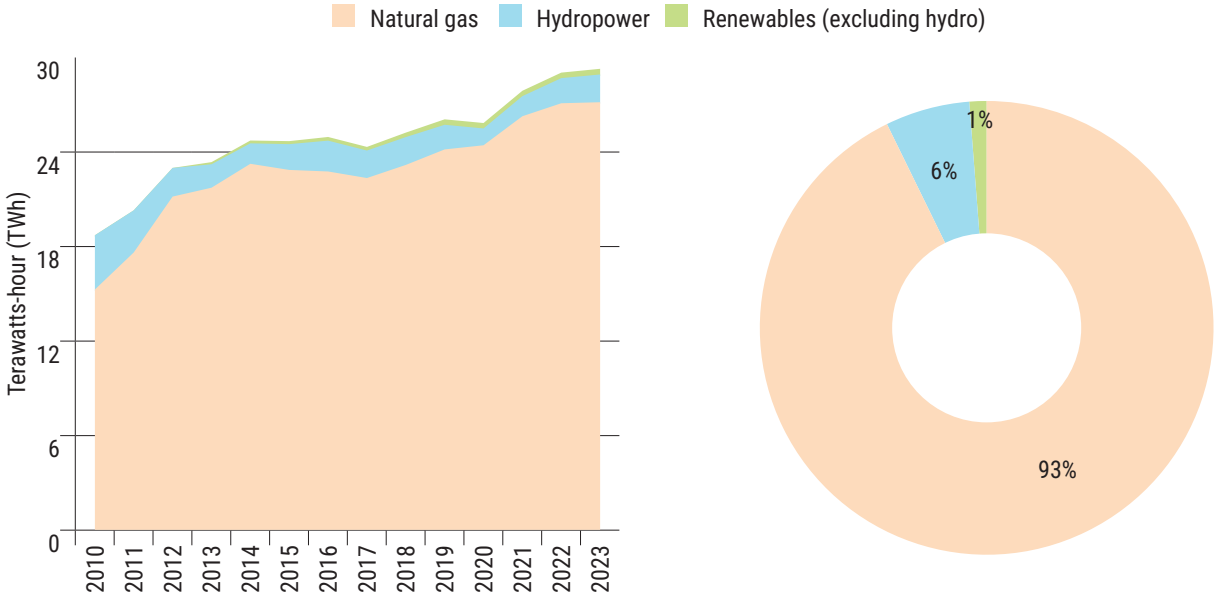


Source: The State Statistical Committee of the Republic of Azerbaijan, "Energy", 2024. Available at https://stat.gov.az/source/balance_fuel/?lang=en; and Azerbaijan, Ministry of Energy, "Annual Reports" page, 2020. Available at https://minenergy.gov.az/az/hesabatlar/illik-hesabatlar

seasons of drought after 2010 and the increased agricultural irrigation where most hydropower plants were being used for both electricity generation and irrigation purposes.

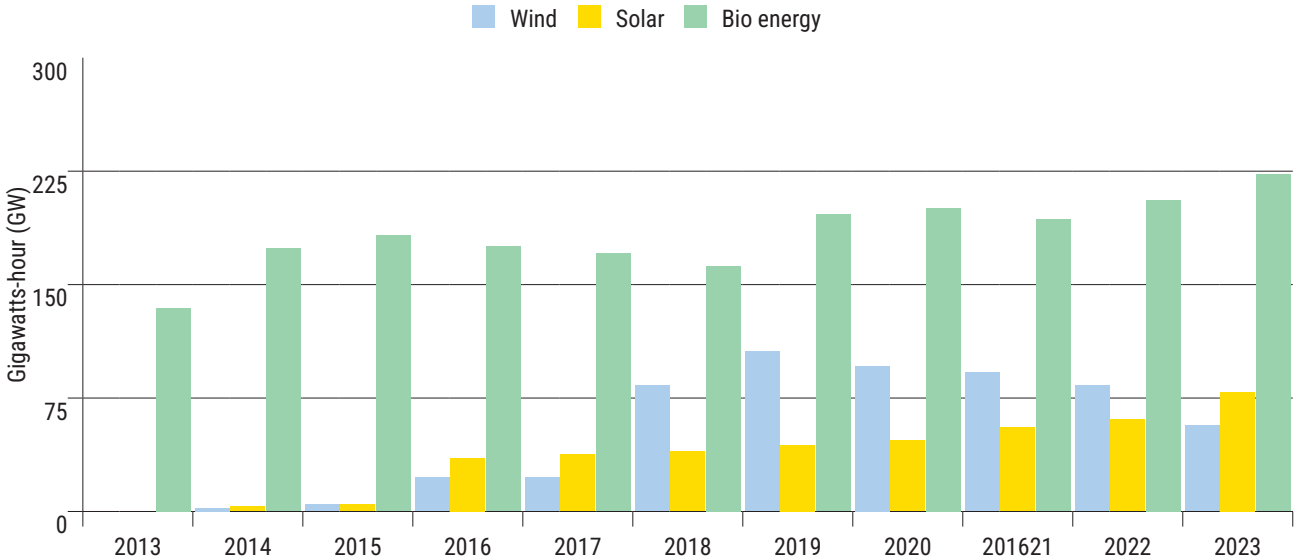
The industrial application of renewable energy sources started in 2013. The share of renewables (excluding hydro) in the total capacity and in the total generation in 2023 constituted only 4 per cent and 1.3 per cent, respectively. Bioenergy plants have the highest share in the renewables. The Government has been undertaking a series of reforms in recent

Figure 10. Trend of electricity generation in 2010-2023 (TWh), and breakdown by sources in 2023, in Azerbaijan



Source: The State Statistical Committee of the Republic of Azerbaijan, "Energy", 2024. Available at https://stat.gov.az/source/balance_fuel/?lang=en; and Azerbaijan, Ministry of Energy, "Annual Reports" page, 2020. Available at https://minenergy.gov.az/az/hesabatlar/illik-hesabatlar

Figure 11. Electricity generation from renewable energy sources (excluding hydro) in Azerbaijan



Source: The State Statistical Committee of the Republic of Azerbaijan, "Home page", 2024b. Available at https://www.stat.gov.az/?lang=en and Azerbaijan, Ministry of Energy, "Home page", 2020. Available at https://minenergy.gov.az/en

years to overcome the technical and financial barriers to renewable energy development.

2.2.3 Imports and exports

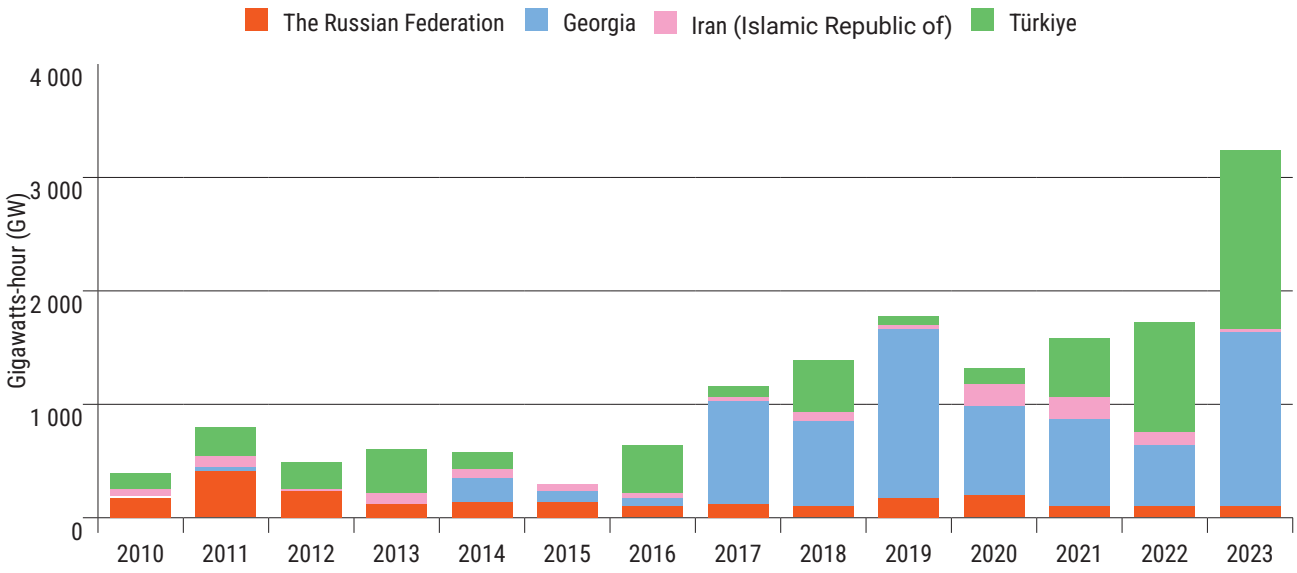
The power system of Azerbaijan is currently interconnected with the grids of Iran (Islamic Republic of), Georgia and the Russian Federation at mainland Azerbaijan, and with the Republic of Türkiye in the Nakhchivan Autonomous Republic. Azerbaijan conducts cross-border electricity trade with these countries based on relevant inter-state agreements. The inter-state agreements and protocols serve as a basis for the strategic vision and future development of inter-state trading between Azerbaijan and its neighbouring countries, and regulate the cross-border trading transactions.

Table 19. Cross-border transmission lines in Azerbaijaan

No.	Country	Transmission line	Voltage in kilovolt (kV)
1.	Azerbaijan-Georgia	Aghstafa-Gardabani	330
2.	Azerbaijan-Georgia	Samukh-Gardabani (Mukhranis-Veli)	500
3.	Azerbaijan- the Russian Federation	Yashma-Darband	330
4.	Azerbaijan-the Russian Federation	Yalama	110
5.	Azerbaijan-Iran (Islamic Republic of)	Parsabad-Imishly	230
6.	Azerbaijan-Iran (Islamic Republic of)	Astara-Astara	110
7.	Azerbaijan-Iran (Islamic Republic of)	Imishly-Mughan	330
8.	Azerbaijan-Iran (Islamic Republic of)	Julfa-Julfa	132
9.	Azerbaijan-Iran (Islamic Republic of)	Araz-Araz	132
10.	Azerbaijan-Türkiye	Ighdir-Arpachay	154
11.	Azerbaijan-Türkiye	Ighdir-Babek	154
12.	Azerbaijan-Türkiye	Sadarak-Igdir	34.5

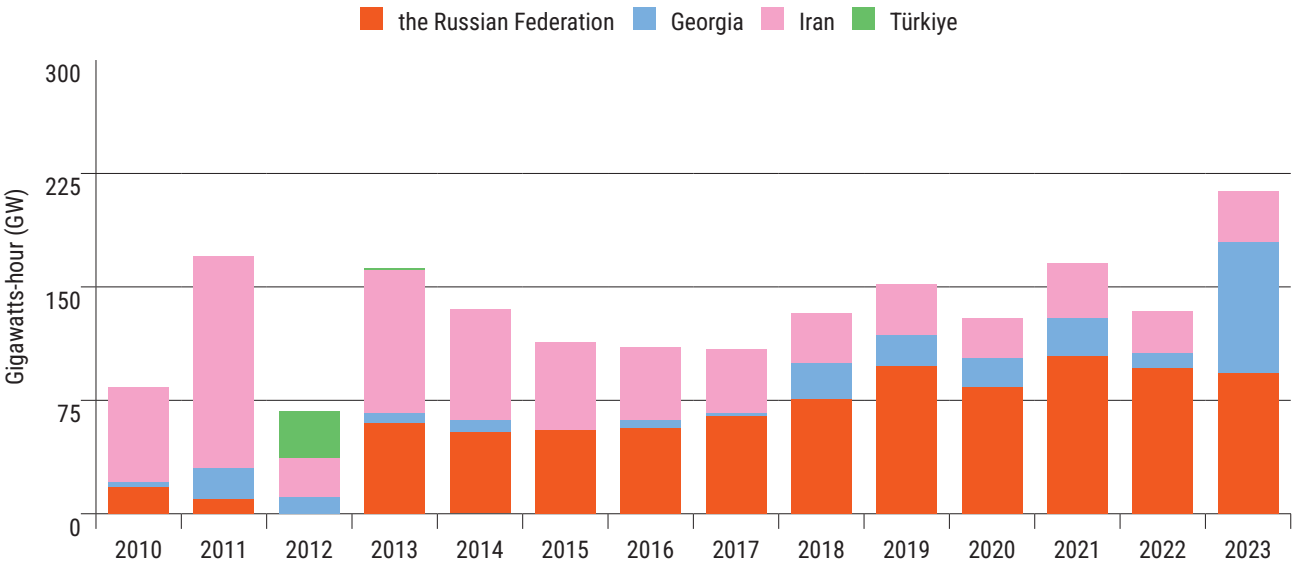
Source: Azerenerji, "Home page", 2023. Available at https://azerenerji.gov.az

Figure 12. Electricity exports in Azerbaijaan, 2010-2023 (GWh)



Source: The State Statistical Committee of the Republic of Azerbaijan, "Home page", 2024b. Available at https://www.stat.gov.az

Figure 13. Electricity imports in Azerbaijan, 2010-2023 (GWh)



Source: The State Statistical Committee of the Republic of Azerbaijan, "Home page", 2024b. Available at https://www.stat.gov.az

The total technical cross-border capacity of Azerbaijan is about 2150 MW or 25 per cent of the installed capacity of the country. The cross-border capacities per countries include Iran (Islamic Republic of) at 350 MW, Georgia at 700 MW, the Russian Federation at 400 MW and Türkiye at 700 MW.

Azerbaijan has been a net electricity exporter since 2007. In 2023, the electricity imports amounted to 211.9 GWh, attributed to Iran (Islamic Republic of), Georgia and the Russian Federation. The exports amounted to 33252.5 GWh (Azerbaijan, Ministry of Energy, 2024e), mainly to Georgia and Türkiye (96 per cent of the exports), in the same year (see figure 21 and figure 13). Currently, Azerenerji Joint Stock Company, the state-owned generation and transmission company, is the only company in the country conducting electricity export and import activities. Table 19 provides information on the cross-border transmission lines (operated by Azerenerji).

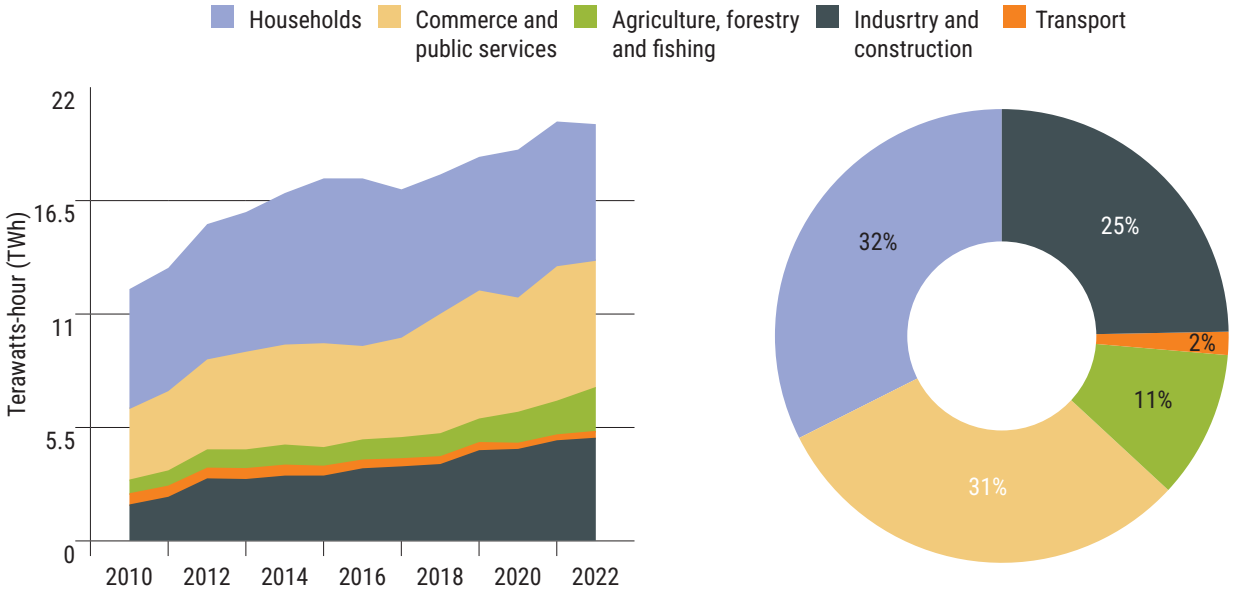
Figures 12 and 13 illustrate the volume of electricity exports to and imports from neighbouring countries in 2010-2023 (GWh) (The State Statistical Committee of the Republic of Azerbaijan, 2024b).

2.2.4 Demand

Electricity consumption in Azerbaijan amounting to 23.2 TWh in 2023 (figure 14) and has increased by 90 per cent between 2010 and 2024 due to population growth and industrial development. The total losses (generation, transmission and distribution) constituted 15 per cent of the total electricity supply. There is 100 per cent access to the electricity grid (World Bank Group, 2024), and its generation capacity fully covers its domestic demand.

The residential sector had the highest share in electricity consumption, followed by commerce and public services (31 per cent), and industry and construction (25 per cent) in 2022 (figure 14). In terms of growth in demand, consumption in agriculture, forestry and fishing increased by 2.2 times and by 1.9 times in industry and construction in the 2010-2022 period.

Figure 14. Electricity consumption by consumer groups in 2010-2022 (GWh) and the breakdown of consumption by categories in 2022, in Azerbaijan



Source: The State Statistical Committee of the Republic of Azerbaijan, "Home page", 2024b. Available at https://www.stat.gov.az

2.3 Electricity market regulation

2.3.1 Power market structure

The Government of Azerbaijan has the largest ownership in the electricity sector. The state-owned companies, Azerenerji OJSC, Azerishiq OJSC and Nakhchivan State Energy Service (operating in the Nakhchivan Autonomous Republic (AR)), dominate electricity generation and transmission, and distribution and supply areas, respectively:

- Azerenerji OJSC is a vertically-integrated state-owned company and is responsible for power generation, transmission and dispatching for the whole country, except the Nakhchivan AR. The total installed capacity of Azerenerji's power plants as of mid-2024 constituted 7067 MW (84.4 per cent of the total installed capacity in the country) (Azerbaijan, Ministry of Energy, 2024f, 2024c; Azerenerji, 2023);
- Azerishig OJSC is responsible for distribution and supply for the whole country, except Nakhchivan AR;
- Nakhchivan AR State Energy Service is responsible for generation, transmission, distribution and supply in Nakhchivan AR (the service has no physical connection with the country's main transmission network system and operates in island mode).

Despite state dominance in the power sector, there are also several thermal power plants owned by industrial companies (mainly oil companies like British Petroleum (BP) and the State Oil Company of Azerbaijan Republic (SOCAR)), and large local and international private companies, such as Azersun Holding, MASDAR, ACWA Power, which operate as 'auto-producers', as well as renewable energy sources plants which are owned by private owners and the state. Azalternativenerji LLC, the state-owned company that owned and operated several renewable energy power plants, was liquidated in 2023 and its assets were put up for privatization (President of the Republic of Azerbaijan, 2024). Azalternativenerji LLC was subordinating to the Azerbaijan Renewable Energy Agency (AERA) which was the dedicated agency under the Ministry of Energy. AERA was established in 2020 to organize, regulate and coordinate

activities in the field of renewable energy sources and their efficient use, as well as to increase the investment attractiveness of the relevant sector (Azerbaijan, Ministry of Energy, 2024b).

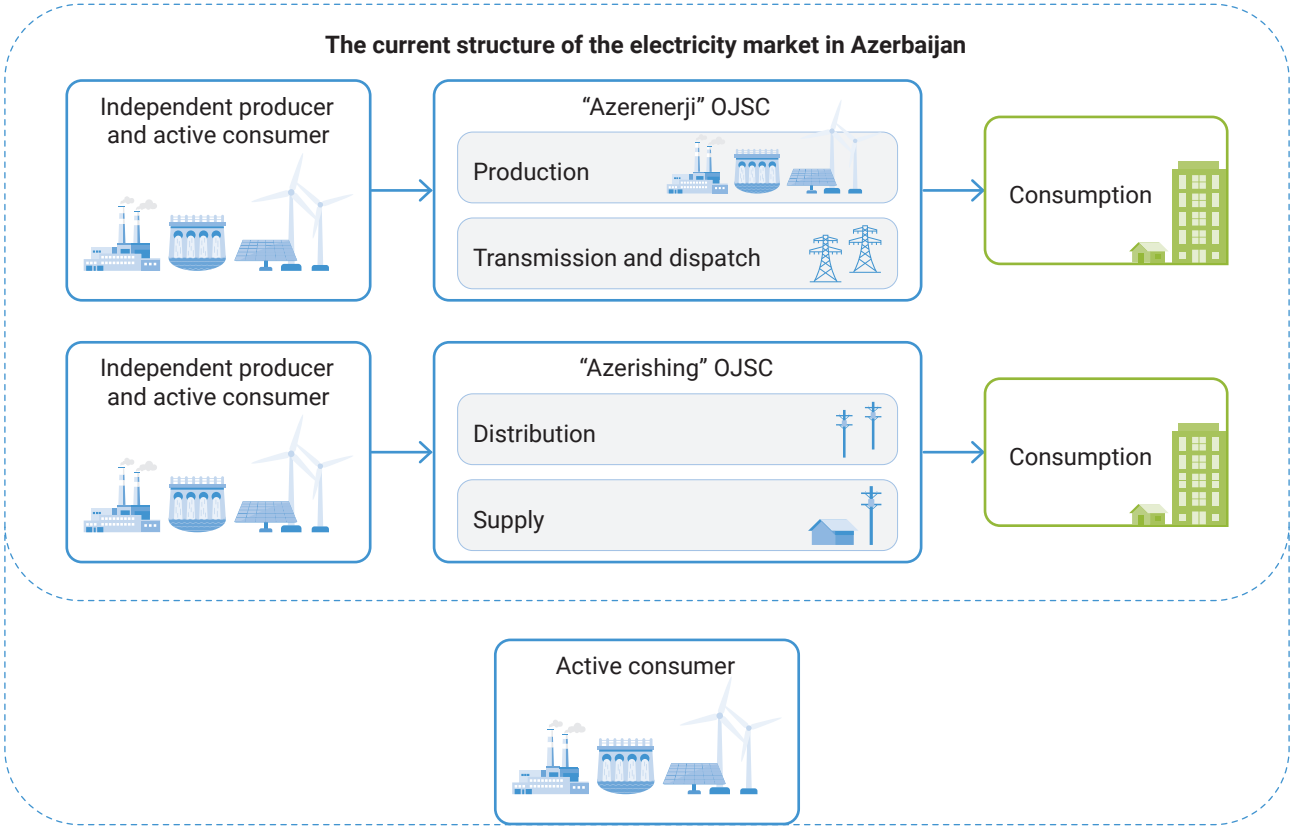
The Azerbaijan Energy Regulatory Agency (AERA) was established in December 2017[5] as a public legal entity under the Ministry of Energy (MoE). The Agency supervises the operation of energy utilities, analyses of public utilities' proposals for electricity, natural gas and heat prices (tariffs), and submits relevant proposals on the state regulation of these prices (tariffs) to the Tariff Council.

The overall current structure of the electricity market in Azerbaijan is illustrated below:

2.3.2 Tariffs

Energy tariffs are regulated in Azerbaijan. Whilst AERA is considered as the regulatory agency, it has the authority to submit tariff proposals only, instead of reviewing and making decisions on them. The Tariff Council is the government agency that holds the mandate to review and approve/reject tariff change proposals. It is an inter-ministerial collegial body, that was established in 2005 according to the Presidential decrees "About strengthening of anti-inflationary measures in the Azerbaijan Republic" (Azerbaijan, 2005b), and "On Approval of the Statute of the Tariff (Price) Council of the Republic of Azerbaijan" (Azerbaijan, 2005c). The Council is chaired by the Minister of Economy and includes

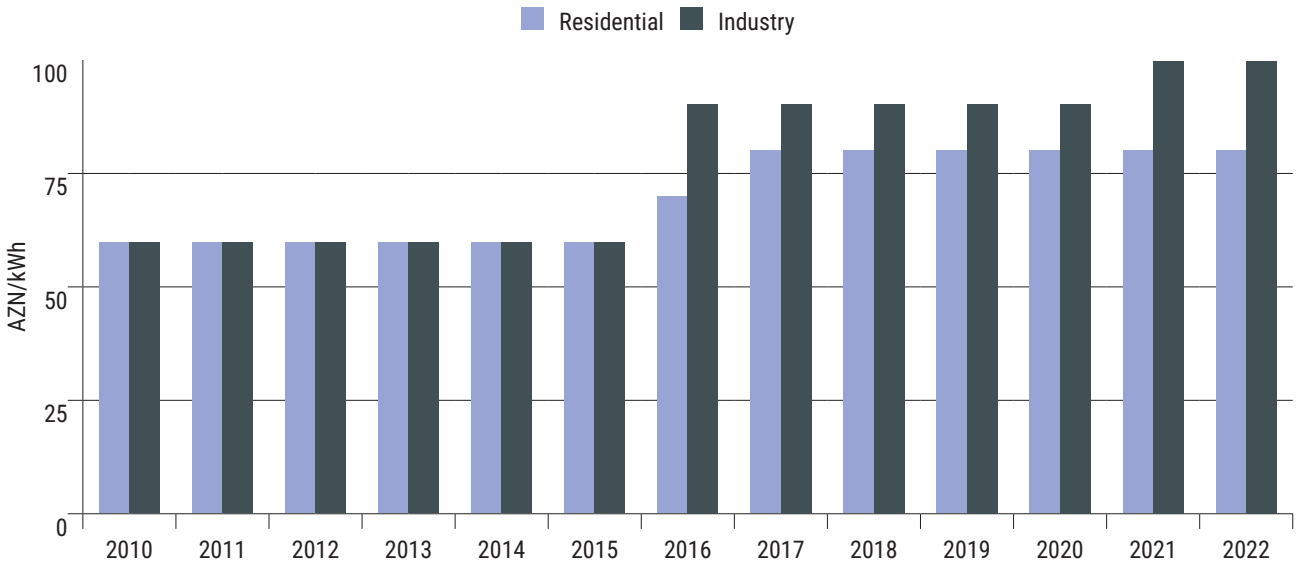
Figure 15. Structure of electricity market in Azerbaijan



Source: Azerbaijan Energy Regulatory Agency, "Electricity network and domestic wholesale market", 2023. Available at https://regulator.gov.az/en/elektrik/elektrik-enerjisi-sebekesi-ve-daxili-topdansatis-bazari

5 Presidential Decree on establishing the Azerbaijan Energy Regulatory Agency and approving the Agency's Charter No. 1750 dated 22 December 2017.

Figure 16. Trend of electricity prices in Azerbaijan Manat (AZN/kWh)



Source: International Energy Agency (IEA), "Energy Statistics Data Browser", 2023. Available at https://www.iea.org/data-and-statistics/data-tools/energy-statistics-data-browser?country=WORLD&fuel=Energy%20supply&indicator=TESby; Tariff (Price) Council of the Republic of Azerbaijan, 2024. Available at https://tariff.gov.az/ckfinder/userfiles/files/Q%C9%99rarlar%20file%202024-davam%C4%B1/Elektrik-c%C9%99dv%C9%99l-01_07_2024.pdf

representatives from relevant ministries and other state authorities, including the Ministry of Energy. The Tariff Council determines the generation, retail and wholesale tariffs (prices) for electricity, gas, heat and hot water supply services provided by Azeristiliktejhizat JSC (the state-owned district heat supply company), for refined petroleum products as well as for purchased tariffs for RES (Azerbaijan, 2005a). Article 9 of the Electricity Law envisages that the regulated prices and tariffs in the power sector will be determined by AERA from 1 July 2028 (Azerbaijan, 2024a). The latter implies that the tariff regulation authority would be transferred to AERA after the aforementioned date. All energy-related tariffs are determined based on a "cost plus" methodology.

Electricity tariffs in Azerbaijan have remained relatively stable, with only three major changes in tariff rates over the last years (figure 16). As of 2024, tariffs for various consumer groups are listed below according to the exchange rates:

- Residential: US$ 0.047/kWh
- Industrial: US$ 0.059/kWh.

2.3.3 Market reform

In Azerbaijan, reforms in the electricity market began in 1996 with the adoption of certain legal acts that, among other provisions, considered some requirements of the European Union's 1st Electricity Directive 1996/92/EC. However, only the legal unbundling of distribution has been achieved so far. The Government has therefore identified objectives for market reforms that are envisaged by the Action Plan of the "2022-2026 Socio-Economic Development Strategy" (Azerbaijan, 2022), and the Electricity Law (Electricity Law, 11 April 2023). The latter envisages three phases of market reforms that are summarized in table 20.

2.4 Plans and measures for the electricity sector development

2.4.1 National goals and plans

"Azerbaijan 2030: National Priorities on Socio-Economic Development" was endorsed by the Presidential Decree on 2 February

Table 20. Planned electricity sector reforms until 2030 in Azerbaijan

Phase	Activities
Phase I (from 1 January 2024 - 30 June 2025)	• Legal and administrative separation of electricity generation and transmission; • Developing and approval of a temporary guideline on the implementation of economic optimization of electricity production; • Financial and functional separation of electricity distribution and supply; • Setting electricity transmission, wholesale and end-user tariffs.
Phase II (from 1 July 2025 – 30 June 2028	• The establishment of a Power Market Operator as a separate legal entity under the transmission system operator (TSO); • Adopting Temporary Wholesale Market Rules for Phase II; • Implementing the 'Single-buyer model'; • Assigning the functions of the renewable energy source guaranteed buyer; • Legal and administrative separation of electricity distribution and supply activities; • Development and approval of methodologies on the calculation of transmission, distribution and supply tariffs by AERA; • Setting electricity distribution and supply tariffs.
Phase III (from 1 July 2028)	• Full liberalization of the power market; • Establishing an independent power market operator, i.e., independent from the transmission system operator; • Reorganizing AERA as an independent energy regulator; • Issuing permits to generators, TSO, DSO and suppliers in accordance with the rules, adopted by the regulator; • Adopting wholesale market rules for Phase III; • Adopting balancing and ancillary service rules; • Adoption of retail market rules; • Adopting commercial accounting rules; • Adopting connection rules.

Source: Electricity Law, 11 April 2023.

2021 (Azerbaijan, 2021), and is the country's visionary road map that encompasses all sectors including energy. The document includes the following priorities for the period of up to 2030 with a particular focus on the Sustainable Development Goals, including on energy and climate change:

- Priority 1. Resilient, growing, and competitive economy
- Priority 2. Dynamic and inclusive society with social justice
- Priority 3. Competitive human capital and place of up-to-date innovations
- Priority 4. "Great Return" to liberated territories
- Priority 5. Clean environment and "Green Growth" country

Priority 5 consists of two sub-priorities: (1) high quality ecological environment; (2) spaces of green energy. As energy is the main emitting sector, Azerbaijan plans to implement measures to incentivize and accelerate the use of alternative (renewable) energy sources with flexible regulation of alternative energy tariffs, develop the institutional environment, strengthen scientific and technical capacity, continue training specialists, raise awareness of energy consumers and involve the private sector in the processes. This document essentially confirms the commitment of the country to meet its decarbonization targets and allows for assuming implementation of the respective policies.

Furthermore, "spaces of green energy" includes the objective to ensure sustainable energy supply across the country through the following activities related to the power sector by 2030:

- Improving regulation and liberalizing the energy sector;
- Expanding the use of renewables;
- Establishing the Azerbaijan – Türkiye – Europe Energy Hub;
- Expanding the use of environment-friendly transport and other green technologies for climate action;
- Ensuring energy efficiency.

"The Social and Economic Development Strategy of Azerbaijan Republic for 2022-2026", was approved on 22 July 2022 (Azerbaijan, 2022), and was prepared in accordance with the Presidential Decree "Azerbaijan 2030: National Priorities for Socio-Economic Development". The concept of a "green energy zone" will be applied by expanding the use of ecologically clean and economically efficient renewable energy sources:

- Achieve 24 per cent share of renewables in the generation mix by 2026 (key target);
- Expand the renewable energy infrastructure via public-private partnership;
- Develop information systems on the use of renewable energy sources;
- Conduct research on potential use of offshore wind power, bioenergy and geothermal power.

2.4.2 Current measures for the development of lower-carbon energy

Azerbaijan possesses a huge potential for the development of renewable energy, however the utilization of RES is very low (apart from the large hydropower plants). Currently, renewable energy sources are mainly used for electricity generation. Table 21 shows the onshore RES potential in Azerbaijan.

According to the World Bank ESMAP report, the technical potential of offshore wind energy in the Azerbaijani part of the Caspian Sea is estimated to be a total of 157 GW, including 35 GW in shallow water and 122 GW in deep water (The World Bank, 2020).

The Government has set the target of having 30 per cent share of renewable energy sources in the total installed capacity by 2030 (Azerbaijan, 2022). The Government has also been implementing proactive measures to increase private sector investments in renewables. With the liberation of the Garabagh Region and the surrounding seven districts in late 2020, the Government has prioritized the development of renewable energy facilities

Table 21. Onshore renewable energy potential in Azerbaijan

Renewable energy type	Potential (MW)
Solar energy	23 000
Wind energy (onshore)	3 000
Bioenergy	380
Small hydropower plants	520
Geothermal energy	615

Source: Azerbaijan Renewable Energy Agency, "Potential of RE", 2024. Available at https://area.gov.az/en/page/yasil-texnologiyalar/boem-potensiali

and green energy zones in these territories. The Government also committed to the following ambitious goals during the COP26 meetings in Glasgow in November 2021:[6]

To achieve 40 per cent reduction in GHG emissions by 2050;

- To increase the share of renewable energy sources in total installed capacity of electricity from the current shares of 17 per cent (in 2021) to 30 per cent by 2030.

The Government has so far concluded agreements with international companies, such as ACWA Power (Saudi Arabia), MASDAR Company (United Arab Emirates), BP (United Kingdom) and Fortescue (Australia), for wind and solar power development in the country with the aim to attract private sector investments for green electricity generation. The Ministry of Energy has recently announced the first ever auction in the country for a 100-MW solar photovoltaic power plant in Gobustan area for investors (Azerbaijan, Ministry of Energy, 2024e).

2.4.3 Key challenges and issues in lower-carbon energy development

At present, the Law "On the Use of Renewable Energy Sources for Electricity Generation" is the primary legislation on renewables (adopted on 31 May 2021) (President of the Republic of Azerbaijan, 2021). The Law sets forth the Government's principles of state regulation in the use of renewable energy sources in electricity generation:

- Application of state support mechanisms and ensure an equal and non-discriminatory use of these mechanisms;
- Ensure equal opportunities in the use of electricity grids for all energy producers;
- Application of international standards in the field of electricity generation from renewable energy sources;
- Ensure the efficient use of renewable energy sources' potential.

The Law requires the adoption of secondary legal acts to achieve necessary legal, technical and economic background for wider renewable energy development. In this context, the low-carbon energy development is facing certain challenges:

- Need for adoption of the required secondary legal and technical regulations for renewable energy development;
- Lack of specific renewable energy tariff methodology for various renewable energy sources;
- Lack of affordable financing schemes for renewable energy and other low-carbon project development;
- Electricity market liberalization that is still under development.

2.4.4 Plans for cross-border power trade development

Azerbaijan has defined two routes for electricity exports to diversify its export and transit potential:

- East-West corridor
- North-South corridor

East-West corridor

- Azerbaijan – Türkiye – Europe Energy Hub is envisaged in the "National Socio-Economic Development Strategy for 2022-2026". Its objective is to ensure an alternate power supply from Azerbaijan to

6 Presentation titled "On track to meet Paris Agreement: Clean Energy Transition in Azerbaijan", made by the Ministry of Energy of the Republic of Azerbaijan during the conference on Developing Climate Change Mainstreaming Policies in EAP Region in November 2021.

Türkiye via Armenia and Nakhchivan AR, in addition to the current route via Georgia.

- Caspian – Black Sea – Europe Green Energy Corridor Project: On 17 December 2022, the Governments of Azerbaijan, Georgia, Hungary and Romania signed the "Agreement between Governments of the Republic of Azerbaijan, Georgia, Hungary and Romania on Strategic Partnership in the Field of Development and Transfer of Green Energy". This initiative envisages the export of renewable electricity from Azerbaijan to Europe via Georgia and the Black Sea. About 2.5 GW of renewable electricity capacity (wind and solar) is planned to be exported from Azerbaijan during the first phase (Trend News Agency, 2022; Azernews, 2023a). In general, Azerbaijan is planning to export 5 GW of electricity to Europe by 2030. A total of 4 GW will be exported via the subsea cable (i.e., Black Sea) from Georgia and 1 GW will be exported from Nakhchivan through Türkiye (Ashirov, 2023; Azernews, 2023b).

- Azerbaijan is also actively negotiating with Central Asian countries to expand electricity trading and involve them in the initiatives on exporting electricity to Europe. A Memorandum of Cooperation has been recently signed between Azerbaijan, Kazakhstan and Uzbekistan to integrate the power systems of these countries (Yevgrashina, 2024).

- International organizations are launching certain regional initiatives to support regional connectivity in South Caucasus, focusing on the development of energy infrastructure in Azerbaijan as well (Martikian, 2024).

North-South corridor

- Synchronization of Azerbaijan, Iranian and the Russian Federation Power Grids: Negotiations on the synchronization of the power grids of the three countries started several years ago. An Iranian consulting company completed the relevant feasibility study on the project last year (Ganbay, 2024).

Legal issues in electricity export from Azerbaijan

The Azerbaijani legislation has certain requirements regarding electricity export and import:

- Special permit: Electricity export and import activities are subject to special permit (Law on Licenses and Permits) (Azerbaijan, 2024b), although state-owned companies can be involved in electricity import-export activities without obtaining a permit.

- Registration of agreements on import-export activities: All electricity export-import agreements will be registered at the Ministry of Economy (Rules on Regulation of Import-Export Activities in Azerbaijan Republic).

- Requirements on electricity swap operations: The period for sending and receiving the equivalent amount of goods is up to 90 days. If the sending party does not receive the equivalent amount of goods within the said period, the goods are considered as counterfeit.

- Payment settlement in export transactions: Any goods sale (export) by state-owned companies and the companies with the state ownership of more than 50 per cent will be carried out only with the precondition of either of the following terms:

- Advance payment for goods by buying party
- Irrevocable letter of credit by buying party
- Bank guarantee by buying party

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3 The Islamic Republic of Iran

3.1 Summary

Being one of the leading economies among ECO member states, Iran (Islamic Republic of) possesses the fourth largest oil and second largest natural gas reserves in the world. Despite having such abundant hydrocarbon resources that are traditionally used in electricity generation, Iran (Islamic Republic of) has shown commitment to develop its renewable energy sources with the aim to reduce emissions from fossil fuels.

The country has been exposed to many international embargoes and prohibitions during the last 45 years, however, it has managed to rehabilitate old and build new power infrastructure. It has also developed the necessary know-how and infrastructure in power generation from nuclear fuel.

With a well-developed internal transmission system, Iran (Islamic Republic of) has cross-border interconnections with Afghanistan, Armenia, Azerbaijan, Iraq, Pakistan and Turkmenistan, many of which are ECO member states.

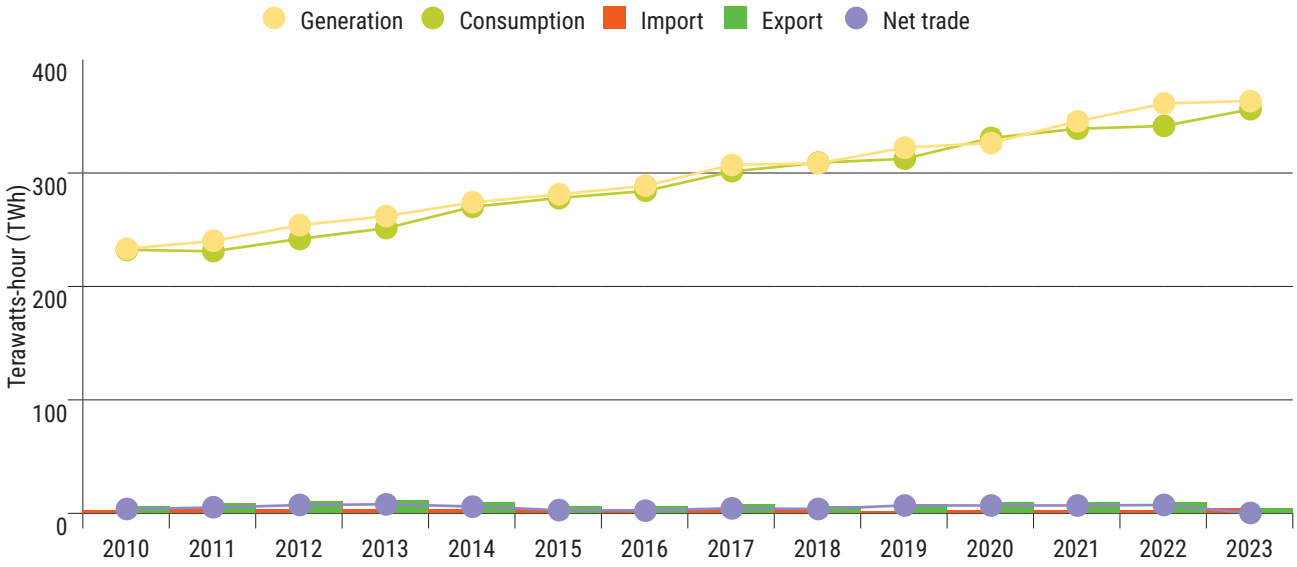
3.2 Current situation in the electricity sector

3.2.1 Supply and demand balance

Although Iran (Islamic Republic of) has diverse and continuously increasing generation capacities, the aging large power plants (both thermal and hydro power) require necessary and constant technical upgrades, resulting in low-level capacity utilization and volatile supplies. Electricity generation and consumption in the country increased by 53 per cent per annum between 2010-2023. The net electricity trade had an upward trend during the same period.

The overall access to electricity for the population in Iran (Islamic Republic of) is 100 per cent (The World Bank, n.d.a.).

Figure 17. Electricity supply, demand and trade in Iran (Islamic Republic of), 2010-2023 (TWh)



Source: International Energy Agency (IEA), "Home page", n.d.b. Available at https://www.iea.org; EMBER, "Iran's vast untapped solar potential can help overcome its fossil gas dependency and slow its rising power sector emissions", 9 October 2024. Available at https://ember-climate.org/countries-and-regions/countries/iran/; United States Energy Information Administration (EIA), "Iran: Overview", 10 October 2024. Available at https://www.eia.gov/international/analysis/country/IRN

3.2.2 Capacity and generation

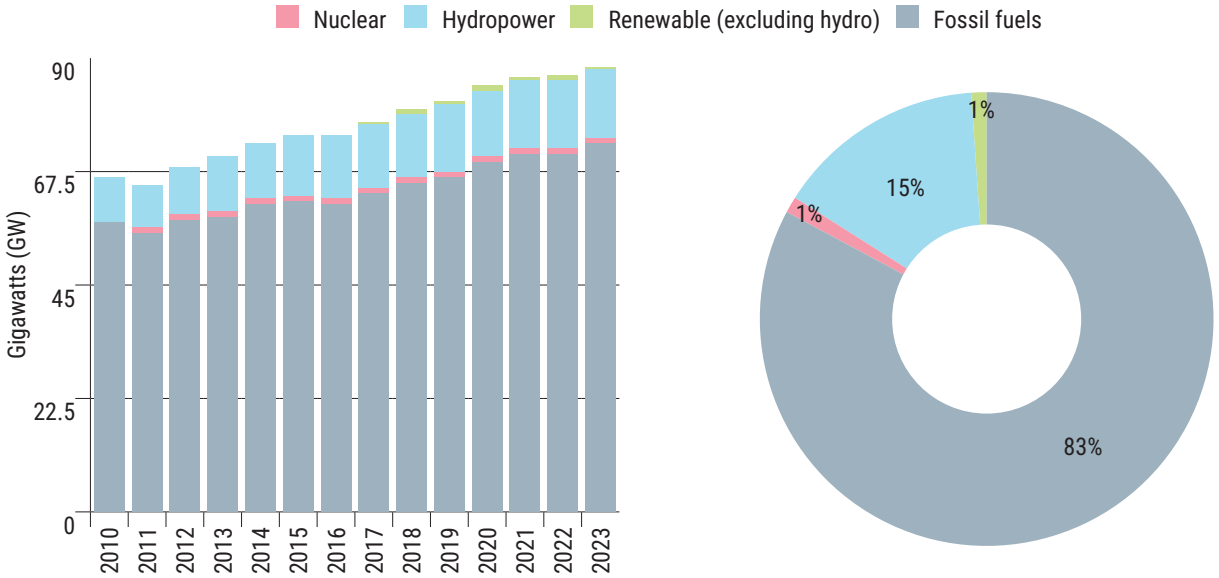
Iran (Islamic Republic of) has one of the most developed power systems in the Middle East region. Fossil fuels have been historically dominating the electricity generation mix of the country, followed by hydropower, other renewables and nuclear power. The total generation capacity of Iran (Islamic Republic of) increased by 33 per cent between 2010 to 2023. The total installed capacity reached about 88.6 GW in 2023: 73.4 GW of which was thermal; 13.2 GW was hydro; and about 2 GW was from renewables and nuclear energy (IEA, n.d.b.; EMBER, 2024; EIA, 2024).

The state-owned vertically-integrated generation, transmission and distribution company, TAVANIR, and the state-owned Iran Water Resources Management Holding Company are the main players in the electricity sector holding a 92 per cent share in thermal generation capacity as of 2022, with the rest owned by private developers (EES EAEC World Energy, 2024). Thermal power plants mainly use domestic natural gas as the primary energy source. Part of them also utilize other fossil fuels (for example, furnace oil). Despite the economic sanctions and international pressure on the economy, the Iranian Government has been promoting the participation of the private sector for power generation since the 2000s.

Figure 19 depicts the trends of power generation in Iran (Islamic Republic of) with 94 per cent of electricity being produced by thermal power plants, 4 per cent by hydro power plants, 2 per cent by nuclear and 1 per cent from renewable energy plants, in 2023. Local natural gas is dominant among fossil fuels in the thermal generation (90 per cent), followed by other fuels.

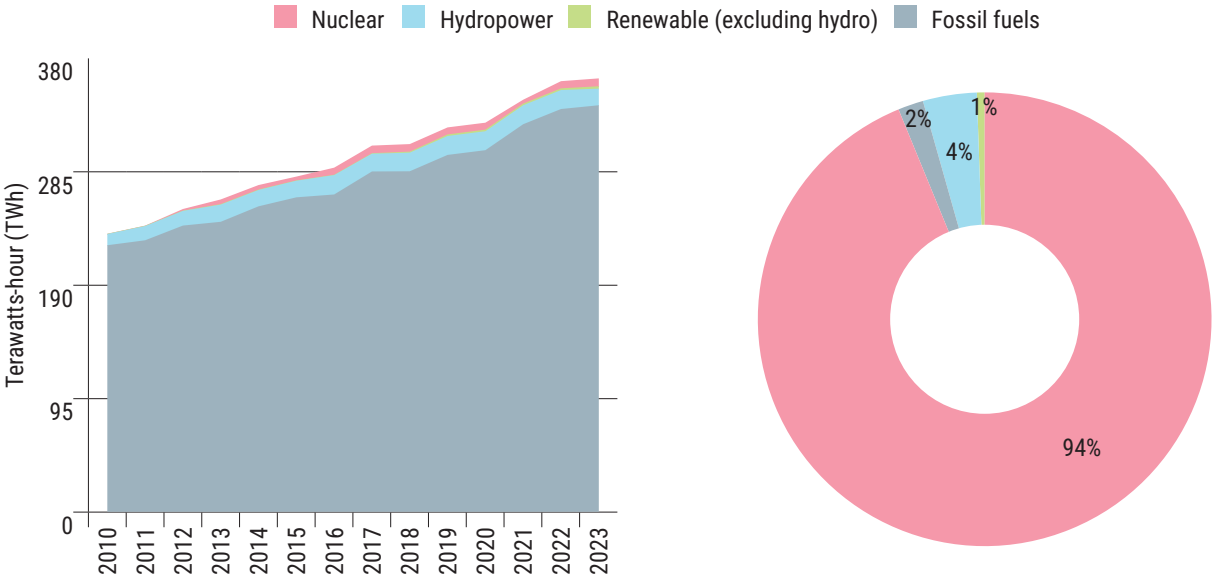
Hydropower is the second main source of power generation in the country. Although, the hydropower generation capacity increased by 56 per cent from 2010-2023, the hydropower electricity generation increased only by 48 per cent in 2023 compared to 2010. This was due to fluctuating water resources caused by climate change.

Figure 18. Trend of electricity generation capacities, 2010-2023 (left), and breakdown by types in 2023 (right), in Iran (Islamic Republic of)



Source: International Energy Agency (IEA), "Home page", n.d.b. Available at https://www.iea.org; EMBER, "Iran's vast untapped solar potential can help overcome its fossil gas dependency and slow its rising power sector emissions", 9 October 2024. Available at https://ember-climate.org/countries-and-regions/countries/iran/; United States Energy Information Administration (EIA), "Iran: Overview", 10 October 2024. Available at https://www.eia.gov/international/analysis/country/IRN

Figure 19. Trend of electricity generation in 2010-2023 (TWh), and the breakdown by sources in 2023, in Iran (Islamic Republic of)



Source: International Energy Agency (IEA), "Home page", n.d.b. Available at https://www.iea.org; EMBER, "Iran's vast untapped solar potential can help overcome its fossil gas dependency and slow its rising power sector emissions", 9 October 2024. Available at https://ember-climate.org/countries-and-regions/countries/iran/; United States Energy Information Administration (EIA), "Iran: Overview", 10 October 2024. Available at https://www.eia.gov/international/analysis/country/IRN

Apart from fossil fuel and renewable energy plants, Iran (Islamic Republic of) has been actively developing nuclear electricity generation since 1980s. One nuclear power plant is currently operating in the country with the installed capacity of 915 MW. The details on the nuclear power facilities, as of May 2024, are provided in tabke 22. The Government, in general, is interested in developing additional nuclear power capacities until 2030. Having certain reserves of uranium, the country has several nuclear enrichment plants to ensure domestic nuclear fuel production.

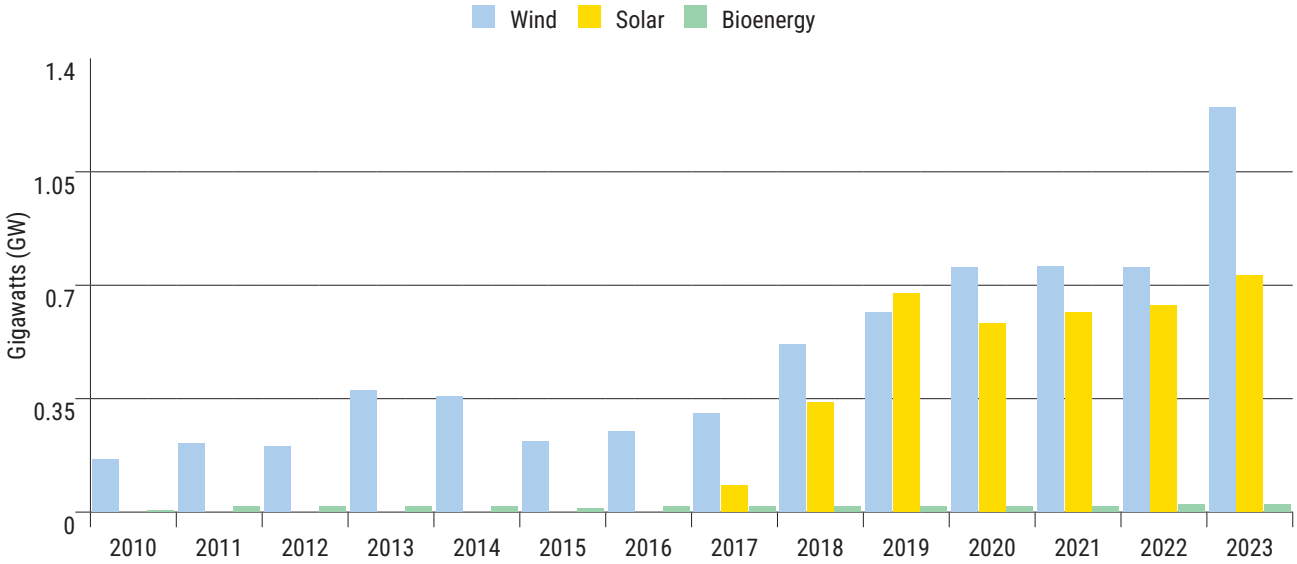
Renewable energy development, apart from hydropower, commenced in Iran (Islamic Republic of) in early 2000s (hydropower development started in 1950s). The share of renewables (excluding hydro) in both the total capacity and in the total generation

Table 22. Current and future nuclear power facilities in Iran (Islamic Republic of)

Reactor name	Model	Reactor type	Capacity (MWe)	Construction commencement	First grid connection
Bushehr-1	VVER V-46	PWR	915	May 1975	September 2011
Bushehr-2 (under construction)	AES-92, VVER-1000/V-466B	PWR	1057	November 2019	2028 (expected)
Bushehr-3	VVER-1000/V-466B	N/A	1057	N/A	N/A
Darkhovin	IR-360	N/A	360	N/A	N/A
Markan coast	ACP100	N/A	2 x 100	N/A	N/A
Hormuz 1-4	N/A*	N/A	4 x 1250	N/A	N/A
Others (total)	N/A	N/A	5200	N/A	N/A

Source: World Nuclear Association, "Nuclear Power in Iran", 3 May 2024. Available at https://world-nuclear.org/information-library/country-profiles/countries-g-n/iran

Figure 20. Electricity generation from renewable energy sources (excluding hydro) in Iran (Islamic Republic of)



Source: International Energy Agency (IEA), "Home page", n.d.b. Available at https://www.iea.org; EMBER, "Iran's vast untapped solar potential can help overcome its fossil gas dependency and slow its rising power sector emissions", 9 October 2024. Available at https://ember-climate.org/countries-and-regions/countries/iran/; United States Energy Information Administration (EIA), "Iran: Overview", 10 October 2024. Available at https://www.eia.gov/international/analysis/country/IRN

in 2023 was 1 per cent. The total installed capacity of renewables as of 2024, excluding hydropower, was 1 GW. Wind power plants have the highest share in the renewables (62 per cent), followed by solar (36 per cent), and bioenergy (2 per cent). The Government has been undertaking a series of reforms in recent years to overcome the technical and financial barriers to renewable energy development. Feed-in-tariff is the most commonly used mechanism for renewable energy development. The average feed-in-tariff for wind and solar power was 0.2 USD/kWh.

2.3.3 Imports and exports

Iran (Islamic Republic of) has interconnections with all its land neighbours: Afghanistan, Armenia, Azerbaijan, Iraq, Pakistan and Turkmenistan. To some extent, Iran (Islamic Republic of) also had cross-border electricity transactions with all these countries between 2010-2022. The current developments in the cross-border trading of Iran (Islamic Republic of) with its neighbouring ECO members states are as follows:

- Afghanistan:
  - Conducting feasibility studies to build the 220 kV Milak-Zaraj interconnection line;
  - Conducting feasibility study on the potential construction of the 500 kV Torbat-e-Jam-Herat interconnection line;
  - Providing electricity to Farah and Nimruz provinces in Afghanistan.
- Azerbaijan: Iran (Islamic Republic of) and Azerbaijan are interconnected through the Imishly interconnection lines in the mainland Azerbaijan (about 800 MW capacity) and through the Nakhchivan region (about 130 MW capacity).
- Pakistan:
  - Completing the construction of the 230 kV Polan-Gwadar double-circuit interconnection line and the associated substation for the electricity export to Pakistan;

Table 23. Cross-border transmission lines in Iran (Islamic Republic of)

Country	Transmission line	Voltage (kV)	Contract type/Purpose of trading
Iraq	Khorramshahr-Basra	400	Export
	Karkheh-Amara	400	Export
	Mersad-Diyala	400	Export
	Sarpol Zahab-Khanaqin	2x132	Export
	Marivab-Panjvin	2x63	Export
Türkiye	Khoy-BTB Van	400	Export/Import
	Barzargan-Dagbayazid	154	Export/Import
Pakistan	Pishin-Mand	132	Export
	Polan-Jiwani	132	Export
Afghanistan	Torbat-e-Jam-Herat	2x132	Export
Azerbaijan	Mughan-Imishly	230	Export/Exchange
	Astara-Astara	230	
	Parsabad-Imishly	230	
	Julfa-Ordubad	132	
	Araz-Nakchivan	132	
Armenia	Arazbaran-Agarak	230	Exchange
		230	Exchange
Turkmenistan	Sarakhs-Satlyk	230	Import
	Gonbad-Balkans	230	Import

Source: Information provided by the Ministry of Energy of the Islamic Republic of Iran.

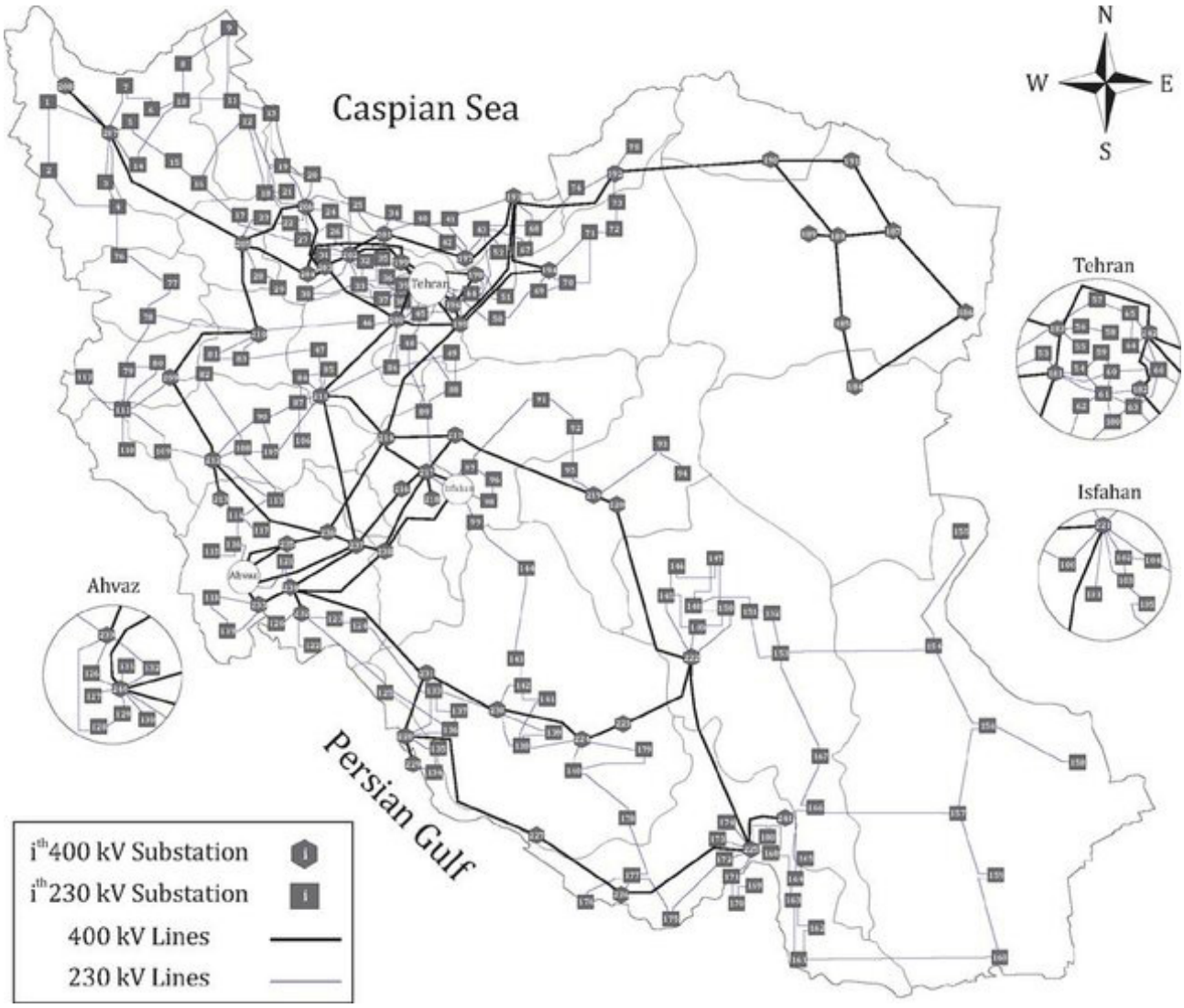
- Increasing the electricity to Pakistan through the Chaveh-Teftan interconnection line.

- Türkiye: The power interconnection capacity between Iran (Islamic Republic of) and Türkiye is 500 MW and recently an HVDC interconnection has been developed between the two countries. This interconnection can enable the connection between ECO member states from across East Asia to Europe.

- Turkmenistan: Iran (Islamic Republic of) will soon launch its part of the Mari-Mashhad Interconnection Line to increase the exchange capacity of the line. Turkmenistan finalized its contract with the Iranian contractor Sama Energy to build the Turkmenistan section of the line. All technical services will be covered by the Iranian contractor and will be paid for by the Iranian power company TAVANIR from the import costs of the electricity from Turkmenistan (the estimated costs of technical services is $15 million). Figure 21 illustrates the information on the cross-border capacities of Iran (Islamic Republic of).

Iran (Islamic Republic of) was a net electricity exporter between 2010-2022, however the share declined in 2023 due to increased domestic demand. In 2022, the country's electricity exports amounted to 4.4 TWh, attributed to Afghanistan, Armenia, Azerbaijan, Iraq, Pakistan, Türkiye and Turkmenistan (figure 22 and figure 23). Table 23 provides information on the cross-border trading arrangements with its neighbouring countries including the information on transmission lines.

Figure 21. Electricity transmission grid Iran (Islamic Republic of)



Source: Mahdi Mazhari, "A multi-objective PMU placement method considering measurement redundancy and observability value under contingencies", *IEEE Transaction on Power Systems*, vol. 28, No. 3 (December 2013). Available at https://www.researchgate.net/publication/260497777_A_Multi-Objective_PMU_Placement_Method_Considering_Measurement_Redundancy_and_Observability_Value_Under_Contingencies
Disclaimer: The boundaries and names shown and the designations used in this map do not imply official endorsement or acceptance by the United Nations.

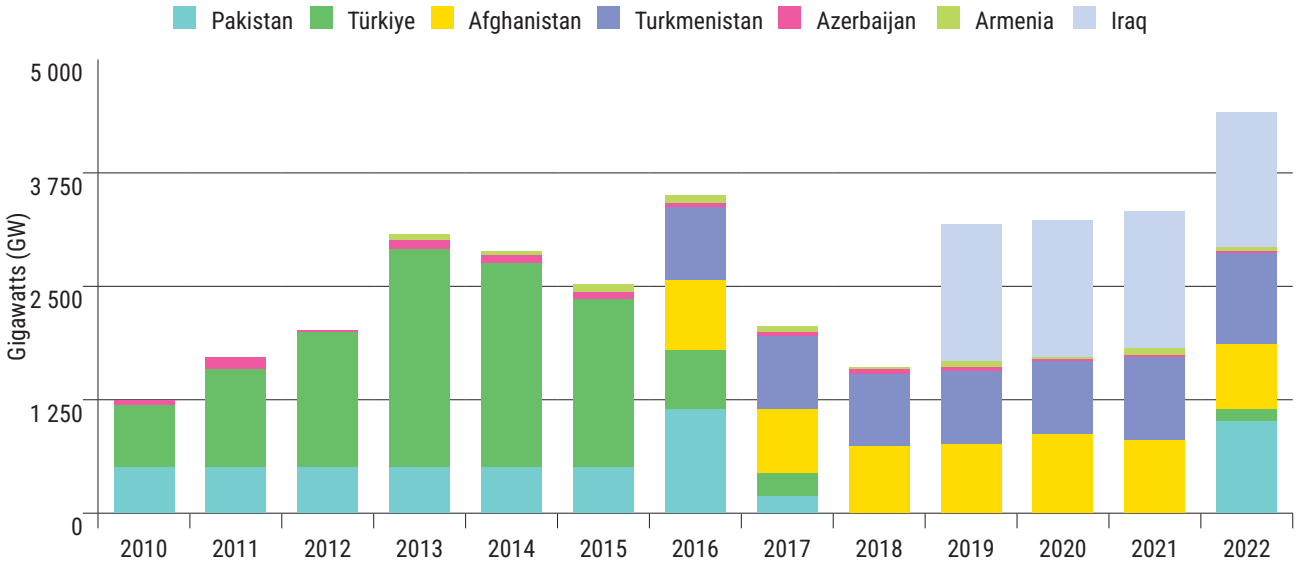
Except with Armenia, Iran (Islamic Republic of) conducts electricity export and import transactions based on "electricity for electricity" or "electricity for money". Armenia has been importing natural gas from Iran (Islamic Republic of) since 2009, which is then used in electricity generation and operates under the gas-for-electricity program.

Figures 22 and 23 illustrate the volumes of electricity export to and import from neighbouring countries in 2010-2022.

3.2.4 Demand

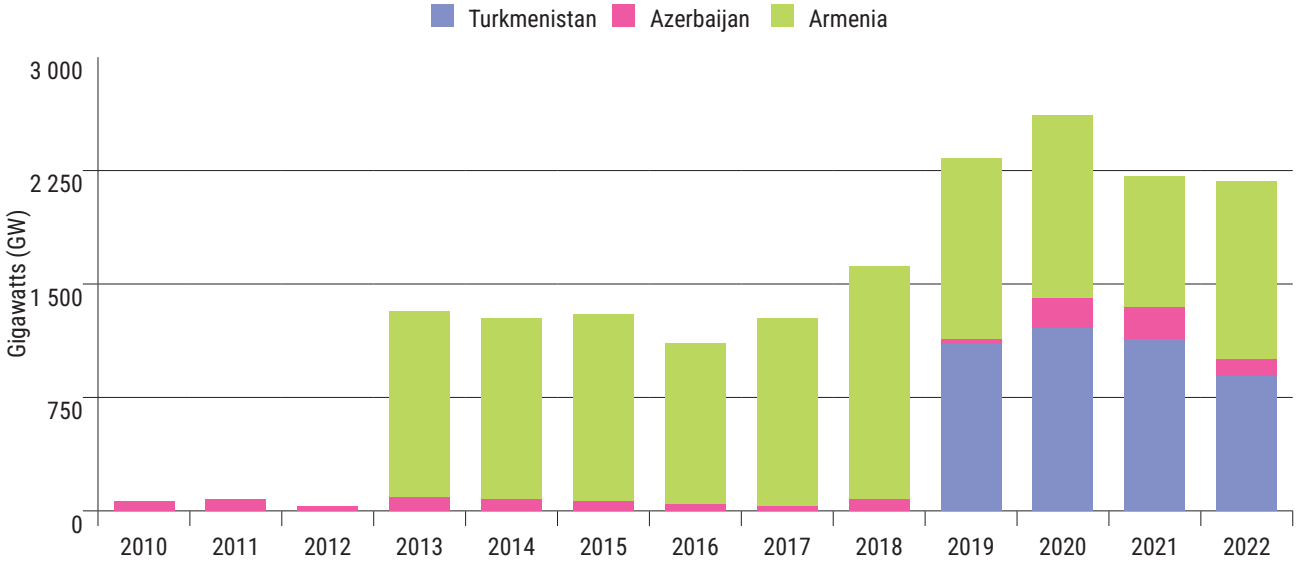
Electricity consumption in Iran (Islamic Republic of) increased by 53 per cent between 2010-2023, attributed to population growth, industrial development, illegal cryptocurrency mining, subsidized electricity prices, amounting to about 356 TWh in 2023 (see figure 24). The losses in all dimensions (generation, transmission and distribution) constituted 20 per cent of the total electricity supply (IEA, n.d.b.; EMBER, 2024; EIA, 2024). Electricity consumption per capita in 2023

Figure 22. Electricity exports in Iran (Islamic Republic of), 2010-2022 (GWh)



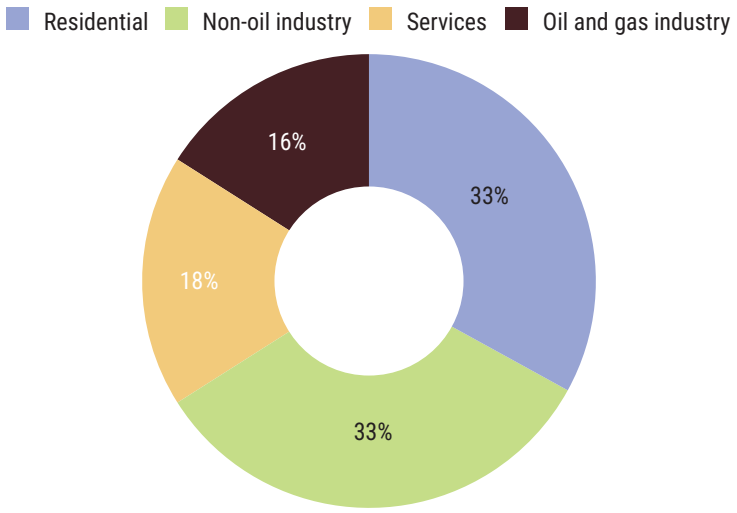
Source: International Energy Agency (IEA), "Home page", n.d.b. Available at https://www.iea.org; EMBER, "Iran's vast untapped solar potential can help overcome its fossil gas dependency and slow its rising power sector emissions", 9 October 2024. Available at https://ember-climate.org/countries-and-regions/countries/iran/; United States Energy Information Administration (EIA), "Iran: Overview", 10 October 2024. Available at https://www.eia.gov/international/analysis/country/IRN; National Statistics and Information Authority (NSIA), "National Statistics and Information Authority (NSIA)", 2024. Available at http://nsia.gov.af/services; United States Energy Information Administration. Available at https://www.eia.gov; National Electric Power Regulatory Authority (NEPRA), Pakistan, "Home page", 2023. Available at https://nepra.org.pk; CDC "Energia", National Statistical Committee of the Kyrgyz Republic. Available at https://www.stat.kg/ru/publications/vneshnyaya-i-vzaimnaya-torgovlya-tovarami-kyrgyzskoj-respubliki/; ORIENT, "Turkmenistan is expanding its electricity supply network to Afghanistan: routes and projects, 4 March 2024. Available at https://orient.tm/en/post/69366/turkmenistan-expanding-its-electricity-supply-network-afghanistan-routes-and-projects

Figure 23. Electricity imports in Iran (Islamic Republic of), 2010-2022 (GWh)



Source: International Energy Agency (IEA), "Home page", n.d.b. Available at https://www.iea.org; EMBER, "Iran's vast untapped solar potential can help overcome its fossil gas dependency and slow its rising power sector emissions", 9 October 2024. Available at https://ember-climate.org/countries-and-regions/countries/iran/; United States Energy Information Administration (EIA), "Iran: Overview", 10 October 2024. Available at https://www.eia.gov/international/analysis/country/IRN; National Statistics and Information Authority (NSIA), "National Statistics and Information Authority (NSIA)", 2024. Available at http://nsia.gov.af/services; Energy Information Administration (eia.gov); National Electric Power Regulatory Authority (NEPRA), Pakistan, "Home page", 2023. Available at https://nepra.org.pk; CDC "Energia", National Statistical Committee of the Kyrgyz Republic. Available at https://www.stat.kg/ru/publications/vneshnyaya-i-vzaimnaya-torgovlya-tovarami-kyrgyzskoj-respubliki/; ORIENT, "Turkmenistan is expanding its electricity supply network to Afghanistan: routes and projects, 4 March 2024. Available at https://orient.tm/en/post/69366/turkmenistan-expanding-its-electricity-supply-network-afghanistan-routes-and-projects

Figure 24. Electricity consumption by categories in Iran (Islamic Republic of), 2022



Source: International Energy Agency (IEA), "Home page", n.d.b. Available at https://www.iea.org; EMBER, "Iran's vast untapped solar potential can help overcome its fossil gas dependency and slow its rising power sector emissions", 9 October 2024. Available at https://ember-climate.org/countries-and-regions/countries/iran/; United States Energy Information Administration (EIA), "Iran: Overview", 10 October 2024. Available at https://www.eia.gov/international/analysis/country/IRN

was 4 MWh (EMBER, 2024), which is similar to the global average (The World Bank, n.d.b). The residential sector had a 33 per cent share in consumption, followed by the non-oil industry (33 per cent), services (18 per cent) and the rest for the oil and gas industry (Enerdata, n.d.).

3.3. Electricity market regulation

3.3.1 Power market structure

Decentralization of the power system in Iran (Islamic Republic of) commenced in 1992. State ownership in the electricity market is still high, and the Ministry of Energy is the main policy and decision maker in the electricity market.

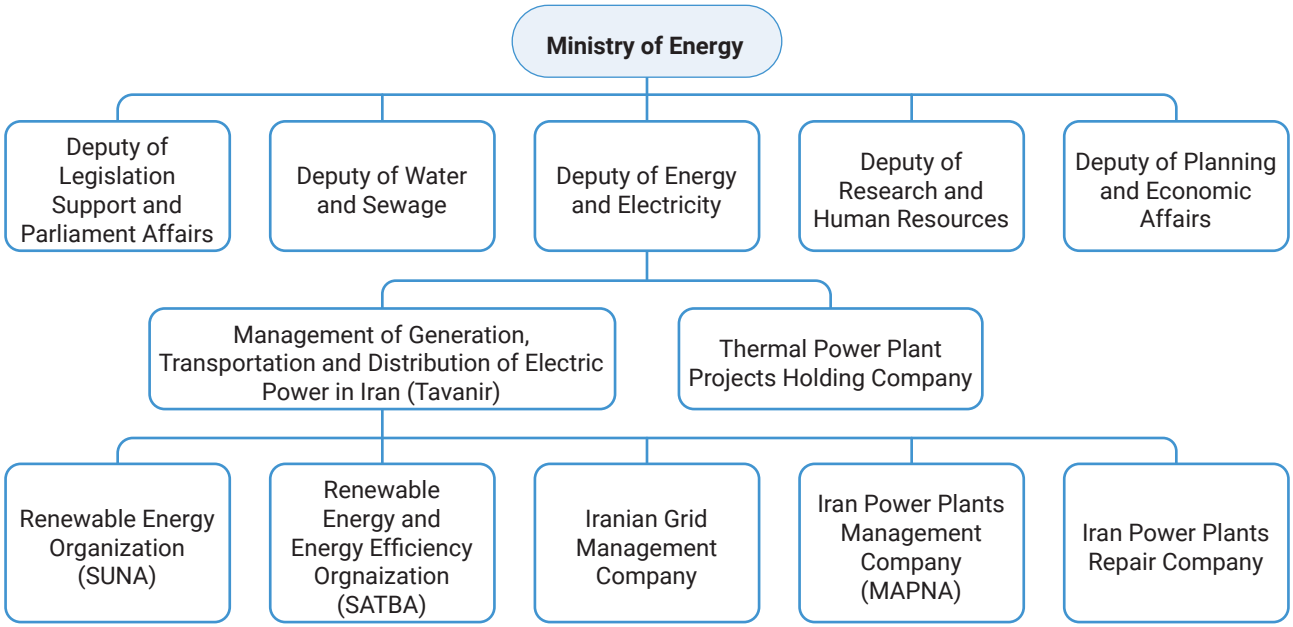
The state-owned company TAVANIR is the main player in the electricity market. In general, the electricity sector functions have been unbundled, although mainly are state-owned companies.

Figure 25 depicts the agencies and companies that are the key state-owned institutions involved in the electricity market:

While some private participants in the Iranian electricity sector are involved in electricity generation, mainly through renewable energy sources, however, there is no publicly available information on them.

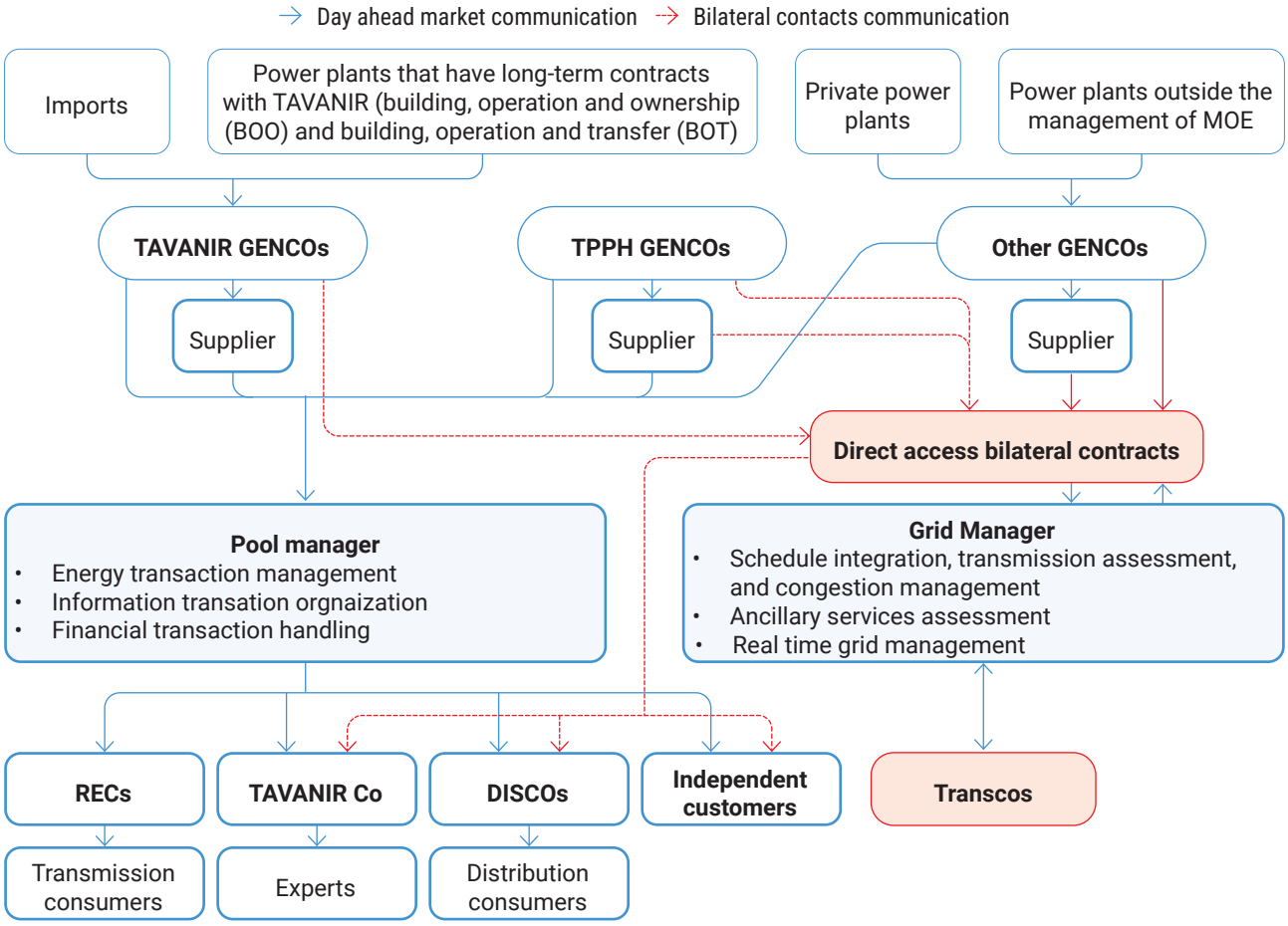
IREMA (Iran Electricity Market) company is the market operator and power pool manager. Although IREMA uses day-ahead market transactions for purchasing electricity from sellers, bilateral agreements still prevail in the electricity market. Iran Grid Management Company (IGMC) is the transmission system operator. The main marketplace for electricity trading in day ahead market is Iran Energy Exchange (IRENEX). Apart from electricity, IRENEX is the market place for other energies (coal, oil, gas, tar) (IREMA, n.d.a.).

Figure 25. Structure of the Ministry of Energy in Iran (Islamic Republic of)



Source: International Council on Large Electric Systems, "The Electric Power System: Islamic Republic of Iran", n.d. Available at https://www.cigre.org/userfiles/files/Community/NC/2018_National-power-system_Iran.pdf

Figure 26. Electricity market operations in Iran (Islamic Republic of)



Source: International Council on Large Electric Systems, "The Electric Power System: Islamic Republic of Iran", n.d. Available at https://www.cigre.org/userfiles/files/Community/NC/2018_National-power-system_Iran.pdf

3.3.2 Tariffs

Publicly available information on the electricity tariff system in Iran (Islamic Republic of) is limited. The Government introduced the day-ahead market arrangement in mid-2000s, but its share in the market is little (IREMA, n.d.c.). The Government heavily subsidizes electricity prices, further strengthening the position of state-owned companies. The latest available information on electricity tariffs according to consumer categories was published in the year 2016 which are as follows:

- Residential: US$ 0.017/kWh
- Industrial: US$ 0.022/kWh
- Commercial: US$ 0.025/kWh

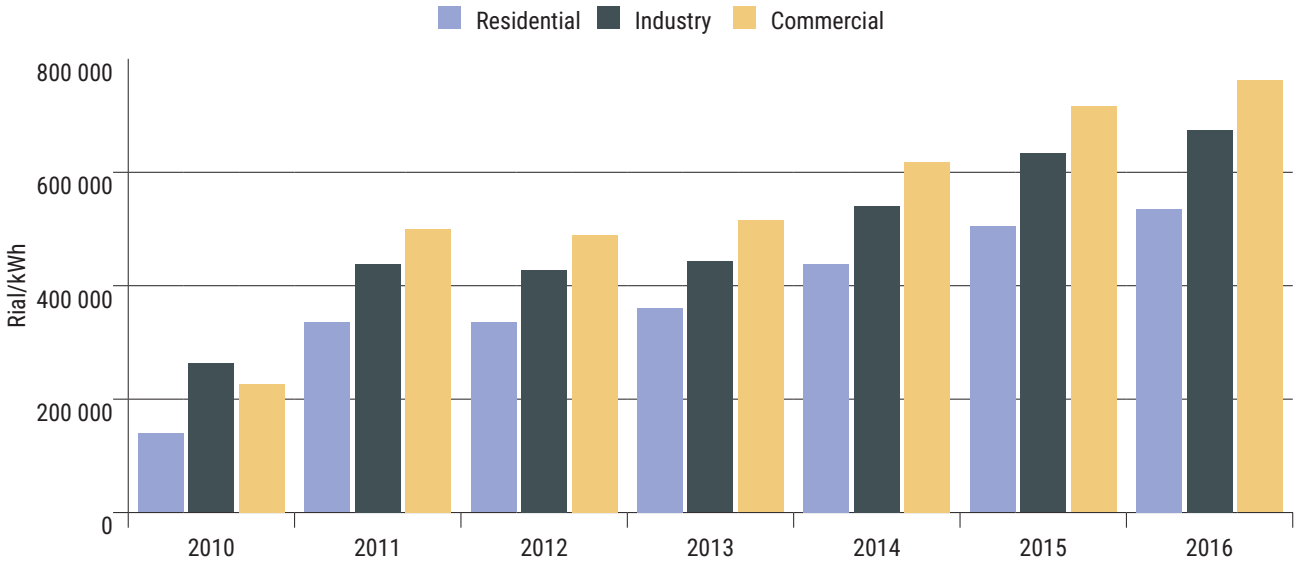
3.3.3 Market reform

With the decentralization of the electricity system in 1990s, new generation facilities were developed based on two major contract types: "building, operation and ownership" (BOO) and "building, operation and transfer" (BOT). Distribution companies were unbundled from the generation and transmission (i.e., from the vertically-integrated TAVANIR company) in 1994 and began to operate as separate legal entities.

- In 2001, Iran Electricity Research Board was established which had the objective of studying the existing electricity markets of other countries. Based on the results of studies, the Iran Electricity Market (IREMA) model was developed and proposed in September 2003. The function of IREMA was to serve as a single buyer in the electricity market. On 23 November 2003, IREMA officially commenced its work as a market operator/power pool manager, marking the start of a functioning electricity market in Iran (Islamic Republic of); a market that provides a competitive environment for trading. The emergence of the electricity market also contributed to the establishment of the Iran Grid Management Company (IGMC) in the fall of 2004 (IREMA, n.d.b.).

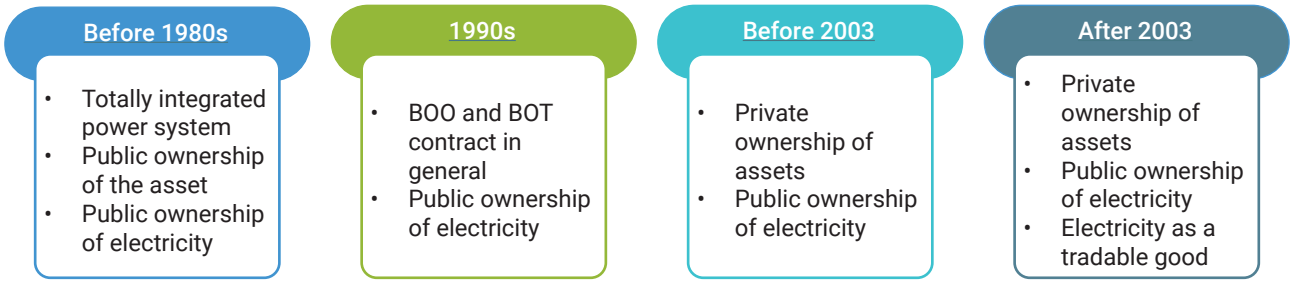
Although the electricity market restructuring and market development began a long-time ago, the Iranian electricity market is mostly

Figure 27. Trend of electricity prices in Iranian Rial



Source: International Energy Agency (IEA), "Data and Statistics", n.d.a. Available at https://www.iea.org/data-and-statistics.
Note: Data is available for only 2010-2016 period.

Figure 28. Evolution of the electricity market in Iran (Islamic Republic of)



Source: Iran Electricity Market (IREMA), "IREMA History", n.d.b. Available at https://www.irema.ir/about-us/history

under state control. While the Government has dominance in the market, it also fosters private sector participation in the renewable energy development. The evolution of the electricity market is illustrated in figure 28.

3.4 Plans and measures for electricity sector development

3.4.1 National goals and plans

Iran (Islamic Republic of) sets priorities and objectives for the electricity sector in its 5-year National Development Plans, as part of a 30-year plan by 2050 since 2010 (Dehhaghi, 2022). The plans typically call for the optimization of production and efficiency of power plants, waste reduction and development of combined heat and power.

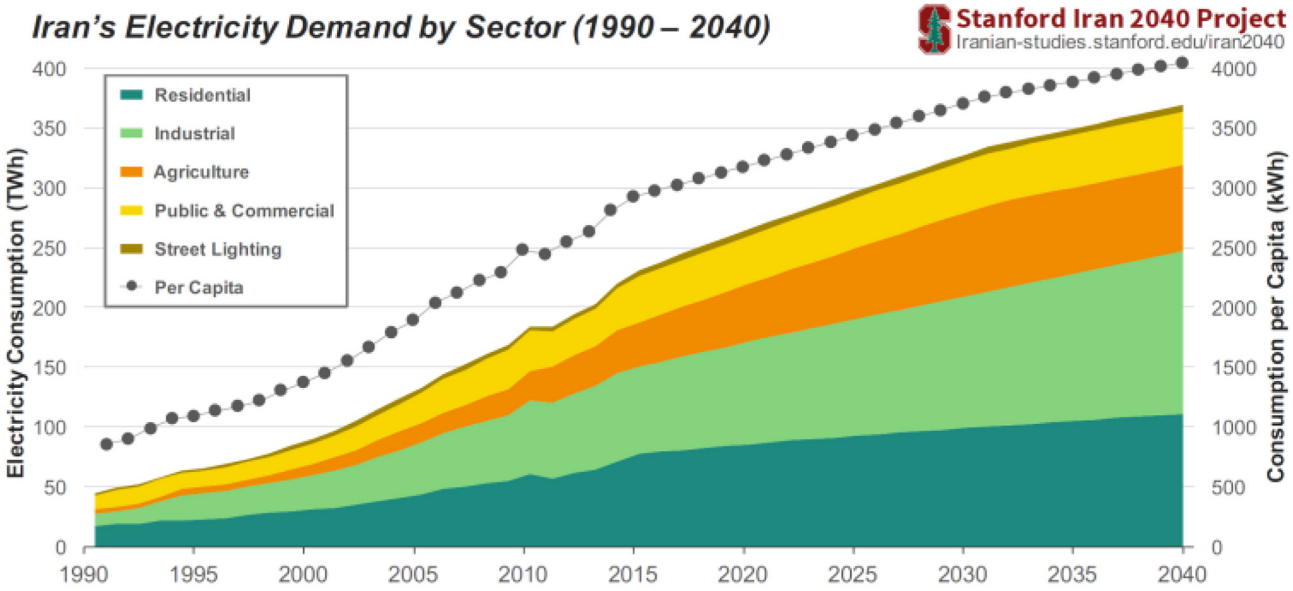
3.4.2 Current measures for the development of lower-carbon energy

The five-year development plans adopted since 2010 have specific topics designated for renewable energy development (Dehhaghi, 2022):

- Construction of power plants and the development of renewables
- Vision and policymaking
- Adoption of laws and regulations
- Institutional capacity-building on renewables
- Use of renewables in agriculture, resource efficiency
- Knowledge and applied research
- Energy efficiency
- Market and developing energy markets
- Education, extension and development of human resources
- Localization of renewable technology and equipment
- International collaboration

The Government's dedicated promotion of using non-hydro renewable energy sources is driven by population growth, heavily subsidized fossil fuel generation and peaking summer loads. It has set the target of 20 GW of renewable electricity by 2027 and 50 GW by 2031 (Bne IntelliNews, 2023). The Renewable Energy and Energy Efficiency Organization (SATBA) of Iran (Islamic Republic of) is quite active in renewable energy projects with the state support. The anticipated green energy production will contribute to harnessing the growing demands of the population and industry. It is estimated that various consumer categories will have the following demand projections for 2040:

Figure 29. Electricity demand projection for up to 2040 in Iran (Islamic Republic of)



Source: Pooya Azadi and others, "The outlook for natural gas, electricity, and renewable energy in Iran", Working Paper 3, Stanford Iran 2040 Project, Stanford University, April 2017.

- Residential sector: 120 TWh
- Industry: 130 TWh
- Agriculture: 70 TWh
- Street lighting and services: 90 TWh

3.4.3 Key challenges and issues in lower-carbon energy development

Iran (Islamic Republic of) is striving to expand low-carbon electricity generation and trading, but the international economic sanctions impede the development of a flexible low-carbon electricity market by SATBA and private sector, causing the following challenges:

- Lack of foreign investments in renewable energy generation and overall electricity trading;
- Limited development of domestic green energy technologies due to limited international cooperation;
- Lack of flexible access to finance for companies and population for renewable energy development.

3.4.4 Plans for cross-border power trade development

There is limited information available on the plans, initiatives and projects related to the expansion of multilateral power trade of Iran (Islamic Republic of Iran) with its neighbouring countries. The notable initiative is the synchronization of the power grids in Azerbaijan, Iran (Islamic Republic of) and the Russian Federation as mentioned in the chapter on Azerbaijan. Furthermore, the Governments of Armenia and Iran (Islamic Republic of) signed an agreement in 2023 on the extension of the "gas for electricity" program until 2030 (Mehdi, 2023; Harutyunyan, 2023).

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4 The Republic of Kazakhstan

4.1 Summary

The electricity grid in Kazakhstan is split into three geographically distinct areas: the north, the south and the west. This feature has a huge impact on the security of power supply in the country. The electricity system is highly dependent on coal, which makes diversifying the generation mix challenging. Moreover, the electricity system lacks flexible generating capacity, and this shortage will only increase as more intermittent renewables are added.

The RES-supporting laws and resolutions appear to be successful in stimulating the construction of new plants and have helped the country meet its 2020 target of producing 3 per cent of power from RES.

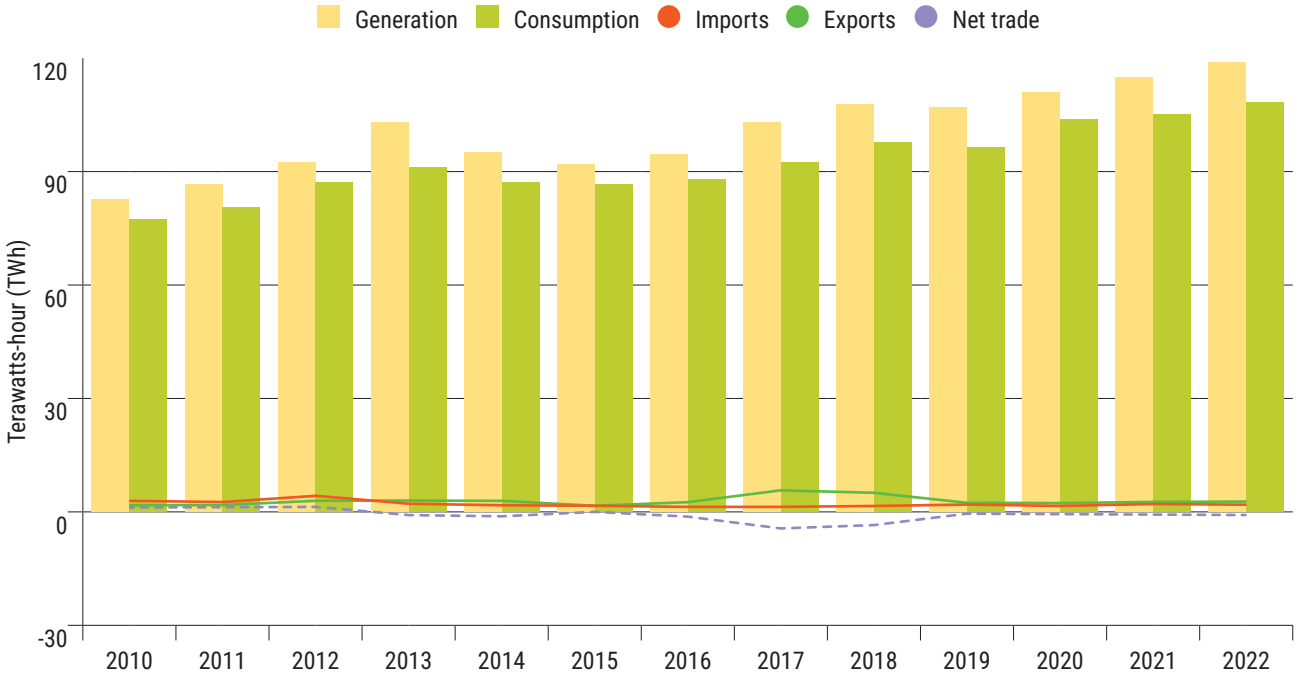
Kazakhstan was the first post-Soviet country to launch a free competitive power market in 2004. However, the wholesale power market liberalization that had been envisaged in the Law has not been fully completed and the market has operated based on bilateral agreements between wholesale consumers and generating companies trading power at free prices (later at capped power tariffs) (Kazenergy, 2023). From 1 July 2023, Kazakhstan began its transition to a new market structure (Single Electricity Buyer model) that should solve complex power industry issues.

4.2 Current situation in the electricity sector

4.2.1 Supply and demand balance

Kazakhstan is self-sufficient in its electricity supply since generation steadily exceeds consumption. According to US Energy Information Administration (EIA) (n.d.), the average electricity surplus in 2010-2022

Figure 30. Electricity supply, demand and trade in Kazakhstan, 2010-2022 (TWh)



Source: United States International Energy Agency (IEA), "Kazakhstan: Data", n.d. Available at https://www.eia.gov/international/data/country/KAZ

was 8.3 TWh. Nevertheless, the high losses in the country's system (9.8 TWh in 2022) negate almost all surplus.

4.2.2 Capacity and generation

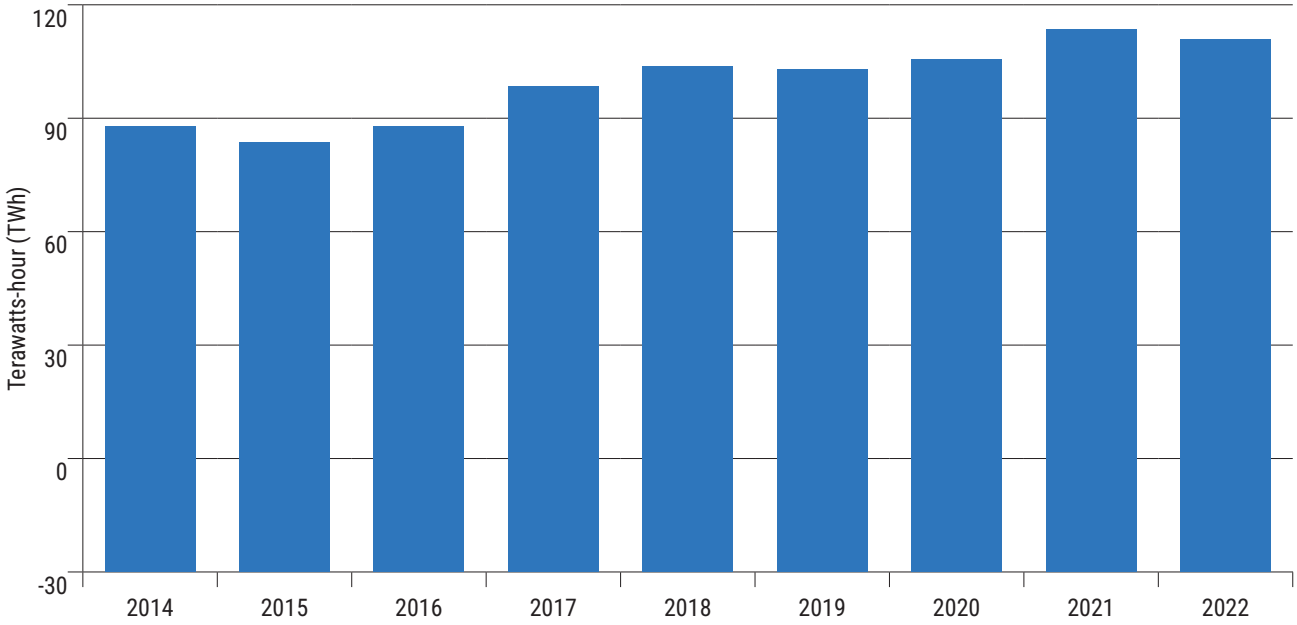
Since early 2023, Kazakhstan has 207 power plants with a total installed capacity of 24.6 GW and an available capacity of 20.4 GW (KEGOC, 2022). Between 2014 and 2022, installed capacity increased by 3.6 GW, or about 17 per cent (Kazenergy, 2023). As noted above, the power sector is dominated by coal (68.2 per cent of generation in 2022), which holds about 55 per cent of total installed capacity. Gas-fired capacity is second with a share of 16 per cent of installed

Table 24. Installed capacity of power plants by type, 2023

Power plants	Installed capacity, MW
Thermal power plants, total	19 461.2
steam turbines	**17 401.5**
pulverized coal	13 375.0
gas and fuel oil	4 026.5
gas turbines	**2 059.7**
Wind farms	**1 107.8**
PV power plants	**1 146.2**
Hydropower	**2 807.5**
including small ones	272.7
Biomass power plants	**1.1**
Total installed capacity	24 523.7

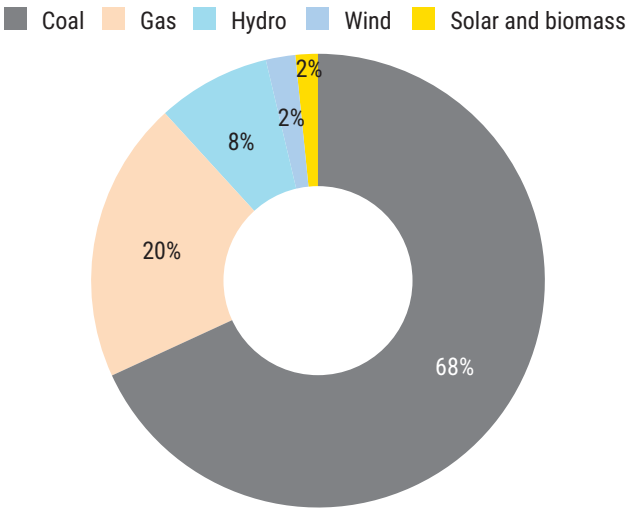
Source: Kazakhstan Electricity Grid Operating Company (KEGOC), "Future Energy: Annual Report 2022", 2022. Available at https://www.kegoc.kz/upload/iblock/a81/heek438rwj9jsig5fmodnhypsqphmsn4.pdf

Figure 31. Electricity generation in Kazakhstan, 2014-2022



Source: Kazakhstan Electricity Grid Operating Company (KEGOC), "Future Energy: Annual Report 2022", 2022. Available at https://www.kegoc.kz/upload/iblock/a81/heek438rwj9jsig5fmodnhypsqphmsn4.pdf

Figure 32. Electricity generation by source in Kazakhstan, 2022

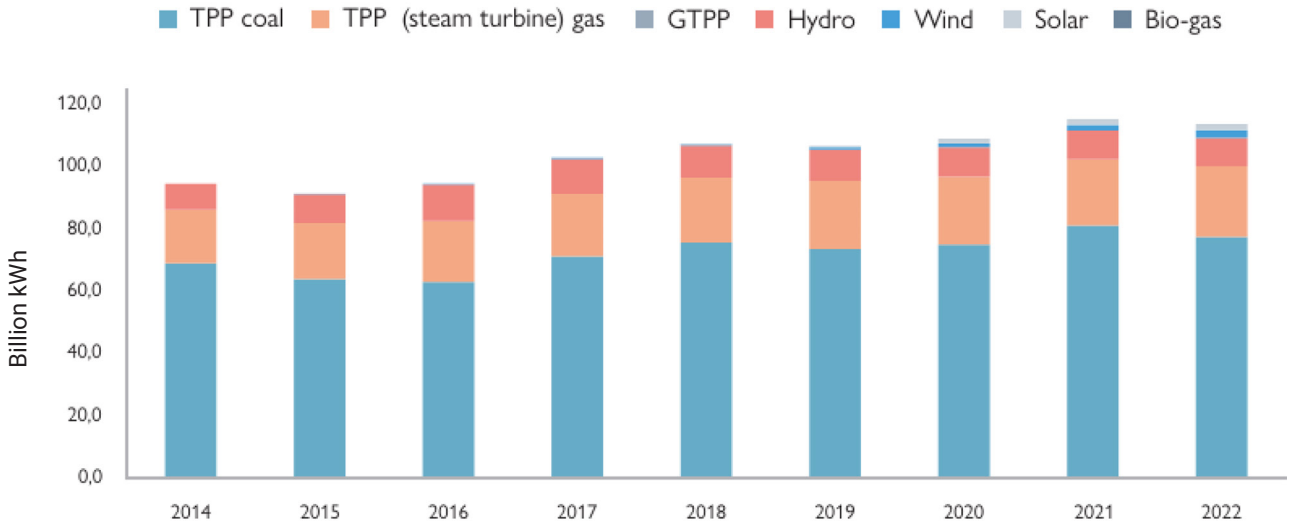


Source: Kazakhstan Electricity Grid Operating Company (KEGOC), "Future Energy: Annual Report 2022", 2022. Available at https://www.kegoc.kz/upload/iblock/a81/heek438rwj9jsig5fmodnhypsqphmsn4.pdf

capacity, most of which is based on steam turbines that are also able to run on fuel oil. RES, including hydropower, wind, solar and biomass, account for nearly 21 per cent of installed capacity, or 9 per cent if hydropower is not included.

Most of the coal-fired generation capacity is concentrated in the northern zone of the United Energy System in Kazakhstan, which is home to most of the country's coal mines and heavy industry. It also contains most of the country's hydropower. The more densely populated southern zone has a more balanced capacity mix and is leading the country in small hydro. However, the zone is also a power deficit region that imports significant amounts of power from the northern zone. The western

Figure 33. Electricity generation by source in Kazakhstan, 2014-2022



Source: Kazakhstan Electricity Grid Operating Company (KEGOC), "Future Energy: Annual Report 2022", 2022. Available at https://www.kegoc.kz/upload/iblock/a81/heek438rwj9jsig5fmodnhypsqphmsn4.pdf

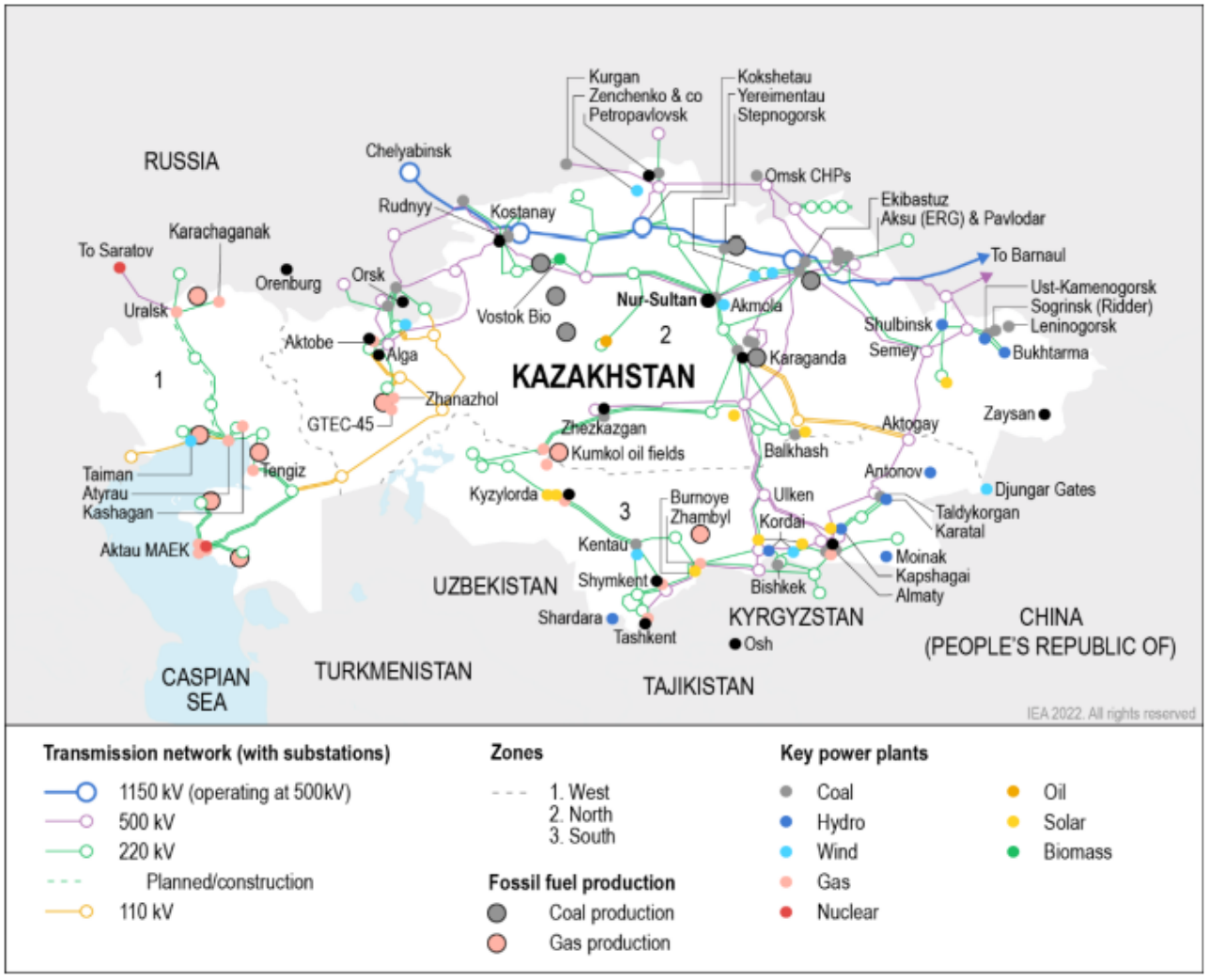
zone, which is the main oil- and gas-producing region, operates independently and has by far the largest share of gas-fired capacity.

Kazakhstan generated 113 TWh in 2022 (KEGOC, 2022), which indicated a 1.3 per cent decrease from 2021. After coal, one-fifth of electricity is generated by gas-fired power plants and most of the electricity generated from renewable sources comes from HPPs (8.1 per cent), and wind and solar (2 per cent each). Since 2014, total electricity production has increased by 20 per cent (18.9 TWh), while the share of coal-fired generation has decreased by almost 5 percentage points due to the development of RES and gas-fired generation.

4.2.3 Imports and exports

The northern zone is connected to and synchronized with the integrated electricity systems (IES) in the Siberian and Ural region of the Russian Federation via nine 500 kV lines, ten 220 kV lines, and numerous 110 kV lines. The southern zone, which is connected to the northern zone, is interconnected to and synchronized with the energy systems in Kyrgyzstan and Uzbekistan as part of

Figure 34. Main power infrastructure in Kazakhstan



Source: International Energy Agency (IEA), "Kazakhstan 2022 Energy Sector Review" (Paris: OECD Publishing, 2022). Available at https://www.oecd-ilibrary.org/energy/kazakhstan-2022-energy-sector-review_73d1d69f-en

Disclaimer: The boundaries and names shown and the designations used in this map do not imply official endorsement or acceptance by the United Nations.

Table 25. Cross-border electricity trade of Kazakhstan (GWh), 2021-2022

Country	2020	2021	2022
Imports	GWh	GWh	GWh
The Russian Federation	1 240.6	1 788.3	1 929.9
Kyrgyzstan	303	305.2	304.4
Uzbekistan			
Tajikistan	12.2		
Exports			
The Russian Federation	1 117.5	1 326.6	1 459.0
Kyrgyzstan	353.6	686.8	696.6
Uzbekistan	810.5	637.7	
Tajikistan	12.2		

Source: Kazakhstan Electricity Grid Operating Company (KEGOC), "Future Energy: Annual Report 2022", 2022. Available at https://www.kegoc.kz/upload/iblock/a81/heek438rwj9jsig5fmodnhypsqphmsn4.pdf

the Central Asia Power System (CAPS). There are five interconnections with Uzbekistan: one 500 kV line, two 220 kV lines and two 110 kV lines. Kazakhstan also has ten interconnections with Kyrgyzstan: two 500 kV lines, four 220 kV lines and four 110 kV lines. The western zone, which is isolated from the country's other two zones, is connected to the Ural and Middle Volga region's IES via three 220 kV lines (IEA, 2022).

The majority of electricity trade in recent years has been related to power exchanges with the Russian Federation to maintain stable frequency and cover supply imbalances. According to the Kazakhstan Electricity Grid Operating Company (KEGOC), imports from the Russian Federation, in 2022, were 1,930 GWh (up from 1,788 GWh in 2021), while exports to the Russian Federation were 1,459 GWh (up from 1,326.6 GWh in 2021) (KEGOC, 2022).

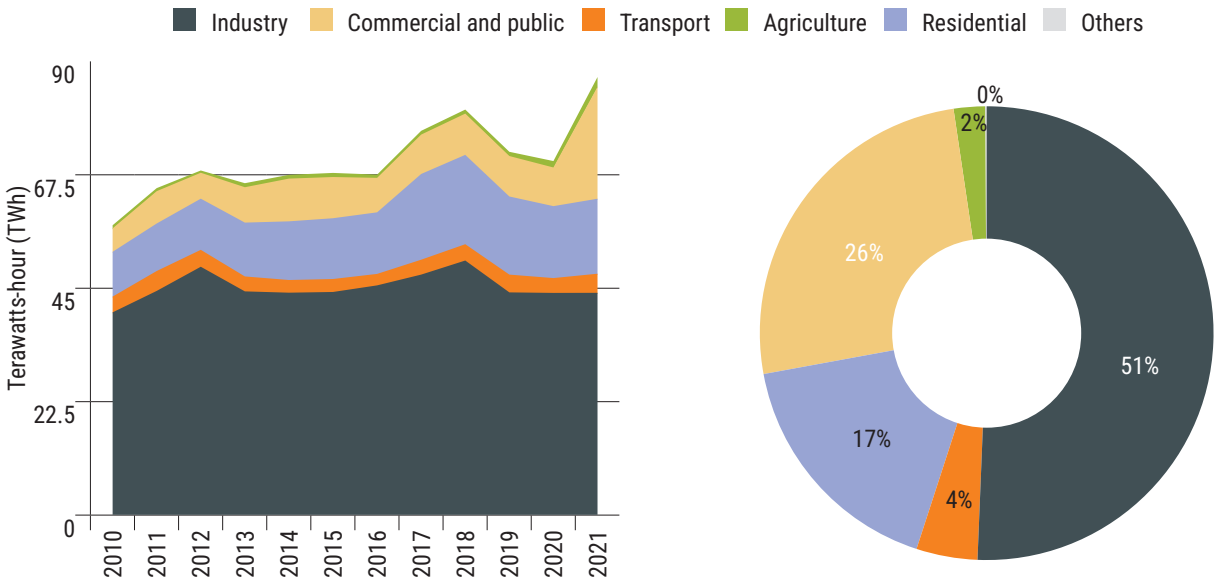
The total amount of energy exchanged with Central Asia was 3,922 GWh. At the same time, exports to Central Asia (Kyrgyzstan) in 2022 were 697 GWh. Imports from Central Asia during the same year were 304 GWh (down from 305 GWh in 2021), all of which came from Kyrgyzstan.

KEGOC plans to build a North-South HVDC line to improve the situation with the southern zone electricity supply and increase sustainability of the whole energy system (EnergyLand, 2024).

4.2.4 Demand

According to the KEGOC, electricity consumption in Kazakhstan in 2022 was 113 GWh, which is 0.8 per cent lower than in 2021. The power consumption largely depends on the pace of industrial growth and the situation in the global commodity markets, since the main exported products are oil and petroleum, natural gas, metal ores and alloys. Thus, the industrial sector is by far the largest power-consuming sector and represents more than half of the electricity demand in the country (58 per cent in 2022). The Aksu Ferroalloy Plant is one of the largest producers and suppliers of ferroalloys in the world and is the largest consumer of electricity in Kazakhstan accounting for about 4.6 per cent of the country's total electricity consumption (Kazenergy, 2023).

Figure 35. Electricity consumption by sector, in 2010-2021 (left) and in 2022 (right), in Kazakhstan



Source: United States International Energy Agency (IEA), "Kazakhstan: Data", n.d. Available at https://www.eia.gov/international/data/country/KAZ

4.3 Electricity market regulation

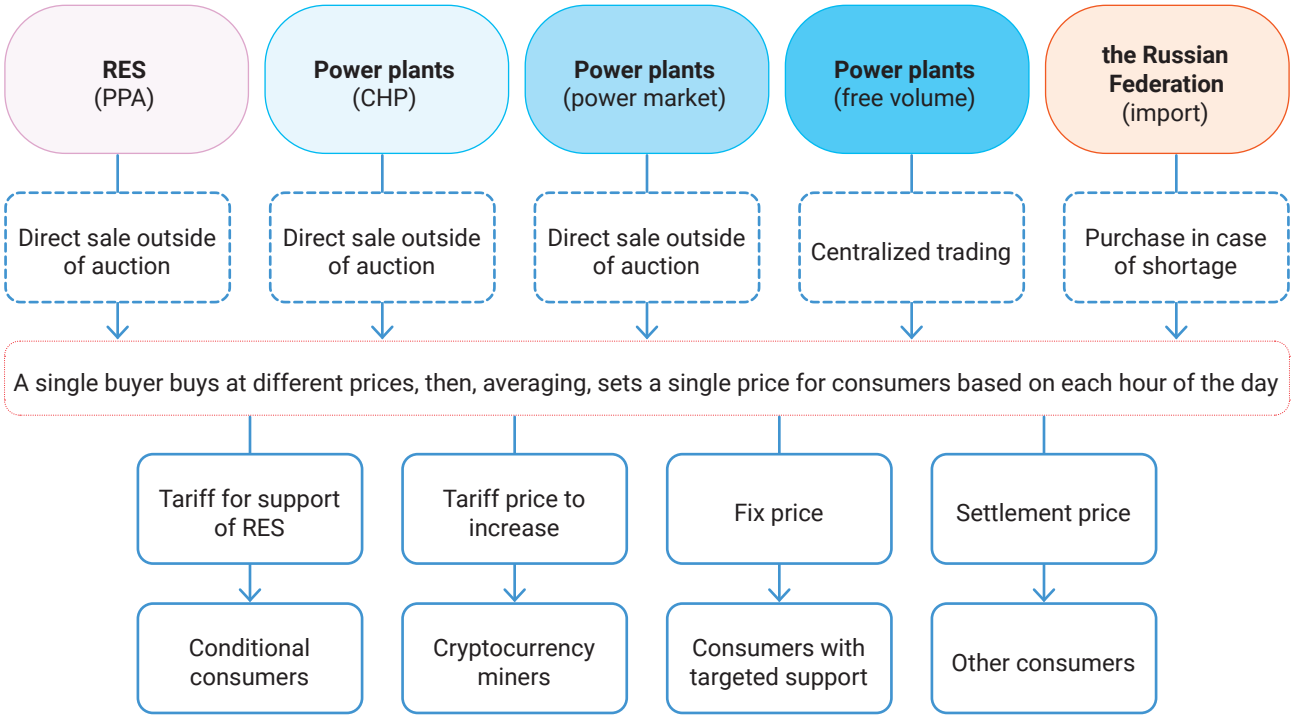
4.3.1 Power market structure

Kazakhstan was the first of the post-Soviet Union countries to launch a free competitive power market in 2004 with the adoption of the Law "On the Electric Power Industry". However, the wholesale power market liberalization as it had been envisaged in the Law has not been fully completed, and the market has operated based on bilateral agreements between wholesale consumers and generating companies trading power at free prices (later at capped power tariffs) (Kazenergy, 2023). The electricity market was formed by a limited number of producers (60 per cent of electricity is supplied by five energy companies) and a limited number of buyers, some of whom were affiliated with the power producers. Such a market structure prevents market mechanisms from being effective and sufficient for the competitive regulation of electricity prices and does not put sufficient competitive downward pressure on prices.

Since 2009, Kazakhstan has been unable to find the necessary balance between market liberalization, and the resources intended for modernization and expansion and required for the energy companies (generation and electric networks) (Kazenergy, 2023). From 1 July 2023, Kazakhstan started its transition to a new market structure (Single Electricity Buyer model) that should solve complex power industry issues, such as aged generation and network infrastructure, and lack of competition. The Financial Settlement Centre for the support of renewable sources of energy (RFC for RES) has been appointed a Single Electricity Buyer.

The Single Electricity Buyer purchases planned RES output in full (agreements with RFC for RES), planned capacity from the power plants (long-term capacity contracts with the Single Electricity Buyer), and planned electricity output from the energy producing companies that comprise of CHPs. It also, if necessary, purchases the remainder of the electric power from energy producing companies based on the results of a centralized trade on a competitive basis and imports electricity and capacity.

Figure 36. Single buyer electricity trading model in Kazakhstan



Source: Kazenergy, "The National Energy Report", Astana, 2023. Available at https://www.kazenergy.com/upload/document/energy-report/NationalReport23_en.pdf

The Single Electricity Buyer sells electricity at fixed prices to the supported consumers, at renewable tariffs to the industrial groups ("conditional" consumers), following the rules of upward price bidding to the digital mining companies, and at a settlement daily price to all other market consumers.

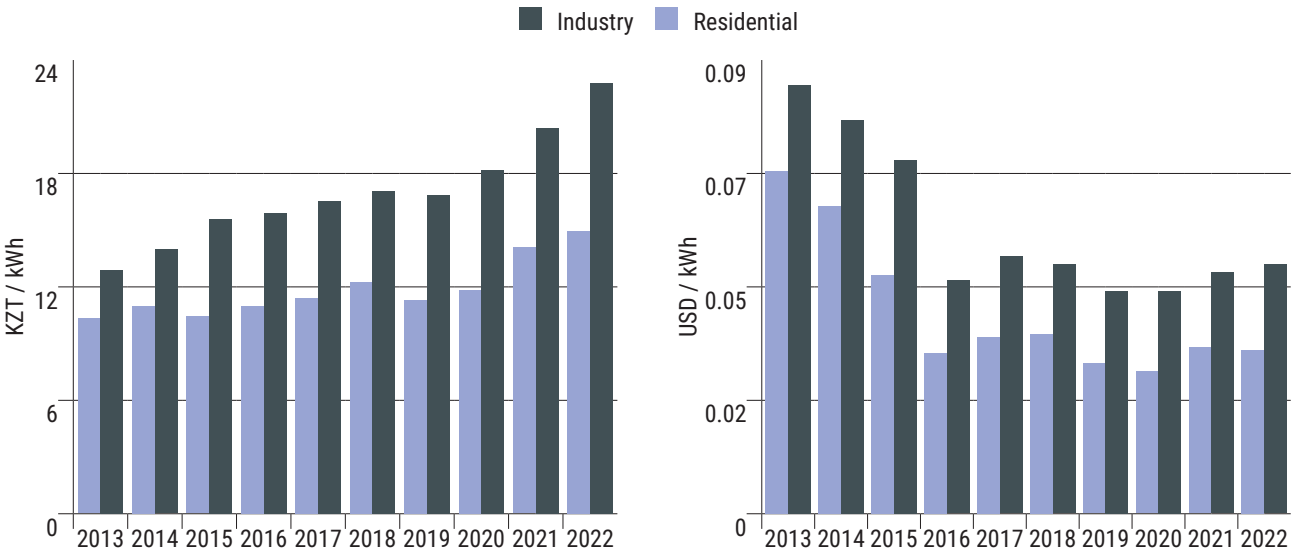
4.3.2 Tariffs

Prices for electricity in Kazakhstan are kept low through regulatory and administrative means for social welfare reasons. The Committee for the Regulation of Natural Monopolies and Protection of Competition (CREM) of the Ministry of National Economy approves the retail tariffs of the local distribution companies, as well as tariffs for heat production and transportation.

4.3.3 Market reforms

Mechanisms of the Single Electricity Buyer model may turn out to be more effective when compared with the earlier model in the context of anticipated growth of generating capacity, need for a competitive selection of electricity suppliers, the requirement to guarantee returns on investment for the new power projects, as well as the possibility of using internal reserves for balancing. However, there are some risks and issues. The immaturity of the regulatory framework before the launch of the Single Electricity Buyer model creates difficulties for the wholesale of electricity and for capacity market participants. But the most significant risks of a Single Buyer model are associated with potentially poor payment discipline and possible cash gaps (Kazenergy, 2023).

Figure 37. Electricity tariffs in Kazakhstan, 2013-2022



Source: United States International Energy Agency (IEA), "Kazakhstan: Data", n.d. Available at https://www.eia.gov/international/data/country/KAZ

Proposals for market reform include (Kazenergy, 2023):

- Gradual automation and digitalization of the Single Electricity Buyer operations with the introduction of the principles of multi-criteria optimization during unit commitment;
- Single out and distribute areas of responsibility between the infrastructure organizations, such as Settlement and Financial Center for Support of Renewable Energy Sources LLP (RFC for RES LLP), the Kazakhstan operator of electricity and power market operator (KOREM JSC), and KEGOC JSC at a legislative level;
- Create the Single Electricity Buyer Reserve Stabilization Fund as soon as possible to solve the issues with late payments and cash gaps.

4.4 Plans and measures for electricity sector development

4.4.1 National goals and plans

In December 2020, President Tokayev announced the intention of Kazakhstan to reach carbon neutrality by 2060 (Satubaldina, 2020), and in February 2023 he approved 2060 Long-term Low-Carbon Development Strategy (Kazakhstan, Ministry of Justice, 2023). It envisages several power industry transformations:

- Replacing coal gradually with alternative and renewable sources;
- Moving away from fossil fuels in final consumption by maximizing economy electrification level;
- Integrating carbon capture and storage technology with coal-fired plants after 2035.

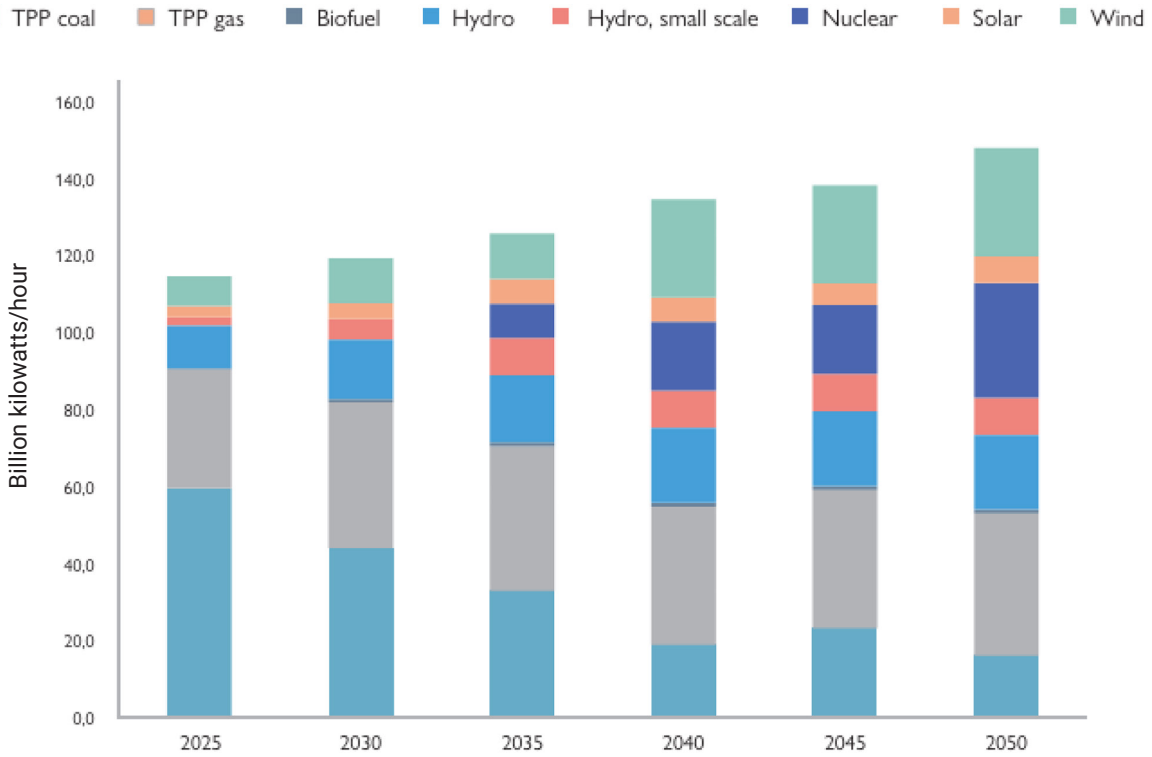
In 2022, the Ministry of Energy approved the Energy Balance until 2035, which forecasts supply and demand and is expected to guide government policies and plans, particularly in the power sector. It particularly anticipated an increase in electricity consumption by up to 153 TWh, while generation would decrease down to 89 TWh. The capacity needed to cover the imbalance, according to the document, includes setting up (Kazakhstan, Ministry of Energy, 2022):

- more than 5 GW gas-fired plants;
- more than 2 GW HPPs;
- 1.5 GW coal-fired plants;
- more than 6 GW RES;
- more than 2 GW nuclear power plants.

In 2021, KAZENERGY presented a long-term forecast for the development of the electric power industry in Kazakhstan until 2050 (Kazenergy, 2021). The forecast assumed a balanced development of generation through both renewable sources, and gas and nuclear generation. In 2023, the forecast has been adjusted to account for the time it would take to build nuclear power plants and the plans for commissioning coal-fired capacity (Kazenergy, 2023). This forecast is aligned with the low-carbon development goals outlined in The Strategy on Achieving Carbon Neutrality by 2060. The recommended balanced approach for the development of power generation in Kazakhstan, according to the forecast, is:

- replacement of coal power plants with modern coal power units for ultra-supercriticalsteamconditions;
- gradual conversion of coal-red boiler houses and CHPs to natural gas;
- construction of several nuclear power plants with a total capacity of at least 4 GW;

Figure 38. Electricity generation by power plants in Kazakhstan in 2025–2050



Source: Kazenergy, "The National Energy Report", Astana, 2023. Available at https://www.kazenergy.com/upload/document/energy-report/NationalReport23_en.pdf

- development of renewable energy and hydropower, including counter-regulatory hydropower plants.

Although Kazakhstan does not have any nuclear power plant (NPP), the Government has been publicly discussing the idea of building the first one with technological assistance from the Russian Federation and has begun to evaluate other reactor technologies from countries such as China, France, Japan, the Republic of Korea and the United States of America.

In 2023, an important political event took place: President Tokayev proposed putting the issue of constructing the NPP to a referendum. If the referendum results are positive, nuclear power could become an important element of the transition to "green" economy (Kazenergy, 2023).

4.4.2 Current measures for the development of lower-carbon energy

In Kazakhstan, RES are being integrated into the energy system through various types of support. Since 2014, Kazakhstan has been constantly improving legislations to support RES. This level of government support created high level of stability for investors, which in turn made it possible to introduce renewable energy capacity. The following RES support mechanisms are currently in effect (Kazenergy, 2023):

- A single buyer of renewable energy (RFC RES) purchases the entire volume of RES output;
- The purchase of the entire volume of RES output at auction prices is warranted for 20 years under an agreement with RFC RES;
- RES tariffs are indexed annually and adjusted to the currency exchange rate in the event of devaluation of the national currency;
- Since 2022, for the auction winners, tariffs are indexed during the construction of RES as soon as the agreement with RFC RES is signed;
- RES producers are exempt from paying for transmission services;
- There is priority for RES connection to the electricity networks;
- RES get land reservations during auctions, subject to grid infrastructure;
- RES developers are eligible for tax preferences.

The power sector is covered by the country's emission trading scheme (ETS), which was initially launched in 2013. However, the trade was suspended in 2015 due to low liquidity and relaunched in 2018. However, despite several amendments and fine-tuning, the number of transactions has been extremely low. Key reasons for this include the large number of free quotas and relatively high benchmarking coefficients, particularly for coal-fired power plants (IEA, 2022).

4.4.3 Key challenges and issues in lower-carbon energy development

Kazakhstan met its 2020 target of producing 3 per cent of power from RES by 2020. But a major challenge for further RES development is the lack of sufficient flexible generating capacity to integrate them. Since the power system is dominated by coal-fired plants, these cannot be started up quickly whenever renewable generation is insufficient to meet demand (OSCE, 2022). KEGOC estimates that the system currently lacks about 1,500 MW to 2,000 MW of flexible capacity for balancing (Marteau, 2021). The shortage of flexible capacity is likely to become an increasing challenge as more intermittent renewables are added to the system.

Table 26. Current and prospective power trade cooperation between Kazakhstan and its neighbours

	Kyrgyzstan	Tajikistan	Uzbekistan	The Russian Federation
Cooperation	• Electricity imports • Electricity exports: up to 1.5 GWh per year	• Potential electricity importer (summer)	• Hydroelectricity imports (supply southern regions)	• Electricity imports (supply northern regions) • Transit country for electricity to Kyrgyzstan

Source: Organization for Security and Co-operation in Europe (OSCE), "Advancing Energy Security in Central Asia", 2022. Available at https://www.osce.org/files/f/documents/8/8/513787_0.pdf

The Government has tasked KOREM with developing a balancing market. This was originally due to be launched in 2008 (IEA, 2022), but it was in simulation mode until 1 July 2023 (Kazenergy, 2023). A balancing market should help stimulate the efficient development of new flexible generating capacity and storage.

Another option for ensuring more flexibility in the power system is electricity storage. However, there is currently no incentive for RES projects in Kazakhstan to include storage, thus most if not all RES projects do not include storage.

4.4.4 Plans for cross-border power trade development

Given that Kazakhstan plans to develop generating capacity, including renewable generation, as well as accounting for the current lack of sufficient volume of flexible generation, the development of regional cooperation with adjacent energy systems is critical for the country's energy security (Kazenergy, 2023).

Kazakhstan is already participating in the creation of the following two markets:

- The common electricity market of the Eurasian Economic Union (EAEU);
- The regional electricity market of Central Asian countries (CAREM – Central Asia Regional Electricity Market).

The common electricity market of the EAEU is being formed as a regional market of its five member states (Armenia, Belarus, Kazakhstan, Kyrgyzstan and the Russian Federation). Considering that the EAEU member states have different designs of the wholesale electricity markets, the parties agreed to preserve the existing national electricity markets when forming the EAEU common electricity market. It is planned that the common EAEU electricity market will be launched in 2025 (Kazenergy, 2023).

In May 2024, the Ministries of Energy of Kazakhstan, Azerbaijan and Uzbekistan signed a memorandum that aims to determine the foundational terms of cooperation for the ambitious project of linking the energy systems of these countries. This initiative seeks to optimize the trade of green energy among the three countries, harnessing technical and economic efficiencies (The Astana Times, 2024).

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5 The Kyrgyz Republic

5.1 Summary

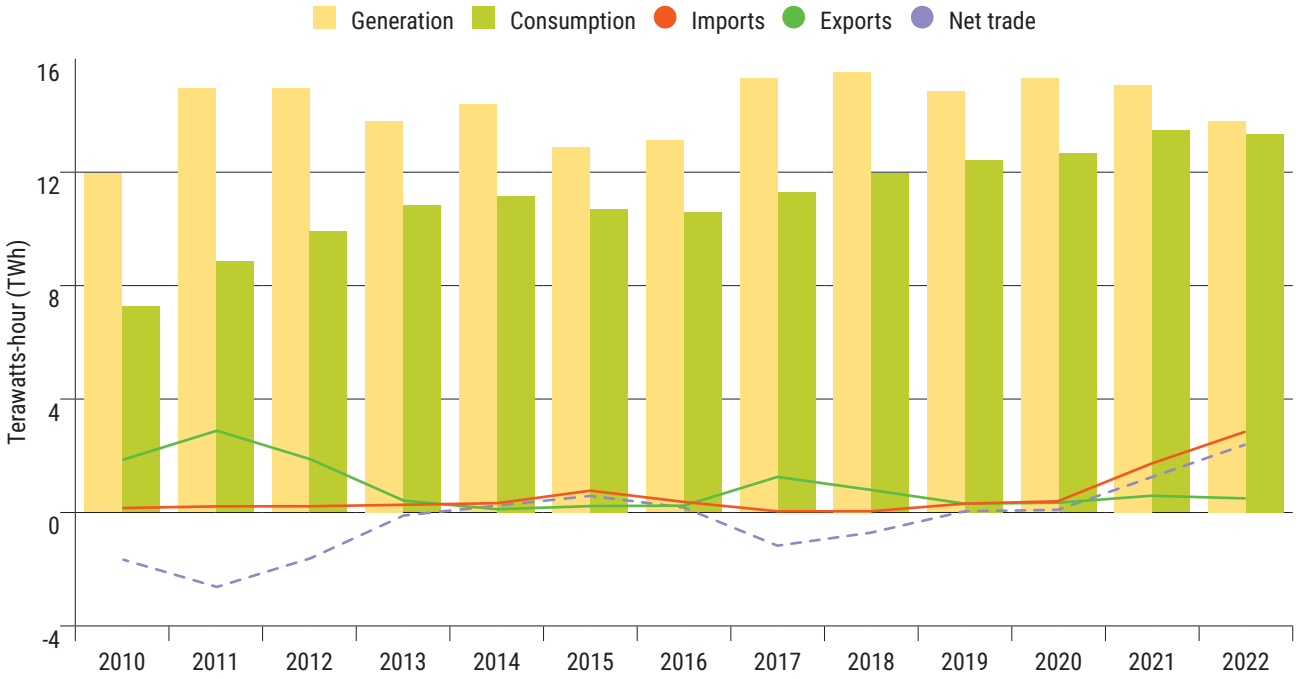
Kyrgyzstan has rich potential in hydropower generation but, currently, the country's power system is subject to supply security threats as well as other challenges. The network is aged and inefficient, and losses are significant (18 per cent in 2020). In addition, hydro-based electricity production is exposed to seasonal and weather-related fluctuations. Another challenge is the growing demand for electricity, mostly from the residential sector, fuelled by unsustainably low regulated electricity prices. Kyrgyzstan is struggling because of its rising power capacity deficit. Small capacity additions and current consumption reduction measures are still insufficient to cope with the power crisis. Deficit is covered by imports of electricity from neighbouring countries.

5.2 Current situation in the electricity sector

5.2.1 Supply and demand balance

Kyrgyzstan is a net importer of electricity. According to the US Energy Information Administration, electricity generation in 2020-2022 decreased by 10 per cent while electricity consumption grew by 6.4 per cent (EIA, n.d.). The average electricity consumption growth rate between 2016-2022 was 4 per cent. Moreover, high losses make this disbalance even worse.

Figure 39. Electricity supply, demand and trade in Kyrgyzstan, 2010-2022 (TWh)



Source: United States Energy Information Administration (EIA), "Kyrgyzstan: Data", n.d. Available at https://www.eia.gov/international/overview/country/KGZ

5.2.2 Capacity and generation

As of 2022, Kyrgyzstan had 31 power plants with a total installed capacity of about 4 GW. Between 2010 and 2021 installed capacity increased by 0.01 GW, or by about 4.3 per cent. The power sector in Kyrgyzstan is dominated by hydropower (7 HPPs). Overall, about 78 per cent of total installed capacity is hydropower, including 1.5 per cent of small hydropower plants (up to 30 MW installed). About 80 per cent of the hydro capacity is concentrated in the south part of the Kyrgyz energy system. Most of the HPPs are over 30 years old, with a weighted average age of over 40 years and nearly 80 per cent of its capital has depreciated (IEA, 2022b).

Small hydropower has always been an important part of the Kyrgyz power system: in 1960, more than a hundred small hydroelectric power plants (SHPPs) operated in the country with an annual electricity production of about 285.3 million kWh, which accounted for 32.7 per cent of the total electricity production. However, with the construction of large HPPs, the country disposed most of the SHPPs. As of 2022, currently only 22 SHPPs with a total capacity of almost 60 MW are operating (OSCE, 2022).

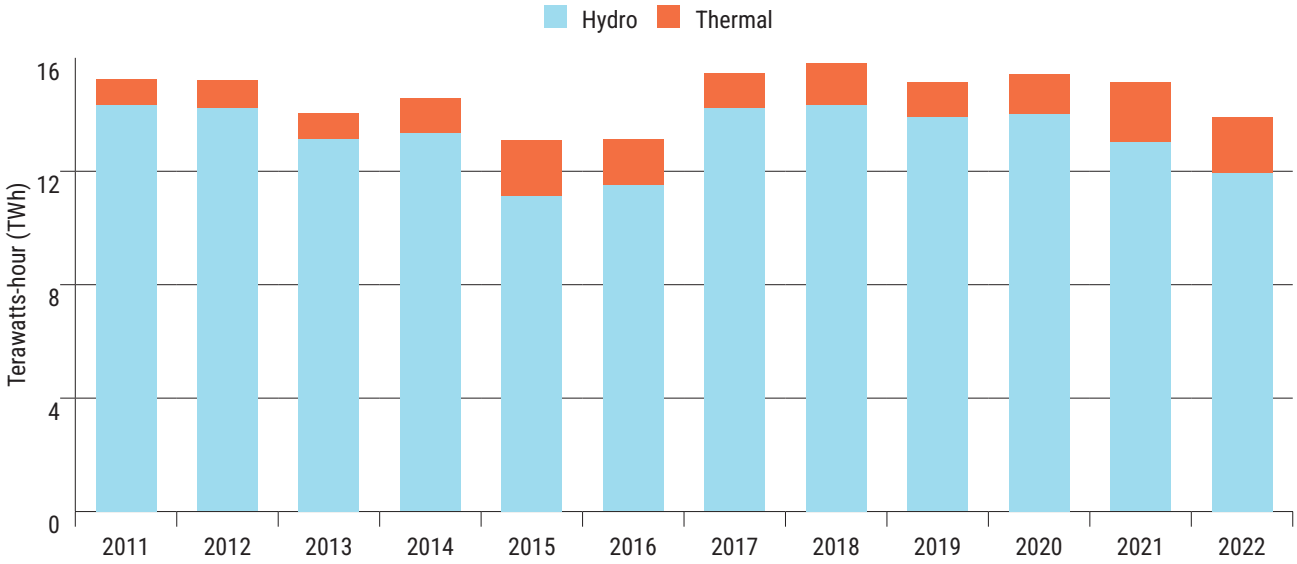
Thermal power capacity (2 combined heat and power plants (CHPPs)) accounts for the remaining 12 per cent. Kyrgyzstan depends on CHPPs to meet the additional load during the

Table 27. Installed capacity (MW), 2005, 2010, 2017-2022

Energy source	2005	2010	2017	2018	2019	2020	2021	2022
Hydro	2 910	3 030	3 030	3 030	3 030	3 030	3 030	3 030
Thermal	716	716	862	862	862	862	862	862
Small hydro	40	42	49	56	56	56	60	60
Total capacity	**3 666**	**3 788**	**3 941**	**3 948**	**3 948**	**3 948**	**3 952**	**3 952**

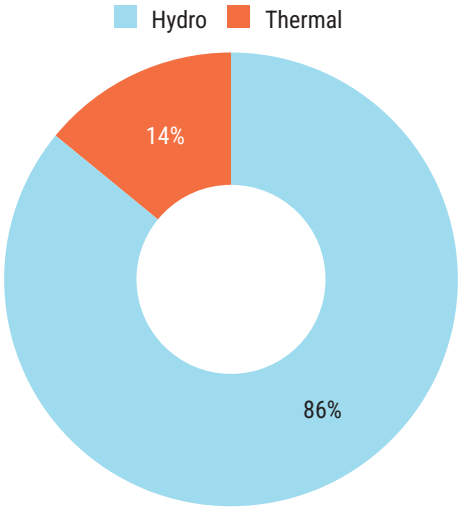
Source: Data shared by the National Statistical Committee of the Kyrgyz Republic, Center for Renewable Energy and Energy Efficiency Development (CREEED).

Figure 40. Electricity generation in Kyrgyzstan, 2011-2022



Source: National Statistical Committee of the Kyrgyz Republic, "Industry", 2015. Available at https://www.stat.gov.kg/ru/statistics/promyshlennost/

Figure 41. Electricity generation by source in Kyrgyzstan, 2022



Source: National Statistical Committee of the Kyrgyz Republic, "Industry", 2015. Available at https://www.stat.gov.kg/ru/statistics/promyshlennost/

winter months when reservoir water levels are low and power demand is high. The Bishkek CHPP is the largest in the country and plays an important role in providing reliable electricity to the capital in winter. It relies primarily on imported coal (OSCE, 2022).

According to National Statistics Committee, Kyrgyzstan generated 13.9 TWh in 2022, which was an 8.3 per cent decrease from 2021 because of low water year. Electricity production in Kyrgyzstan is dominated by hydropower plants (HPPs). This dependence is reflected in domestic power production levels, with hydropower typically representing around 90 per cent of the country's annual power output during normal hydrological periods (OSCE, 2022).

Kyrgyzstan is suffering from aging and inefficient electricity infrastructure with high transmission and distribution losses (14.8 per cent in 2022, according to National Statistics Committee data). The most recent failure was in February 2024, when a large explosion and fire destroyed roof of Bishkek's CHPP and plunged parts of the Kyrgyz capital into darkness, while leaving most of the city without heat and hot water for almost a day (Putz, 2024).

5.2.3 Imports and exports

Electricity exports in Kyrgyzstan declined substantially over the 2010s, falling from an average of around 22 per cent, between 2011 and 2012, to an average of less than 4 per cent of the total final electricity consumption between 2014 and 2021.

5.2.4 Demand

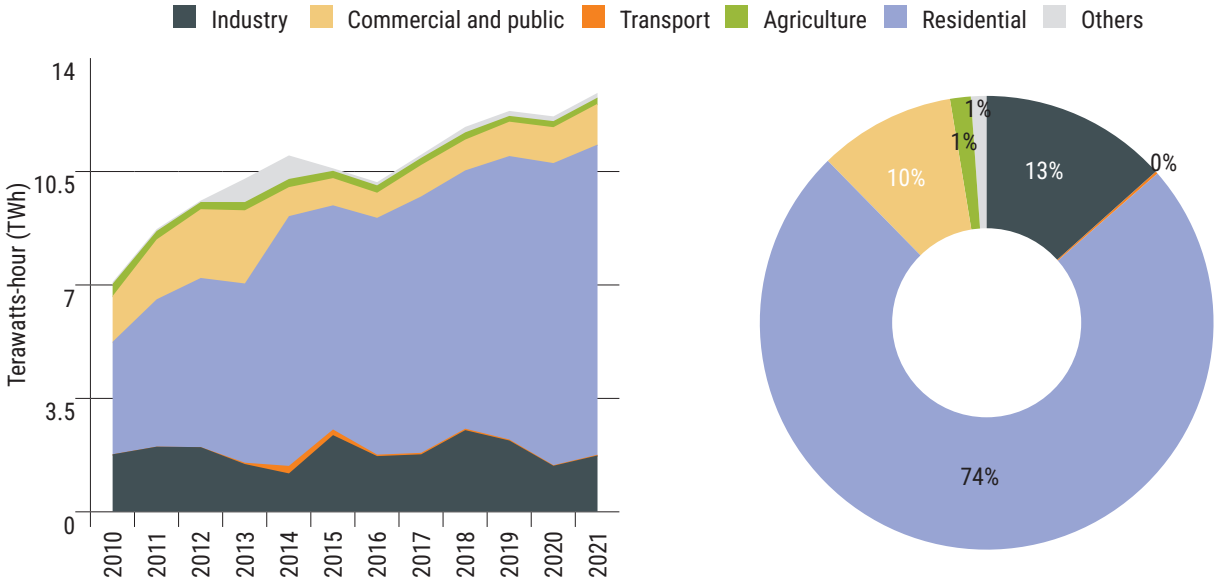
Electricity consumption in Kyrgyzstan in 2022 was 12.9 GWh, marking a 5 per cent increase from 2021. Residential customers account for the largest share of consumption (74 per cent) and almost three times more than in 2010. Growth in residential consumption was driven largely by the increased use of electricity for heating. This was triggered by a combination of low electricity tariffs and rising fossil fuel prices (IEA, 2022a). The industrial sector is the next-largest electricity consumer, accounting for around 13 per cent of total final electricity consumption. Consumption patterns vary significantly by season. The minimum summer load is less than three times of the winter maximum load (IEA, 2022a).

Table 28. Electricity trade by country (GWh), 2015-2021

	2015	2016	2017	2018	2019	2020	2021
Exports	182.3	197.8	1 143.2	1021.5	0.0	300.0	546.2
Kazakhstan	182.3	197.8	0.3	269.3	-	300.0	300.0
Uzbekistan	-	-	1 142.9	752.2	-	-	246.2
Imports	547.3	133.2	0.0	0.0	269.3	52.6	1 683.6
Kazakhstan	400.7	1 33.2	-	-	269.3	52.6	681.0
Tajikistan	146.6	-	-	-	-	-	-
Uzbekistan	-	-	-	-	-	-	504.4
Turkmenistan	-	-	-	-	-	-	498.2
Net trade	**365.0**	**-64.6**	**- 1143.2**	**-1 021.5**	**269.3**	**-247.4**	**134.8**

Source: Kyrgyz Electricity Settlement Center. Available at: https://esep.energo.kg/?cat=142

Figure 42. Electricity consumption by sector, 2011-2022 (left) and 2022 (right), in Kyrgyzstan



Source: International Energy Agency (IEA), "Energy Statistics Data Browser", 2023. Available at https://www.iea.org/data-and-statistics/data-tools/energy-statistics-data-browser?country=WORLD&fuel=Energy%20supply&indicator=TESbySource

5.3 Electricity market regulation

5.3.1 Power market structure

The electricity and heat production sector used to be owned and operated by the state-owned KyrgyzEnergo. In 2002, KyrgyzEnergo was restructured and unbundled into seven state-owned companies operating in generation, transmission and distribution, and JSC BishkekTeploSet (district heating DSO) (IEA, 2022a).

In a recent sector restructuring, four distribution companies were merged into one company and further consolidated with the National Electric Grid of Kyrgyzstan (JSC NESK). Since the beginning of 2024, the institutional scheme includes the Ministry of Energy. In addition to developing policy, and as a result of the liquidation of the National Energy Holding Company OJSC, the mandate includes managing energy companies, including shares of Electric Stations OJSC, four distribution companies merged with

NESK OJSC, Kyrgyzkomur State Enterprise, Kyrgyzteploenergo State Enterprise, Energy Service Supervision, Research Institute of Energy and Economics. Furthermore, the Department for Regulation of the Fuel and Energy Complex works under the Ministry of Energy for the state regulation and management of the fuel and energy complex.

In 2018, OJSC "Kyrgyz Energy Settlement Center" was created as a monitoring body to centralize information on energy flows and losses, draw up balances and perform calculations for all market participants.

The Energy Supervision Service is a subordinate unit of the Ministry of Energy of Kyrgyzstan authorized to carry out state control and supervisory functions for compliance with legislation in the field of energy and is the legal successor of the State Inspectorate for Energy, Mining Supervision and Industrial Safety.

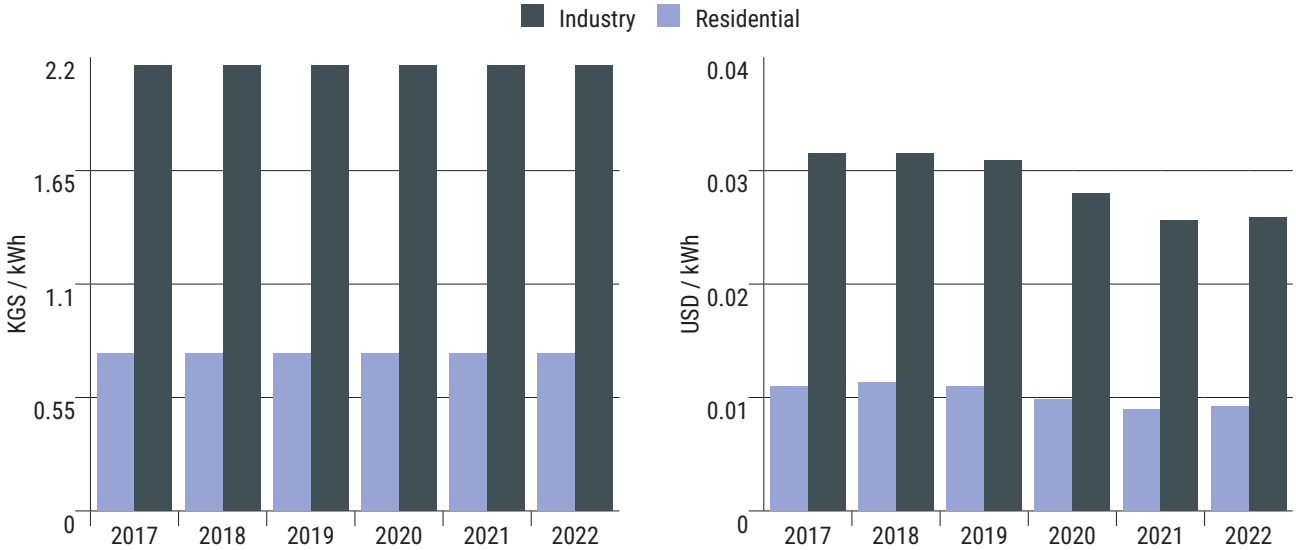
In November 2022, by resolution of the Cabinet of Ministers of the Kyrgyz Republic, the State Green Energy Fund was created under the Cabinet of Ministers in order to accumulate funds for financing the design, maintenance, subsidies, repairs, reconstruction, construction and development of green energy, as well as stimulating the development, implementation and production of energy-saving technologies of renewable energy sources. In accordance with the resolution No. 429 of the Cabinet of Ministers of Kyrgyzstan, "On the development of renewable energy sources", dated 28 August 2023, the Fund was given the status of an authorized institution in the field of renewable energy sources, and the regulations on the procedure for transferring lands managed by an authorized institution in the field of renewable energy sources were approved for the construction of renewable energy facilities.

The open joint-stock company "Directorate of Power Plants under Construction" was created in accordance with the order of the Cabinet of Ministers of Kyrgyzstan, dated 10 July 2023, for constructing and commissioning large hydroelectric power plants (IEA, 2022a).

5.3.2 Tariffs

The rapid growth in residential consumption was driven by regulated electricity prices which have been set below the cost of production (IEA, 2022b). Residential electricity tariffs, which represent the majority of consumption,

Figure 43. Electricity tariffs in Kyrgyzstan, 2017-2022



Source: International Energy Agency (IEA), "Energy prices", 2024. Available at https://www.iea.org/data-and-statistics/data-product/energy-prices

are cross-subsidized by higher tariffs for large industrial consumers and non-residential consumers. Residential tariffs remained unchanged between 2015-2022 due to social security reasons, despite several policy announcements to incorporate tariff increases over recent years (IEA, 2022b). However, in 2023, main residential tariffs were raised by almost 30 per cent, and by another 11 per cent in 2024 (National Statistical Committee of the Kyrgyz Republic, n.d.).

End-user electricity tariffs are set by the Department for the Regulation of the Fuel and Power Complex (DFPC) within the Ministry of Energy based on the Mid-Term Tariff Policy (MTTP) approved by the Government. Residential consumers pay a low socially-oriented tariff (1.1 KGS/kWh, or 0.01 USD/kWh) on all consumption up to 700 kWh (the social tariff threshold), and a higher tariff (2.39 KGS/kWh, or 0.27 USD/kWh) on all additional consumption (Kyrgyzstan, Ministry of Justice, 2021b).

5.3.3 Market reforms

Policies in relation to electricity pricing have the potential to substantially strengthen power system reliability and resilience in Kyrgyzstan. In 2021, President Zhaparov said that reforming electricity tariffs would allow Kyrgyzstan to overcome its energy crisis by 2026 while establishing a financially sustainable energy system (Sputnik, 2021). However, the critical challenge of lifting residential electricity tariffs towards cost-reflective levels remains unresolved (Kyrgyz Republic, 2021).

In February 2022, the Cabinet of Ministers approved the Concept of Restructuring Energy Sector Management System, which provides for several measures designed to address and mitigate the key challenges in the power sector, including deficit of generating capacities and lack of funding for energy companies. However, following changes to institutional arrangements could be viewed as a retrograde step from the perspective of establishing a more liberalized power sector characterized by greater efficiency, innovation, competition and transparency (IEA, 2022b).

5.4 Plans and measures for electricity sector development

5.4.1 National goals and plans

The "National Development Strategy of the Kyrgyz Republic" for 2018-2040 (NDS) and the accompanying medium-term "National Development Program" (NDP) until 2026 lay out the following goals for the energy sector:

- Increase the share of RES (SHPPs, solar systems, wind and biogas plants) to 10 per cent in the total energy balance of the country;
- Reduce the country's fossil fuel dependence through more large-scale development of hydropower and the transition to alternative energy;
- Exploit the hydropower potential of the Naryn River basin by building several promising large HPPs;
- Gradual increase in tariffs coupled with social protection measures.

However, Kyrgyzstan lacks a long-term policy for electricity sector development with clearly specified strategic goals based on solid economic and technical analysis (IEA, 2022a). Neither the target of increasing the share of renewables to be at least 10 per cent of the country's total energy balance, set by NDS, has economic and technical analysis regarding its achievability, nor is there a clear implementation plan supported by technical studies to identify any risks to the reliability of the national power system.

The Government is elaborating on Rosatom's proposal for the construction of a low-power nuclear power plant (LPNPP). The RITM-200N reactor is under consideration which includes

up to three reactors with total capacity of 330 MW (Tass, 2024).

5.4.2 Current measures for the development of lower-carbon energy

In 2021, Government of Kyrgyzstan approved regulations aimed at streamlining procedures for providing land plots for the construction of power plants using RES. In addition, the "Regulation on procedure for issuing documents for the design, construction and commissioning completed construction facilities" was approved by the decree of the Government on 6 August 2021. This regulation aims at facilitating the process of accepting renewable energy facilities for operation (IEA, 2022a).

In October 2021, the Cabinet of Ministers of Kyrgyzstan approved VAT exemptions for a number of goods and equipment for the construction of renewable energy facilities (Kyrgyzstan, Ministry of Justice, 2021a).

In June 2022, the Government of Kyrgyzstan adopted a new law on renewable energy (RE Law) (Kygryzstan, Ministry of Justice, 2022). Preparation and adoption of the new RE Law was driven by a number of issues, including the power deficit, lack of mechanisms for reimbursement of costs to energy companies for purchase of renewable energy at a higher price, amongst others (IEA, 2022a). One of the new developments of the RE Law guarantees purchase of the renewables output. The RE Law also establishes following incentives (Kyrgyzstan, Ministry of Justice, 2022):

- Preferential feed-in tariffs during the project payback period;
- Preferential feed-in tariffs subject to indexation on an annual basis;
- Guaranteed non-discriminatory access of renewable energy output to the grid and obligation on the national transmission and distribution companies to ensure unobstructed transit of renewable power to consumers

5.4.3 Key challenges and issues in lower-carbon energy development

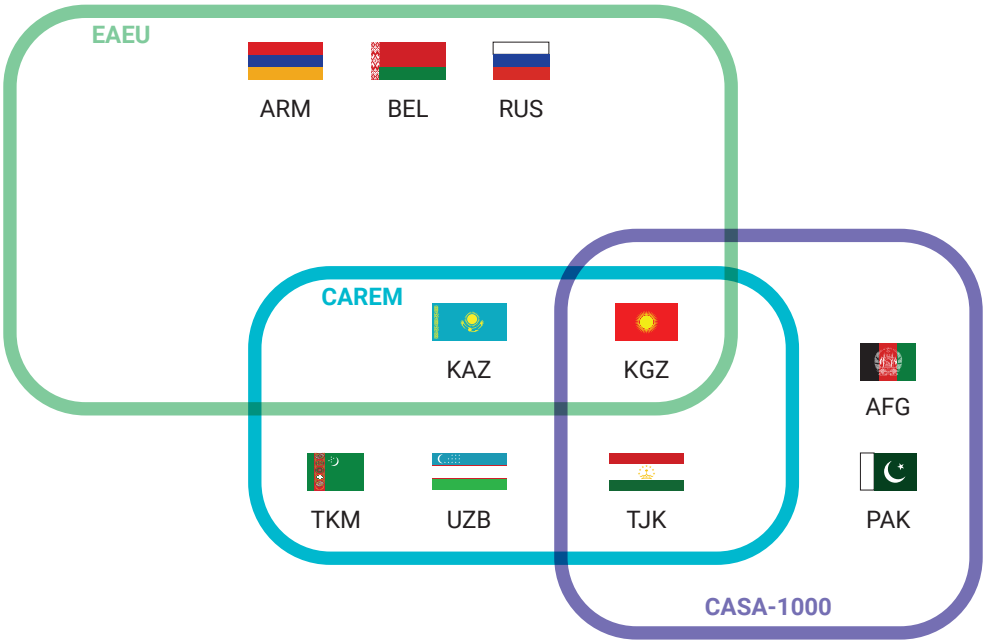
A number of RES (solar and wind) projects are being planned for implementation, but the RES regulatory framework has not yet been fully developed in Kyrgyzstan. Moreover, Kyrgyzstan lacks rules for integration of new variable capacity additions to the national power system (IEA, 2022a). Another serious issue is that electricity tariffs do not reach cost recovery level and planned tariff reform is restrained. Low tariffs make it challenging to attract private investments in the RES sector or the entire power sector.

5.4.4 Plans for cross-border power trade development

Kyrgyzstan is part of Central Asian Power System (CAPS) operating as a united power system that cones the country with Kazakhstan, Tajikistan and Uzbekistan. Power exchanges through the CAPS could be a timely and cost-effective mean to help alleviate the country's growing power system reliability, resilience and imbalance issues (IEA, 2022a). Moreover under the framework of CAPS, the hydropower system was designed not only to produce electricity, but to provide major ancillary services, frequency regulation and operating reserves for the regional power system. However, these functions are not fully operational due to a lack of agreement among the neighbouring power systems on pricing mechanisms (IEA, 2022a). Kyrgyzstan is also a member of the EAEU and participates in the development of the EAEU common electricity market which is planned to start operations by 2025.

New integration plans include the CASA-1000 project consisting of a 500 kV alternating current transmission line connecting Kyrgyzstan and Tajikistan, and a 500 kV

Figure 44. Kyrgyzstan in regional electricity market initiatives



Source: International Energy Agency (IEA), "Cross-Border Electricity Trading for Tajikistan: A Road map", Paris. Available at https://www.iea.org/reports/cross-border-electricity-trading-for-tajikistan-a-road map
Note: EAUE = Eurasian Economic Union; CAREM = Central Asia Regional Electricity Market. AFG = Afghanistan; ARM = Armenia; AZE = Azerbaijan; BEL = Belarus; KAZ = Kazakhstan; KGZ = Kyrgyzstan; PAK = Pakistan; RUS = The Russian Federation; TKM = Turkmenistan; TJK = Tajikistan; UZB = Uzbekistan

Table 29. Current and perspective power trade cooperation between Kazakhstan and its neighbours

	Kazakhstan	Tajikistan	Uzbekistan	the Russian Federation
Cooperation	• Electricity imports: up to 1.5 billion kWh per year	• Partners within the CASA-1000 • Electricity imports: up to 240 million kWh per year • Common interests in hydro potential	• Electricity imports (winter) • Electricity export: up to 1.25 GWh per year with stable water release	• Potential electricity exporter (via Kazakhstan)

Source: Organization for Security and Co-operation in Europe (OSCE), "Advancing Energy Security in Central Asia", 2022. Available at https://www.osce.org/files/f/documents/8/8/513787_0.pdf

direct current transmission line connecting Afghanistan, Pakistan and Tajikistan. The project was approved in 2012 by all member countries. In 2019, a subcontractor was selected and construction began (IEA, 2022a). However, the project is losing its value for Kyrgyzstan given the power crisis in the country and high interest in electricity imports (Panfilova, 2024).

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6 The Islamic Republic of Pakistan

6.1 Summary

Pakistan is experiencing a high growth in electricity demand and production due to its expanding economy and population, and this trend will continue in the future. The country still faces low levels of electrification with about 5 per cent of the country's population (12 million people) currently without access to electricity. In the period until 2031, Pakistan aims to prioritize the development of renewable energy sources, primarily solar, hydro and wind, and plans to reduce dependence on thermal power plants which imported gas and oil products. This should ensure a reduction in electricity prices in the domestic market and a decrease in volatility. The development of cross-border trade in electricity is one of the priorities of the national energy sector. In 2025, Pakistan plans to launch the CASA-1000 interconnect with the supply of up to 1 GW of power to the country. The domestic market is undergoing reforms aimed at creating an electricity market.

6.2 Current situation in the electricity sector

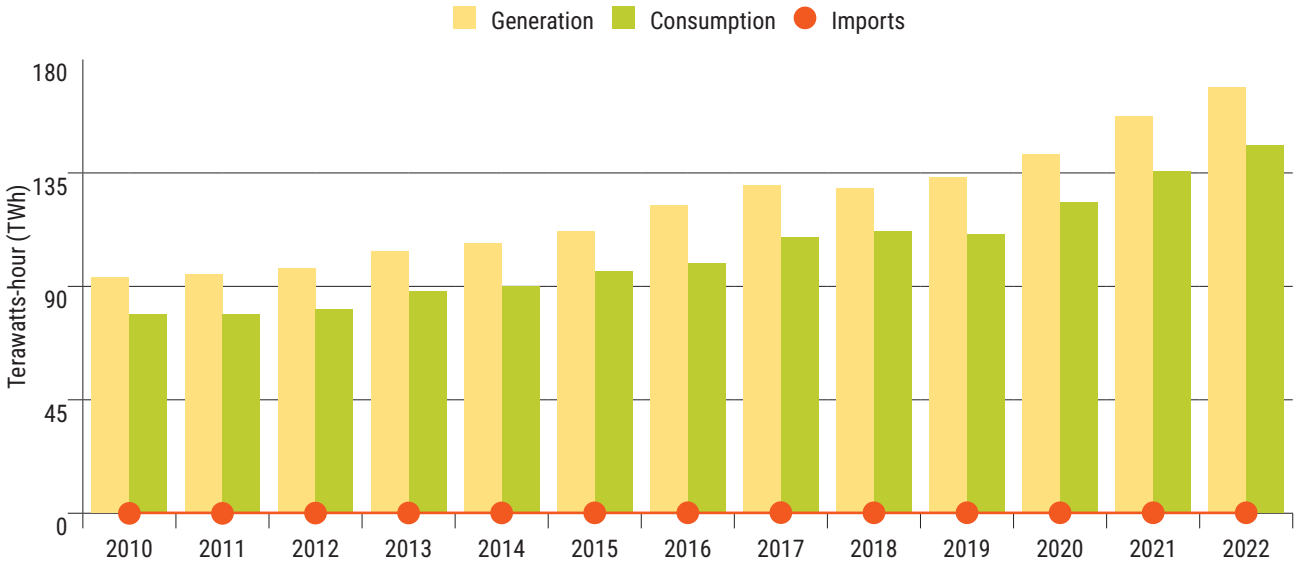
6.2.1 Supply and demand balance

Pakistan met its domestic electricity needs through its own production between 2010-2022. Electricity production and consumption were characterized by high growth rates, mainly due to a high population growth rate and industrial development. About 0.3-0.5 per cent of domestic demand is covered by imports.

In 2022, per capita electricity consumption for Pakistan was about 620 kWh/person (EIA, n.d.), which is almost four times lower than the global average (about 3,400 kWh/person).

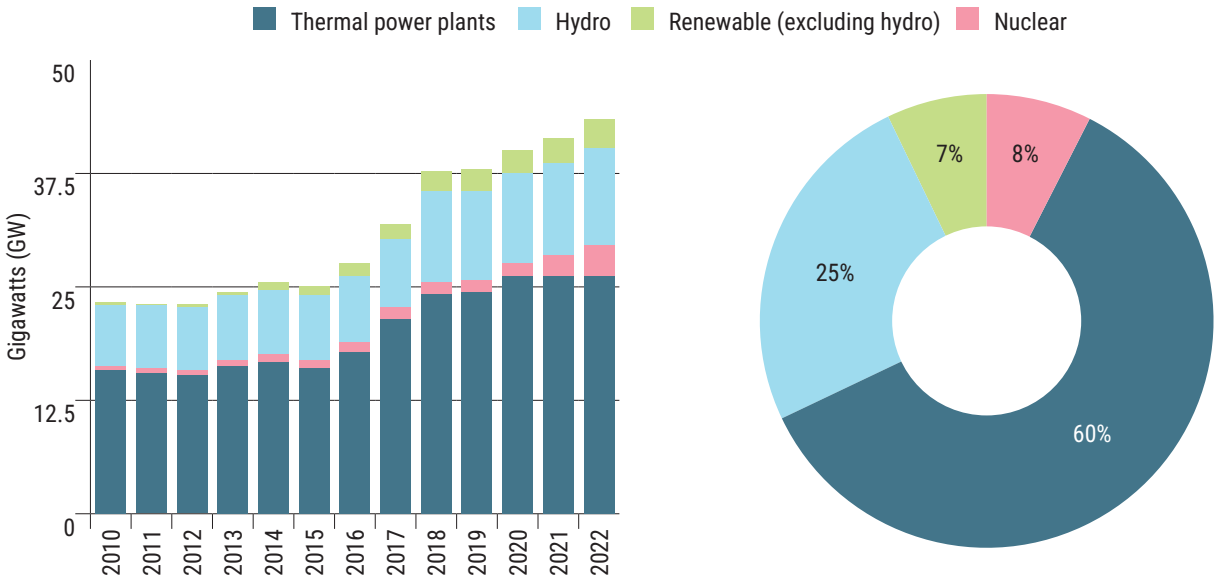
One of the problems that the energy sector faces is low public access to electricity. According to the World Bank, 5 per cent of the population of Pakistan, or about 12 million

Figure 45. Electricity supply, demand and trade in Pakistan, 2010-2022 (TWh)



Source: United States International Energy Agency (IEA), "Pakistan: Data", n.d. Available at https://www.eia.gov/international/data/country/PAK

Figure 46. Electricity capacity, 2010-2022 (left) and by source, 2022 (right), in Pakistan



Source: United States International Energy Agency (IEA), "Pakistan: Data", n.d. Available at https://www.eia.gov/international/data/country/PAK

people, lacked access to electricity in 2022, which is one of the lowest rates in the world (The World Bank, 2023). However, the rate has improved significantly in recent years: from 27.2 per cent in 2000 and 12.9 per cent in 2010 to 5.0 per cent in 2022.

6.2.2 Capacity and generation

In 2022, the installed capacity of power plants in Pakistan was 43.5 GW, which is 86 per cent higher than in 2010. High rates of capacity growth have been observed since 2016, mainly due to the commissioning of thermal power plants (TPP) and hydropower plants (HPP). The capacity of renewable energy sources (RES) and nuclear power plants has also increased.

TPPs dominate in the power capacity in Pakistan with a 60 per cent share in 2022. The TPP capacity was 26.3 GW in 2022, which is 65 per cent higher compared to 2010.

Hydropower is the second source of energy with a share of 25 per cent in 2022. Between 2010-2022, growth in hydropower capacity was 61 per cent, and its share in the energy mix fell from 29 per cent in 2010 to 25 per cent in 2022.

Alternative RES (excluding HPP) have not received widespread development in Pakistan, but their share has been growing rapidly in recent years. The share of RES in the energy balance increased from 1 per cent in 2010 to 7 per cent in 2022, from 0.3 to 3.1 GW.

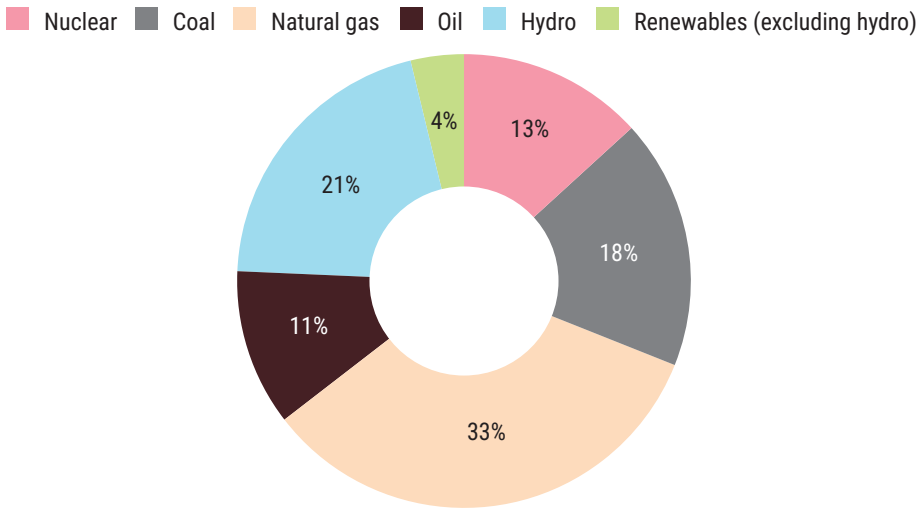
In 2022, nuclear energy (two nuclear power plants) accounted for about 8 per cent of the installed electricity capacity.

The total installed electricity capacity in Pakistan stood at 42.1 GW as of March 2024, with percentage shares of hydro, nuclear, renewable and thermal energy standing at 25.4 per cent, 8.4 per cent, 6.8 per cent and 59.4 per cent, respectively (Ghumman, 2024).

Electricity generation in the country grew by 78 per cent from 2010-2022 and in 2022 amounted to 168.5 TWh.

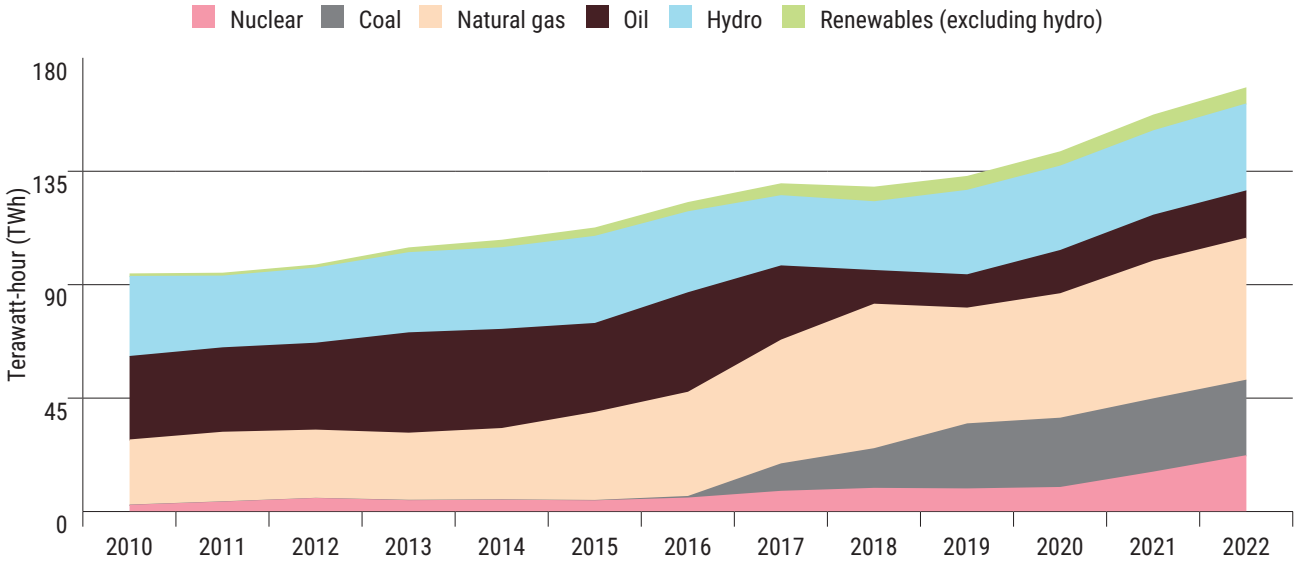
The power generation mix is dominated by TPP with a 62 per cent share in 2022, of which gas accounted for 33 per cent and coal for 18 per cent. HPP produced about 20 per cent

Figure 47. Electricity generation by source in Pakistan, 2022



Source: United States International Energy Agency (IEA), "Pakistan: Data", n.d. Available at https://www.eia.gov/international/data/country/PAK

Figure 48. Electricity generation by source in Pakistan, 2010-2022



Source: United States International Energy Agency (IEA), "Pakistan: Data", n.d. Available at https://www.eia.gov/international/data/country/PAK

of the national electricity and nuclear power plants produced 13 per cent of electricity. The share of alternative RES was only 4 per cent.

In 2010-2022, the greatest increase in electricity production in Pakistan was through coal-fired power plants, which operate mainly on imported coal. In 2022, coal-fired power plants produced 18 per cent of the nation's electricity, up from 0.1 per cent in 2015. There was also an increase in electricity production from gas TPPs.

In Pakistan, power grids run from the north to the south of the country. Hydrogeneration is mainly in the northern part of the country and major thermal generation is located in the south. Large load centres are located at remote distances from major generation sources.

Table 30. Transmission network in Pakistan

Kilovolt (kV)	Number of grid stations	Transmission line, km	Capacity, million volt-amps (MVA)
500 kV	16	5 970	22 350
220 kV	45	11 322	31 060
Total	61	17 292	53 410

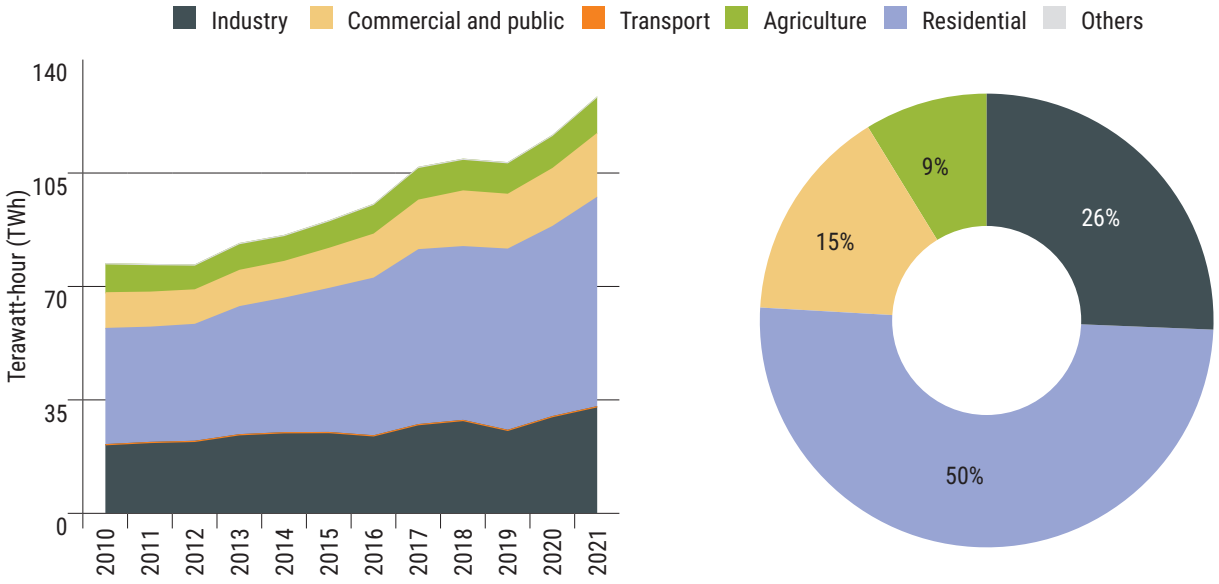
Source: National Transmission & Dispatch Company (NTDC), "Transmission Networks", 2019. Available at https://ntdc.gov.pk/transmission

Table 31. Cross-border electricity trade of Pakistan, TWh, 2020-2022

Country	2020	2021	2022
Imports	0.50	0.50	0.50
Iran (Islamic Republic of)	0.50	0.50	0.50
Exports	-	-	-
Net trade	0.50	0.50	0.50

Source: United States International Energy Agency (IEA), "Pakistan: Data", n.d. Available at https://www.eia.gov/international/data/country/PAK

Figure 49. Electricity consumption by sector, 2010-2021 (left) and 2021 (right), in Pakistan



Source: International Energy Agency (IEA), "Energy Statistics Data Browser", 2023. Available at https://www.iea.org/data-and-statistics/data-tools/energy-statistics-data-browser?country=WORLD&fuel=Energy%20supply&indicator=TESbySource

There are seasonal variations in generation dispatch and in power flows (NTDC, 2019):

- Bulk power flows from the north to mid-country in the summer
- Bulk power flows from the south to mid-country and to the north in winter

6.2.3 Imports, exports, transit

Pakistan does not export electricity; imports come from Iran (Islamic Republic of). Annual electricity supplies from Iran (Islamic Republic of) amount to about 0.5 TWh. Moreover, there is no transit of electricity through Pakistan to third countries.

6.2.4 Demand

In 2021, domestic electricity supply in Pakistan amounted to 156 TWh (an increase of 65 per cent compared to 2010 (IEA, 2023)). About 22 TWh (14 per cent) were losses. The structure of final electricity consumption (129 TWh in 2021) was dominated by domestic consumer use (50 per cent in 2021) and the industrial sector (26 per cent). Between 2010-2021, 56 per cent of the increase in electricity demand was by the population and 23 per cent by industry.

6.3 Electricity market regulation

6.3.1 Power market structure

The Ministry of Energy of Pakistan is the responsible authority for developing and implementing the national energy policy. The Power Division of the Ministry of Energy deals with electricity issues. Nuclear energy is regulated by the Pakistan Atomic Energy Commission and is not regulated by the Ministry of Energy (Pakistan, Ministry of Energy, 2024).

The National Electric Power Regulatory Authority (NEPRA) is the regulator of the power sector in Pakistan, including generation, transmission and distribution of electric power. NEPRA is also responsible for:

- issuing licenses for generation, transmission and distribution of electricity,
- establishing and enforcing standards to ensure quality and safety of operation and supply of electric power to consumers,
- approving investment and power acquisition programs of utility companies, and determining tariffs for the generation, transmission and distribution of electric power (NEPRA, 2023).

In Pakistan, the electricity sector is divided into separate functional areas from a management perspective. The areas of electricity production, electricity transmission and electricity distribution are highlighted separately.

The power generation sector in Pakistan has a mix of public and private companies.

The hydropower and nuclear power sectors are dominated by state-owned companies. As noted above, nuclear power plants are operated by the Pakistan Atomic Energy Commission and most hydropower plants are owned by the state-owned Water and Power Development Authority (WAPDA). However, there are a number of private companies in the hydropower sector. The thermal generation sector includes public and private companies. Power plants in the renewable energy sector are owned by private companies.

The electricity system in the country is divided into two zones from a management perspective. The core zone includes most of the country and is operated by the state-owned National Transmission and Dispatch Company (NTDC). The second zone covers the city of Karachi and surrounding areas and is operated by a private company, K-Electric (KE).

NTDC links power generation units with load centres spread all over the country and thus establishes and governs one of the largest interconnected networks. NTDC is responsible for the generation of power from the HPPs (mainly in the north). It also generates power from public and private partners. Public partners include generation companies (GENCOs), and the private sector includes through IPPs (mainly in the south). Power is distributed through the primary network (NTDC, 2019a). NTDC operates and maintains 16 500 kV grid stations and 45 220 kV grid stations in Pakistan (NTDC, 2019b).

As of June 2022, KE's transmission system comprises of a total of 1,355 km of 220 kV, 132 kV and 66 kV transmission lines, 71 grid stations, 20 auto transformers and 175 power transformers. K-Electric grid is interconnected with the NTDC grid system through four 220 kV transmission circuits (Ahmadani, 2023).

Electricity distribution in Pakistan is carried out by 10 territorial distribution companies (DISCOs) and K-Electric in the Karachi area.

6.3.2 Tariffs

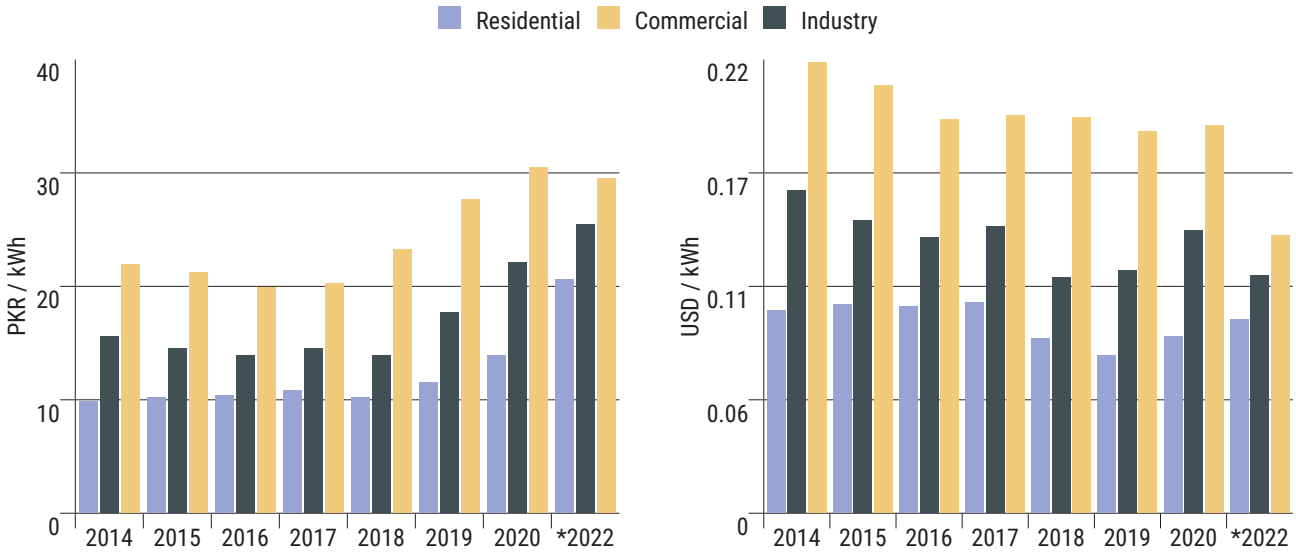
NEPRA is responsible for setting tariffs for generation, transmission, distribution and supply across different categories of licenses. The detailed procedure for tariff determination is outlined in the NEPRA (Tariff Standards & Procedure) Rules, 1998.

The consumer-end tariff comprises energy purchase price (EPP), capacity purchase price (CPP), the impact of transmission and distribution losses, distribution and supplier margin, and prior year adjustments. In the fiscal year (FY) 2022, EPP constituted around 60 per cent of the tariff, while CPP accounted for about 40 per cent. The percentage of CPP in the overall tariff is on an increasing trend. During FY 2023, the percentage of EPP and CPP was around 50 per cent each, while for FY 2024, it is projected to be around 67 per cent for EPP and 33 per cent for CPP. The increase in CPP percentage is due to the augmented capacity of power generation plants and the addition of the HVDC line in the system (NEPRA, 2023c).

At present, fixed charges billed to electricity consumers range from approximately Rs. 200 to Rs. 500 per kW/month, determined by their actual maximum demand for the month or 50 per cent of sanctioned load, whichever is higher. In contrast, capacity charges billed to DISCOs by the Central Power Purchasing Agency (Guarantee) Limited (CPPA-G) remain consistently over Rs. 4,000 per kW/month. This highlights that only around 3 to 4 per cent of the fixed costs is accounted for as fixed charges, while the rest is billed based on variable charges depending on energy consumption (NEPRA, 2023c).

Between 2017-2022, end-user electricity prices were on a rapid upward trend in Pakistan. The main reason was the devaluation of the national currency and the increase in world prices for imported fuel (gas, coal, petroleum products). Rising prices for electricity affect the consumer opportunities of the population and can also negatively affect economic development.

Figure 50. Electricity tariffs in Pakistan, 2014-2022



Source: International Energy Agency (IEA), "Energy Prices", 2023. Available at https://www.iea.org/data-and-statistics/data-product/energy-prices#overview; National Electric Power Regulatory Authority (NEPRA) "State of Industry Reports", 2023c. Available at https://nepra.org.pk/publications/State%20of%20Industry%20Reports.php
Note: * NEPRA

6.3.3 Market reforms

Pakistan is undergoing reforms to develop market relations in the electricity sector. These include:

- Separation of the system operator functions from NTDC (NEPRA, 2023c)
- Separation of market operator function from CPPA-G as an agent of DISCOs (NEPRA, 2023c)

The system operator is responsible for maintaining the overall stability and reliability of the power system, ensuring that electricity generation matches demand in real-time. The network operator manages the physical infrastructure, including transmission and distribution networks. The separation of system operator and network operator serves a crucial purpose. Having separate and independent entities for these functions prevents conflicts of interest and ensures that both operational and commercial interests are balanced. It fosters transparency, fair competition and efficient grid management. This division of responsibilities is vital in preventing undue influence in grid operations and safeguarding the integrity of the power system, ultimately benefiting both the industry and the end-user.

The NEPRA Act, amended in 2018, envisions the development of a policy and regulatory framework for the electricity wholesale market in the country. The separation of the system operator from the transmission network company is a fundamental requirement for the development of this wholesale market. NEPRA has therefore granted a license to NPCC to act as an independent system operator. The timely functional and legal separation of the NPCC from NTDC, as outlined in the system operator license, is essential to realize the benefits of an independent system operator. This step ensures a level playing field for market competition, efficient grid operation, innovation, investment, and an opportunity to uphold transparency and accountability in the electricity sector. Adhering to regulatory standards along with the timelines is paramount for ensuring a technically resilient and financially viable power sector.

CPPA-G holds two distinct roles; first as a market operator and second as a special purpose agent for centralized power procurement under the single buyer regime. Whereas the former involves overseeing wholesale market settlements, the latter entails managing legacy contracts. The separation of these functions is deemed necessary for various reasons, including ensuring fairness and competition, enhancing transparency, avoiding concentration of power, mitigating conflicts of interest, ensuring regulatory compliance, fostering innovation and flexibility, and managing risks. The Authority has already issued licenses for the market operator and system operator, establishing them as independent and distinct functions. Furthermore, the moratorium specified in the amended NEPRA Act, 2018, has been lifted by operation of law, rendering the above two licenses now effective, alongside the Market Commercial Code and Grid Code. For the desired outcome of appointing independent market and system operators, it is imperative for all stakeholders to adhere to regulatory decisions while upholding their intended purpose and spirit.

6.4 Plans and measures for electricity sector development

6.4.1 National goals and plans

In 2023, Pakistan adopted a strategic development document; the National Electricity Plan 2023-27 (Pakistan, Ministry of Energy, 2023), which details the National Electricity Policy 2021 (Pakistan, Ministry of Energy, 2021).

The National Electricity Policy identifies three over-arching goals for the power sector, namely: access to affordable energy, energy security and sustainability. Furthermore, nine

Table 32. Strategic Architecture of the National Electricity Plan for Pakistan, 2023-2027

Objectives	Priority areas	
Diversification	Integrated energy planning	Distributed energy resources
	Generation expansion	Cross-border trade of electricity
Resilience and accessibility	Transmission network expansion	Electrification
	Robust distribution infrastructure	Risk assessment and management
	System and market operations	
Self-sufficiency	Localization of fuel and technology	
Affordability	Social protection	Incentive schemes
Financial viability	Tariff design	Recovery of open-access charge
	Subsidy rationalization	
Sustainability	Decarbonization	Institutional improvements and capacity-building
	Energy efficiency and conservation	
	Research and development institutionalization	Digitalization

Source: Pakistan, Ministry of Energy, "National Electricity Plan 2023-27", 2023. Available at https://www.power.gov.pk/SiteImage/Policy/National%20Electricity%20Plan%202023-27.pdf

areas have been identified under the National Electricity Policy for the attainment of these goals.

Generation Expansion

The generation policy framework will take into account the following key considerations (Pakistan, Ministry of Energy, 2023):

- the scope of the policy framework will include all prospective generation technologies such as hydel, thermal, nuclear, renewables, etc.;
- all hydel generation will be included in the definition of renewable energy and accordingly, subject to the least cost criteria following on-grid (utility and distributed scale) renewable energy targets. These have been envisaged as:
- 40 per cent of total generation capacity by FY 2025;
- 60 per cent of total generation capacity by FY 2030.

Decarbonization

The Government aims to gradually achieve 65 per cent of the generation mix through the clean energy sources by FY 2030 (Pakistan, Ministry of Energy, 2023).

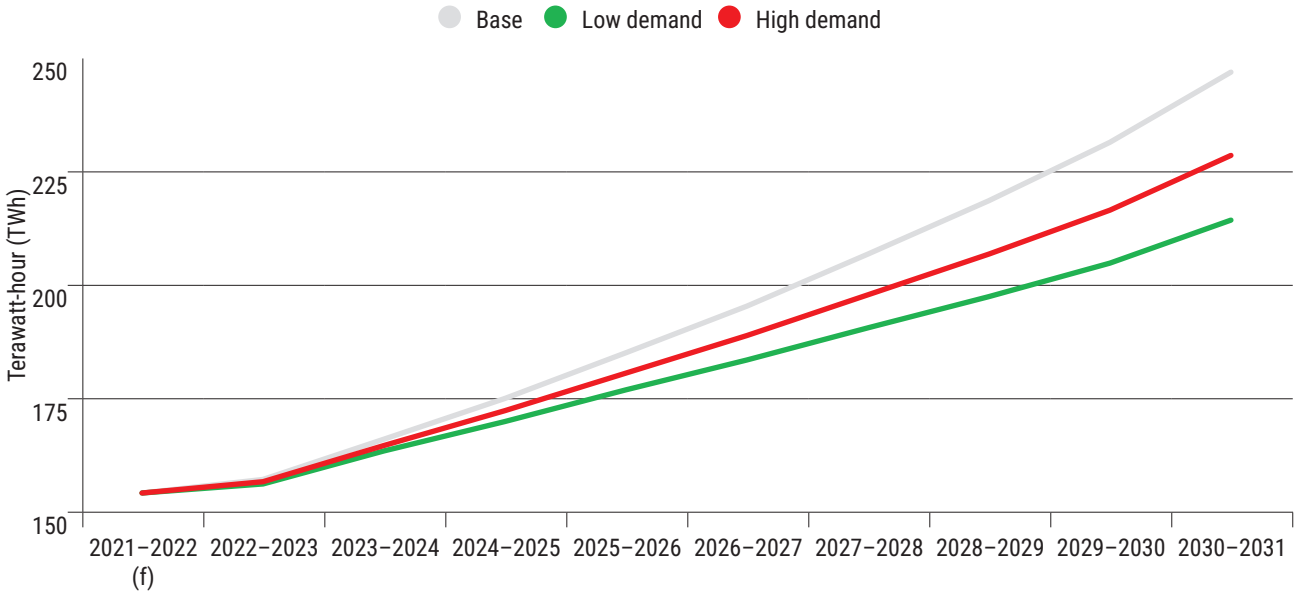
In Pakistan, the Indicative Generation Capacity Expansion Plan (IGCEP) 2022-2031 was adopted in 2022 (NEPRA, 2023b). In all three scenarios, electricity demand in Pakistan will grow at a high rate until 2031: an increase of 48 per cent by 2022 in the base scenario; increase of 39 per cent in the low scenario; and increase of 60 per cent in the high scenario.

In 2023-2031, in all IGCEP scenarios, the largest increase in energy capacity will come from RES, primarily from solar, hydropower plants and wind. The share of low-carbon energy in the energy mix will increase from 41 per cent in 2023 to about 66-68 per cent in 2031 under various scenarios. The use of gas in the energy sector will decrease, including expensive imported LNG, as well as refined petroleum products (RFO). There are plans to increase the use of local coal through the Thar deposit.

The NTDC has entered into new initiatives of transmission network in the ambit of the China – Pakistan Economic Corridor (CPEC) and through international collaboration. These include (NEPRA, 2023c):

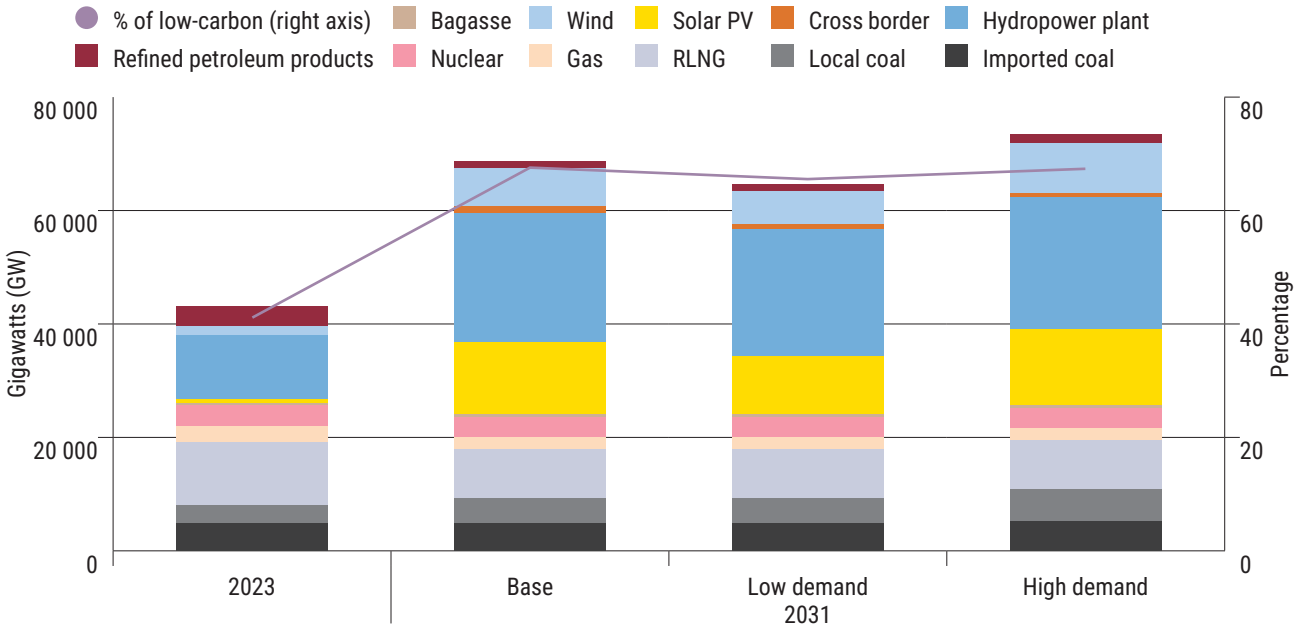
- CASA-1000 for evacuation of 1000 MW of power (during the summer season) through ±500 kV HVDC Transmission Line emanating from Sangtuda, Tajikistan and

Figure 51. Electricity consumption in Pakistan, 2022-2031



Source: National Electric Power Regulatory Authority (NEPRA), "Determination of the Authority in the Matter of Indicative Generation Capacity Expansion Plan of National Transmission and Despatch Company Limited (IGCEP – 2022-31)", 1 February 2023b. Available at https://www.nepra.org.pk/licensing/Licences/IGCEP/LAT-01%20NTDC%20IGCEP-2022-31%2001-02-2023%201550-90.PDF
Note: f = fiscal year

Figure 52. Electricity generation mix in Pakistan, 2023-2031



Source: National Electric Power Regulatory Authority (NEPRA), "Determination of the Authority in the Matter of Indicative Generation Capacity Expansion Plan of National Transmission and Despatch Company Limited (IGCEP – 2022-31)", 1 February 2023b. Available at https://www.nepra.org.pk/licensing/Licences/IGCEP/LAT-01%20NTDC%20IGCEP-2022-31%2001-02-2023%201550-90.PDF
Note: * Includes Nuclear, Bagasse, Solar PV, HPP, Wind

passing through Kyrgyzstan, Afghanistan and terminating in Nowshera, Pakistan;

- 765 kV Transmission Line Project (250 km length) for dispersal of power from upcoming Dasu Hydropower Project and culminating at the future 765 kV Islamabad West Grid Station (the first of its kind in Pakistan).

- Construction of grid stations and allied transmission lines at Swabi (for Rashakai SEZ), Haripur (for Hattar SEZ), Allama Iqbal Industrial City (for FIEDMC SEZ), Dhabeji (for Dhabeji SEZ) etc., for the provision of electricity to Special Economic Zones (SEZs) under CPEC.

- Installation of Pilot 20MW/ 20 MWh Battery Energy Storage System (BESS) at 220 kV Jhampir-I Grid Station, a first in the history of Pakistan.

6.4.2 Current measures for the development of lower-carbon energy

The Alternative Energy Development Board (AEDB) has been promoting and facilitating the development and deployment of alternative and renewable energy technologies in the country, particularly in the private sector (NEPRA, 2023c).

In order to reduce the impact of prevailing high prices of oil and LNG in the international markets which result in high electricity tariffs and drain precious foreign exchange, the Government has approved the Framework Guidelines for Fast-Track Solar PV Initiatives 2022 for fast-track deployment of solar PV. These initiatives include:

- Substitution of expensive imported fossil fuels with solar PV energy;

- Solar PV generation on 11 kV feeders - 40 MW maximum capacity through a competitive bidding process among all DISCOs.

- Solarization of public sector buildings: Initially, 85 public sector buildings on and own-cost model for solarization have been tendered.

AEDB undertook a number of supportive measures in order to promote RE technologies and to attract private sector investments. These include (NEPRA, 2023c):

- Engaging with the World Bank to carry out an initial study on renewable energy development in Balochistan, titled "Balochistan Renewable Energy Development Study", with the objective of strategic development of utility-scale solar and wind power in Balochistan to help meet the ambitious renewable energy targets for the power sector and support the broader transition that is needed to achieve "affordable, reliable, sustainable and modern energy for all".

- Developing a capacity-building programme to train solar technicians. This programme has been initiated with the support of GIZ under which customized training to 500 technicians at relevant Pakistani training institutions will be provided on a Competence Based Training and Assessment approach as per National VocationalQualificationFramework(NVQF).

6.4.3 Key challenges and issues in lower-carbon energy development

The National Electricity Plan 2023-27 sets ambitious plans for green energy development. However, there are challenges in the country's energy sector, including:

- low level of electrification;

- insufficient development of power transmission lines;

- high level of electricity losses;

- lack of enterprises to produce the necessary equipment for RE power plants;

- insufficient level of financing for energy projects;
- insufficient attraction of foreign direct investment for the development of RE.

6.4.4 Plans for cross-border power trade development

In accordance with the National Electricity Plan 2023-27, increased cross-border electricity cooperation can help reduce electricity prices, enhance resilience, aid high penetration of renewables and facilitate clean energy transition.

Guidelines will facilitate the import/export of electricity through regional integration. Such guidelines will include provisions for, inter alia:

- scope and modes of participation;
- institutional framework and definition of roles;
- eligibility and evaluation methodology;
- tariffs;
- regional planning and system operations;
- security packages.

The CASA-1000 interconnect (primarily designed for import of electricity) will also be utilized for export of electricity through bilateral/multilateral arrangements. In this regard, the CASA open access rules will be formulated at the latest by July 2024. Future opportunities for cross border export and import of electricity will be explored to enable efficient utilization of available capacity and/or energy, system stability and geo-spatial diversity.

As per IGCEP 2022-31, Pakistan plans to supply electricity through CASA-1000 with a capacity of 1000 MW from 2025 (NEPRA, 2023b). As part of this project, it is planned to import about 3.67 TWh of electricity annually (about 2.5 per cent of demand in 2022).

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7 The Republic of Tajikistan

7.1 Summary

The power sector in Tajikistan relies highly on hydropower (almost 90 per cent of installed capacity), which provides the country with one of the cleanest electricity mixes in the world, but also entails electricity shortages in winter and surpluses in summer.

With the disconnection from the Central Asian Power System (CAPS) in 2009, which helped to balance seasonal patterns of hydropower, the country's power sector had to adapt by diversifying its electricity mix (predominantly by coal) and by implementing market reforms. In this regard, development institutions have played a prominent role in supporting and reforming the power sector in Tajikistan.

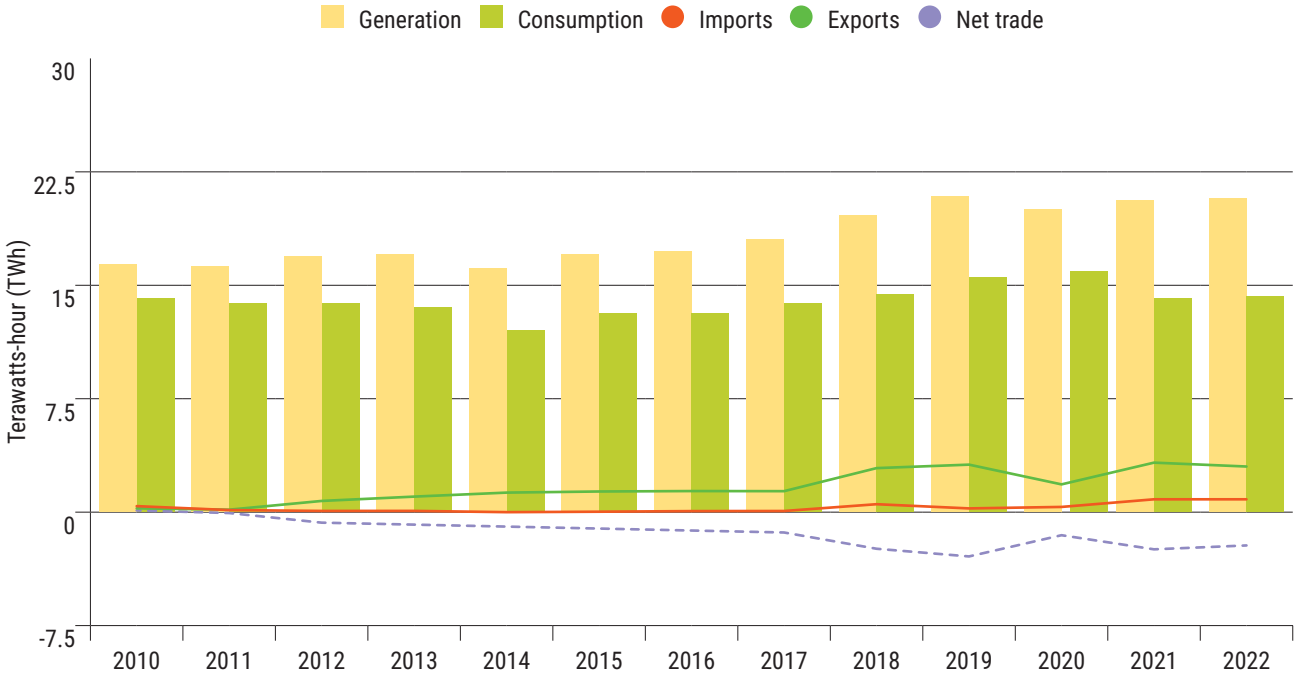
Tajikistan has recently set ambitious green energy goals including for alternative renewable energy sources (RES) which are at the early stage of development. The country aims to become a major exporter of electricity in the region, supplying markets of Central and South Asia, as well as other countries with environmentally sound electricity. In 2018, Tajikistan began reconnecting to CAPS which was formally finalized in June 2024.

7.2 Current situation in the electricity sector

7.2.1 Supply and demand balance

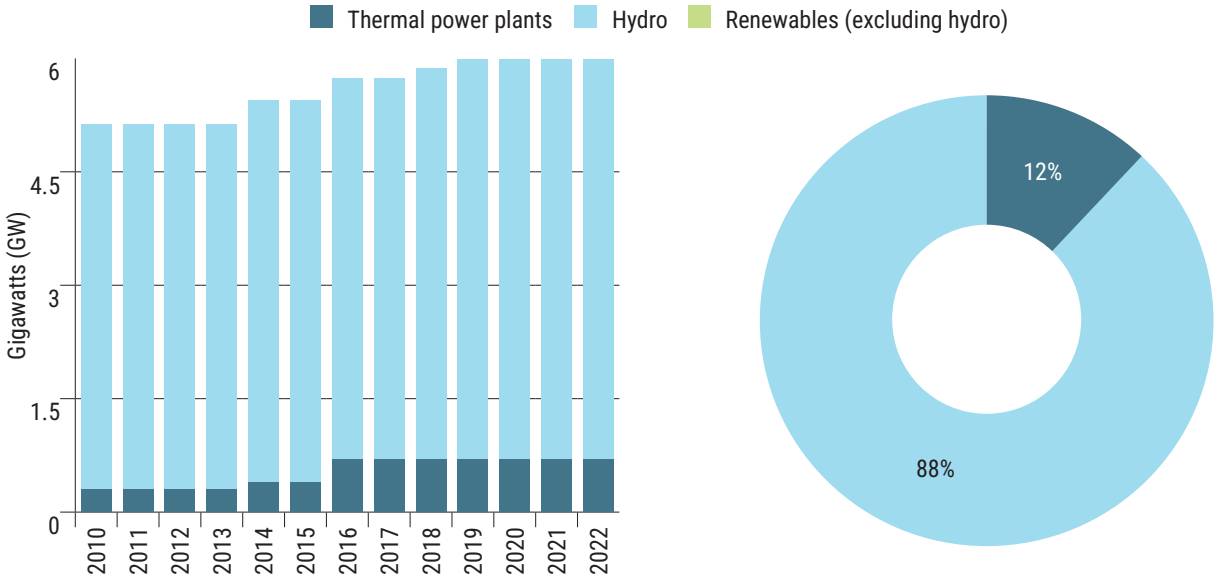
With the increase in electricity generation by 27 per cent between 2010–2022, domestic consumption increased (though has stalled in recent years). Cross-border electricity trade to balance supply and demand is reviving with the reconnection to CAPS. On an annual basis, Tajikistan is a net-exporter of electricity, but there are seasonal shortfalls of supply.

Figure 53. Electricity supply, demand and trade in Tajikistan, 2010-2022



Source: International Energy Agency (IEA), "Energy Statistics Data Browser", n.d. Available at https://www.iea.org/data-and-statistics/data-tools/energy-statistics-data-browser?country=WORLD&fuel=Key%20indicators&indicator=CO2PerCap

Figure 54. Installed capacity of power plants (GW) in 2010-2022 (left) and by source in 2022 (right), in Tajikistan



Source: International Energy Agency (IEA), "Energy Statistics Data Browser", n.d. Available at https://www.iea.org/data-and-statistics/data-tools/energy-statistics-data-browser?country=WORLD&fuel=Key%20indicators&indicator=CO2PerCap

7.2.2 Capacity and generation

Total installed capacity of power plants in Tajikistan is 5.8 GW, of which over 5 GW accounts for HPPs and 718 MW – for TPPs (Tajikistan, Ministry of Energy and Water Resources, 2024).

Tajikistan has 12 large and medium HPPs and 285 small HPPs (from 5 to 4300 kWT) (Tajikistan, Ministry of Energy and Water Resources, 2024). Most of the country's HPPs are over 30 years old and need to undergo rehabilitation and reconstruction, mainly with the support of development institutions.

In addition to HPPs, Tajikistan has thermal power generation capacities, which are in operation during winter season to meet peak demand, and balance seasonal patterns of HPPs. Currently, there are two operational HPPs: Dushanbe-1 (gas and fuel oil) and Dushanbe-2 (coal). Coal-fired generation is expanding as domestic oil and natural gas reserves are limited and alternative RES are at an early stage of development.

Tajikistan has started to introduce off-grid installations in remote regions such as the Gorno-Badakhshan Autonomous Region (GBAO). In 2020, the first 200 kW solar PV plant in Murghab was commissioned. The project was supported by USAID and upgraded to 800 kW (USAID, 2023).

Gross electricity generation in 2022 was 20.8 TWh. From this capacity, 89 per cent was generated from HHPs, 9 per cent from coal and 2 per cent from gas. The share of TPPs grew from 0.2 per cent in 2010 to 11 per cent in 2022. Network losses also remain relatively high averaging 15.5 per cent of generation between 2010–2022 (21.2 per cent in 2023 (Tajikistan, Ministry of Energy and Water Resources, 2024)).

Table 33. Generation capacity

Name	Units	Installed capacity (MW)
Hydropower plants (HPPs)		
Nurek (rehabilitation with the support of the World Bank, Asian Development Bank, Eurasian Development Bank) (World Bank Group, 2019).	9	3000
Sangtuda-1	4	670
Sangtuda-2	2	220
Baypaza	4	600
Kayrakkum (rehabilitation with the support of the European Bank for Reconstruction and Development, European Investment Bank, Green Climate Fund) (Strategeast, 2019).	6	126
Vaksh Cascade: Golovnaya, Perepadnaya, Central	6/3/2	240/30/15
Varzob Cascade	6	27
Pomir-1	-	28
Khorog	-	9
Namangut	-	2.5
Tajikistan	-	1.5
Khujand	-	0.6
Rogun(under construction towards 3780 MW with the support of the World Bank) (World Bank Group, 2023).	2	240
Small HPPs	285	26.6
Thermal power plant ((TPPs)		
Dushanbe-1 co-generation	4	400
Dushanbe-2 co-generation	4	198
Yavan co-generation	2	120

Source: Tajikistan, Ministry of Energy and Water Resources, *Electric Power System*. 2024. Available at https://www.mewr.tj/?page_id=552

7.2.3 Imports and exports

Historically, Tajikistan relied on imports from CAPS to make up for seasonal electricity shortages. In 2009, the country was disconnected from CAPS which led to a fall in trade volumes and higher exposure to power outages. In 2018, Tajikistan, with support from ADB (ADB, 2018), reconnected and initiated bilateral electricity trade with Uzbekistan (in island mode), and complete reconnection was formally finalized in June 2024.

Through existing cross-border infrastructure, Tajikistan also trades with Kyrgyzstan where trade volumes are negligible, and with Afghanistan where exports are growing. Afghanistan continues to receive small quantities of electricity from Tajikistan even in winter in order to keep key infrastructure up.

7.2.4 Demand

Electricity consumption in Tajikistan was 18.3 TWh in 2021. Most of the consumption falls within the residential sector, followed by industry, commercial and public services and agriculture.

Electricity consumption per capita in Tajikistan is below the world average: in 2021 it was 1,459 MWh/capita against 3,358 MWh/capita on average (IEA, n.d.).

Table 34. Major cross-border infrastructure

Name	Capacity	Connected Country
CASA-1000 (planned)	1300 MW	Afghanistan, Kyrgyzstan, Pakistan
Guzar–Regar 500 kV line	2470 MVA	Uzbekistan
Surhan–Regar 500 kV line	2070 MVA	Uzbekistan
Uzlovaya–Syrdarya 220 kV line	690 MVA	Uzbekistan
Geran–Afghanistan 220 kV line	600 MW	Afghanistan
Geran–Afghanistan 110 kV line	100 MW	Afghanistan
Kanybadam–Aigultash 220 kV line	600 MVA	Kyrgyzstan
Proletarsk–Samat 110 kV line	450 MVA	Kyrgyzstan
Zumrat–Aigultash 110 kV line	445 MVA	Kyrgyzstan

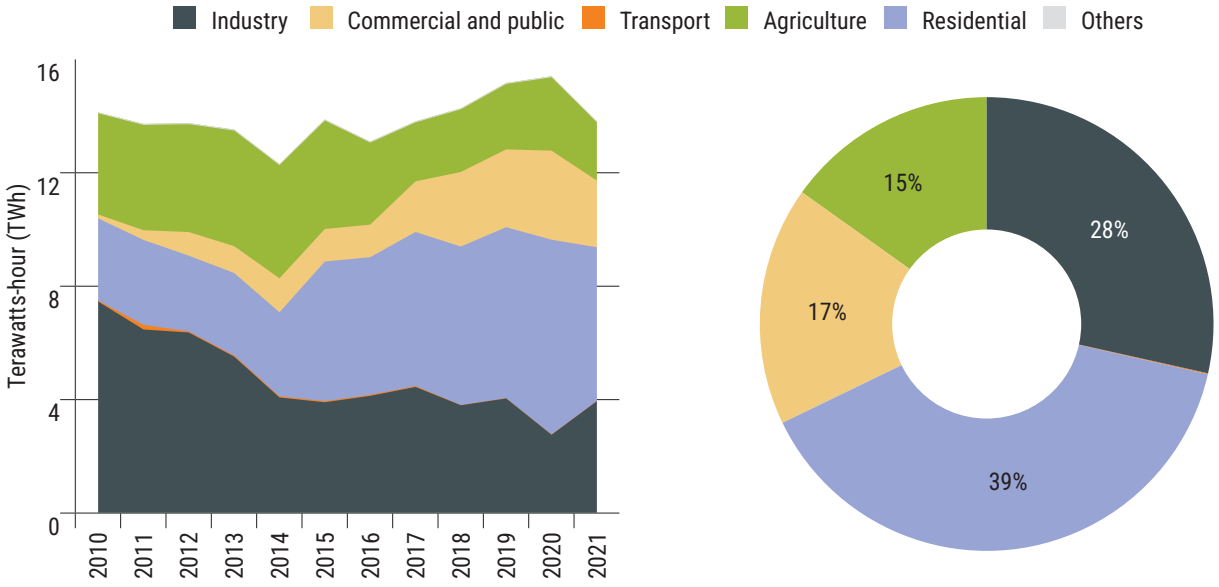
Source: Asian Development Bank (ADB), "CAREC Energy Outlook 2030", Manila, 2022. Available at https://www.adb.org/publications/carec-energy-outlook-2030

Table 35. Cross-border electricity trade of Tajikistan (GWh), 2020–2022

Country	2020	2021	2022
Imports			
Uzbekistan	182.6	769.8	795.6
Kyrgyzstan	111.7	101.5	14.5
Exports			
Afghanistan	922.8	1 308.6	1 691.7
Uzbekistan	756.9	1 784.6	1 670.1
Kyrgyzstan	134.9	159.3	17.8
Kazakhstan	12.2	0	0

Source: International Trade Centre (ITC), "Trade Map", 2019. Available at https://www.trademap.org/Country_SelProduct_TS.aspx?nvpm=1%7c%7c%7c%7c%7cTOTAL%7c%7c%7c2%7c1%7c1%7c1%7c2%7c1%7c2%7c1%7c1%7c1

Figure 55. Electricity consumption by sector, 2010-2021 (left) and 2021 (right) in Tajikistan



Source: nternational Energy Agency (IEA), "Energy Statistics Data Browser", n.d. Available at https://www.iea.org/data-and-statistics/data-tools/energy-statistics-data-browser?country=WORLD&fuel=Key%20indicators&indicator=CO2PerCap

The proportion of population with access to electricity has reached 100 per cent (United Nations, High-Level Political Forum on Sustainable Development, 2023). In 2022, the GBAO was connected to the national grids which improved the access of the population to green electricity all year round. The time of outages and the number of accidents is being reduced as well (United Nations, High-Level Political Forum on Sustainable Development, 2023).

Within the industrial sector, the Tajik Aluminium Company (TALCO) accounts for nearly half of the total consumption. In agriculture, electricity is mainly used for irrigation.

7.3 Electricity market regulation

7.3.1 Power market structure

The Ministry of Energy and Water Resources (MoEWR) is the core ministry that regulates the power market in Tajikistan. All activities related to electricity production, transmission and distribution (except for self-generation) are subject to licensing.

The power market is centralized and vertically integrated, but market reforms are underway (IEA, 2022). Barqi Tojik, the state-owned monopoly, which controlled generation, transmission, distribution and retail, was unbundled in 2021 into three independent state-owned companies: JSC Barqi Tojik is responsible for generation and regional trade; OJSC Shabakahoi Intiqoli Barq for transmission; and OJSC Shabakahoi Taqsimoti Barq for distribution. The public-private company, Pamir Energy, is responsible for generation, transmission, distribution and retail of electricity in the GBAO under a 25-year concession agreement, which expires in 2027.

There are three independent power producers (IPPs). Two of them, the Sangtuda-1 and Sangtuda HPPs were constructed with investments from the Russian Federation and Iran (Islamic Republic of), and supply electricity to Barqi Tojik under 20-year power purchase agreements (PPA) with JSC Barqi Tojik. The third IPP, Roghun HPP, has a PPA which is renewed annually.

7.3.2 Tariffs

Antimonopoly Service (AMS) under the Government of Tajikistan is responsible for the tariff methodology, tariff level proposals and service quality. The electricity tariffs for end users are regulated and approved by Government Decrees. For some end-users, the summer and winter tariffs are differentiated.

Trying to ensure universal public access to electricity, the Government kept low power prices. Constrained revenues in combination with growing investment needs (after disconnection from CAPS) led to Barqi Tojik's negative equity status since 2016 (ADB, 2021). Given the financial difficulties of Barqi Tojik, the Government began to increase end-user tariffs. For example, tariffs for general consumers,

Table 36. Electricity tariffs (excluding VAT) 2010-2023, TJS-2/kWh

End-user	1 Jan 2010	1 Apr 2012	1 Jul 2014	1 Nov 2016	1 Oct 2017	1 Nov 2018	1 Sep 2019	1 Oct 2022	01.23. 2023	01.23.2023 USD-2 kWh8
Industrial and non-industrial consumers	21.3	26.63	30.6	35.65	40.99	47.13	55.14	60.65	70.35	6.90
Public sector, utilities, sport complexes	8.5	10.63	12.2	14.2	16.85	19.37	22.66	26.51	30.75	3.01
Electric transport	5.7	7.13	8.2	9.55	16.85	19.37	22.66	26.51	30.75	3.01

Continued next page

Table 36 continued

End-user	1 Jan 2010	1 Apr 2012	1 Jul 2014	1 Nov 2016	1 Oct 2017	1 Nov 2018	1 Sep 2019	1 Oct 2022	1.23. 2023	1.23.2023 USD-2 kWh8
Water pumps, pumping stations of machine irrigation and repair and production bases of Agency for Land Reclamation and Irrigation (Apr-Oct-Nov-Mar)		1.88–7.13	2.20–8.20	2.55–9.55	5.86–16.85	6.73–19.37	7.87–22.66	9.20–26.51	10.67–30.75	1.05–3.01
Reclamation vertical wells and reclamation pumping stations		1.88	2.2	2.55	5.86	6.73	7.87	9.2	10.67	1.05
Population (including VAT)	9	11	12.6	14.65	16.85	19.37	22.66	26.51 (including hostels and hotels)	30.75 (including hostels and hotels)	3.01 (including hostels and hotels)
Use of electric boilers and electrical installations, in order to provide hot water and heating of buildings										
Non-budgetary sphere	52.7	65.88	75.8	88.3	101.54	116.77	136.62			
Budgetary bodies and institutions	15.6	19.5	22.4	26.1	30.015	34.51	40.37			
Educational institutions without budget funding								45.51	52.79	5.17
Drinking water supply pumps (except individual) and sanitation					8	9.2	10.76	12.6	14.62	1.43
Metallurgical plant of Tajikistan LLC (May-September -October-April)					7.20 (May-Sept)	8.28–47.13	9.68–55.14	10.64–60.65	12.34–70.35	1.21–6.90
TALCO (May-September-October-April)		6.25–10.25 (SUE)	7.20–11.80 (SUE)					15.57 (JSC)	18.06 (JSC)	1.77 (JSC)
Tajik Azot								40	46.4	4.55

Source: Decrees of the Government of the Republic of Tajikistan. For the full list of Decrees please refer to the reference list at the end of the chapter.

and industrial and non-industrial consumers increased more than three times between in 2010–2022. Nonetheless, electricity tariffs in the country are still amongst the lowest in the world.

In 2017, with the help from the World Bank and ADB, MoEWR prepared a new tariff methodology, aiming at bringing electricity tariffs gradually to cost recovery levels by 2025 (World Bank, 2020). The methodology was approved by the Government in 2019 and currently is under implementation. It is regarded as a transitional methodology from vertically-integrated market model to an unbundled model.

7.3.3 Market reforms

In 2010s, the Government made efforts to restore financial sustainability of the power sector including increasing tariffs, restructuring JSC Barqi Tojik and revitalizing exports.

In 2020, the Power Sector Development Program developed jointly by the Government of Tajikistan, ADB, EBRD and the World Bank was approved to accelerate the implementation of ongoing reforms (ADB, 2020). The program is set to run until 2026 and includes the following components (ADB, 2021):

- unbundling of the vertically-integrated power utility JSC Barqi Tojik;
- restructuring JSC Barki Tojik's debt;
- setting up a new centralized cash control system among the unbundled entities to ensure priority payments to commercial liabilities;
- establishing a new power sector regulator;
- adopting a tariff methodology;
- enhance retail electricity metering and low- and medium-voltage distribution networks in seven priority cities: Dushanbe, Buston, Dangara, Isfara, Istaravshan, Konibodom and Panjakent

7.4 Plans and measures for electricity sector development

7.4.1 National goals and plans

The main goals and development trends for the energy sector are reflected in the National Development Strategy 2030 (Tajikistan, 2016) and the Green Economy Strategy (developed with the support of UNDP) (Tajikistan, Ministry of Economic Development and Trade, 2022).

Table 37. Key energy benchmarks of the National Development Strategy

Benchmarks	Unit of measurement	2015 (fact)	Industrial scenario			Industrial-innovative scenario		
			2020	2025	2030	2020	2025	2030
Population (end of year)	Thousands of people	8 547.4	9 500	10 490	11 580	9 500	10 490	11 580
Real GDP growth rate	Percentage	6	6.7	6.9	7.8	7.5	8.9	9.6
Electricity generation, total	TWh	17.1	26.2	37.5	40.7	26.2	37.6	45
Electric power generation at HPP	TWh	16.8	24.5	34.4	37.6	24.5	34.5	41.6
Electricity generation per capita	TWh/capita	2.02	2.78	3.64	3.67	2.78	3.65	4.06
Coal production	Millions of tons	1.04	4.05	6.9	10.4	5.3	10.3	15.1
Gas production	Thousand m^3	4 102	4 600	5 000	6 000	5 750	6 250	7 500
Oil production	Thousand of tons	24.6	25	30	36	30.6	37.5	45

Source: Tajikistan, *National Development Strategy of the Republic of Tajikistan for the Period up to 2030*, 2016. Available at http://nafaka.tj/images/zakoni/new/strategiya_2030_en.pdf

Specifically, for the power sector there is also the Power Sector Development Master Plan (2017, with the support of ADB) (ADB, 2021).

The National Development Strategy along with the scenario benchmarks for electricity generation sets the following goals for 2030 known as the "10-10-10-10-500" concept:

- design capacity of the electric power system increased to 10 GW;
- annual electricity export to neighbouring countries is to reach 10 TWh;
- diversification of the country's electric energy system capacity by at least 10 per cent through the increase of capacities of other energy sources, including coal, gas, oil and RES;
- power losses reduced to 10 per cent:
- enhanced energy efficiency: energy saving is 500 GWh of hours of electricity.

For Tajikistan, the Green Economy Strategy lays the foundations for its transition to "green" economy. Potential directions for the formation of "green" economy include a direction toward low-carbon economy, which is based on the principles of reliable energy supply, which in turn rest on energy conservation, its efficiency and the transition to RES. In the field of efficient use of green energy and energy efficiency, the strategy is aimed at:

- strengthening the process of development of production and use of green energy;
- providing universal access to cheap, reliable and modern energy resources for all social and economic sectors of the country (SDG 7.1);
- increasing the share of alternative renewable energy sources in the country's energy sector (SDG 7.2);
- improving the efficiency of the country's energy infrastructure through the introduction of environmentally sound technologies (SDG 7.3);
- exporting environmentally sound electricity to the markets of Central, South Asia and other countries;
- ensuring energy saving and energy efficiency;
- attracting investments for the development of RES.

Expected outcomes in this field includes the following:

- align legislation with the principles of green economy, as well as adopt relevant by-laws, norms, standards and programs;
- increase electricity production capacity of the country from RES (solar, wind and bioenergy) by 10 per cent;
- increase solar energy generation capacity to 800 MW;
- double electricity generation from RES;
- become a major exporter of electricity in the region (up to 10 TWh per year);
- increase the energy potential of the country 10 GW in the next seven years;
- attract foreign direct investment to ensure energy efficiency and increase energy saving;
- adopt state standards in the field of energy and reduce the total losses of electricity by 10 per cent.

The strategy has five implementation stages within its first action plan for 2023–2025.

Table 38. Key energy goals and activities in the first action plan of the Strategy for Green Economy Development

Goals and activities	Expected outcome indicators	2021 (basic indicators)	Target value of the indicator (Target) / X – Deadline for activities		
			2023	2024	2025
Green energy and energy efficiency					
Enhance and strengthen the development of production and use of green energy	Electricity generation, TWh	20 623.8	22 029.1	22 786.3	2 3920.2
	Electricity generation by solar power plants, TWh	0.6	0.8	1	1.4
	Electricity export volume, TWh	3 302.6	3 450	3 580	3 730
	The volume of electricity losses, per cent	23.3	19	17	15
Improvement and development of regulatory legal acts and policy documents on the efficient use of green energy and energy conservation	A legislative framework has been developed and the sector management system has been strengthened	-	-	-	-
Construction of various HPPs and reconstruction of existing HPPs	Small and medium HHPs put into operation	-	-	-	-
Production of electricity from other RES (solar, wind and bioenergy) in mountainous and favourable areas	Alternative power plants put into operation	-	-	-	-
Promotion of the widespread use of modern energy-saving and environmentally sound equipment by the population.	Increased public awareness of energy conservation	-	-	-	-
Gradual transition to the use of energy-saving technologies in the socioeconomic spheres of the country by improving legislation	A legislative framework has been established for the use of energy-saving technologies	-	-	-	-
Implementation of modern systems and technologies to reduce commercial and technological losses in the energy sector, including a billing system	Billing system works	-	-	-	-
Development and implementation of pilot projects for the construction of administrative, residential and industrial energy-saving facilities in Dushanbe and Khujand	Implemented energy saving systems in administrative, residential and industrial buildings	-	-	-	-

Source: Tajikistan, Ministry of Economic Development and Trade, Strategy for Development of the 'Green' Economy in the Republic of Tajikistan for 2023-2037 (2023). Available at https://www.gov.kz/memleket/entities/medt/documents/details/519312?lang=tg

7.4.2 Current measures for the development of lower-carbon energy

Tajikistan has a significant RES potential, especially for hydropower. The country ranks 8th in the world for hydropower potential and first in terms of hydropower potential per unit of the country's territory (3.6 million kWh/km^2 per year (Tajikistan, 2022)). Technical potential for hydropower in Tajikistan consists of 317 TWh of which only around 6 per cent is currently deployed. It is concentrated in the Vakhsh and Panj rivers. The potential for small hydropower constitutes around 23 GW. Among non-hydropower RES the technical potential of solar and wind power is estimated at 195 GW and 2 GW, respectively (ADB, 2022).

According to the Green Economy Strategy (Tajikistan, Ministry of Economic Development

and Trade, 2022), the main activities in the field of green energy and energy efficiency encompass, among others:

- improving legislation and developing regulatory legal acts in the field of efficient use of green energy and energy conservation;
- constructing HPPs of various capacities;
- producing electricity from other RES (solar, wind and bioenergy) in mountainous and favourable areas;
- introducing industrial production of solar batteries and panels using domestic raw materials;
- expanding the installation of solar panels at social and economic facilities;
- introducing the use of bioenergy in the economic and social spheres;
- encouraging the widespread use by the population of modern energy-saving and environmentally sound equipment;
- introducing modern systems and technologies to reduce commercial and technological losses of electricity, including a billing system.

National legislation provides several support measures for RES including effective pricing policy, protection from unfair competition, tax benefits, accelerated depreciation of equipment, guaranteed connection to networks, etc. (Tajikistan, 2010).

In addition, the Government is actively attracting development institutions to modernize existing HHPs' infrastructure, to support RES and to promote energy efficiency.

7.4.3 Key challenges and issues in lower-carbon energy development

There are ambitious green energy goals set in Tajikistan's Green Economy Strategy but there are also challenges for their achievement including:

- insufficient funding for the development of the country's energy sector;
- insufficient attraction of foreign direct investment for the development of a wide range of alternative energy sources;
- large difference between accounts receivable and accounts payable of JSC Barqi Tojik;
- lack of enterprises to produce the necessary equipment for power plants and enterprises for the production of electricity from alternative energy sources;
- lack of highly qualified specialists with international experience in this field;
- obsolete state of equipment for the production, transmission and distribution of electricity;
- high level of electricity losses;
- insufficient level of corporate governance in energy companies;
- a small proportion of the use of modern digital energy metering technologies (Tajikistan, Ministry of Economic Development and Trade, 2022).

7.4.4 Plans for cross-border power trade development

In Tajikistan, interest in developing cross-border electricity trade relates to the possibility of improving flexibility during winter to meet peak demand with imports and to gain revenues from exports. Besides, by exporting green energy from HPPs, Tajikistan will contribute to higher sustainability of the regional power sector. For example, in 2022 Tajikistan reached an agreement with Uzbekistan on 140 MW Yavan HHP which will export electricity to Uzbekistan (President of the Republic of Uzbekistan, 2022).

Along with reconnection with CAPS, Tajikistan has various near- and long-term regional electricity trading opportunities. The power sector development master plan (Tajikistan, Ministry of Energy and Water Resources, 2017), regards such options as:

CASA-1000 project: 500 kV link between Afghanistan, Kyrgyzstan, Pakistan and Tajikistan;

Turkmenistan-Uzbekistan-Tajikistan-Afghanistan-Pakistan (TUTAP) interconnection;

500 kV transmission line to Rogun-Peshawar (to Pakistan through Afghanistan);

500 kV transmission line to Xinjiang Uyghur Autonomous Region (China).

The CASA-1000 transmission line is under construction: the project was paused in 2021 due to political changes in Afghanistan, but at the beginning of 2024 the World Bank agreed to restart it (World Bank Group, 2024).

The prospects of other options are less clear. In particular, the IEA assessed connection with China as a long-term yet questionable opportunity as the Xinjiang Uyghur Autonomous Region is rich in energy resources.

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8 The Republic of Türkiye

8.1 Summary

Located at the cross-roads of Europe and Asia and having an advanced market economy, Türkiye has been experiencing significant economic growth over the last two decades. To meet the growing demands of its economy and population, Türkiye is continuously striving to increase its generation potential with diverse sources, despite having limited fossil fuel resources. It also partially covers the growing demand through imports and encourages the development of renewable energy.

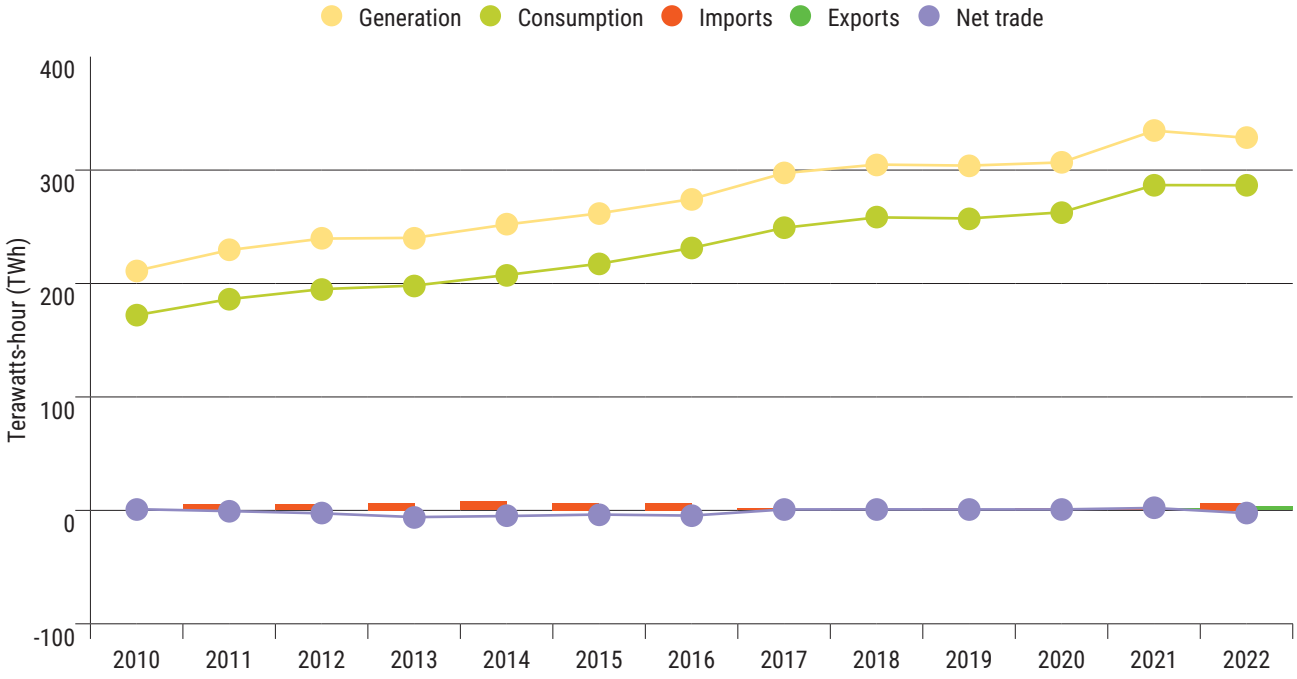
Overall, Türkiye has cross-border interconnections with all its onshore neighbours: Armenia, Azerbaijan, Bulgaria, Georgia, Greece, Iran (Islamic Republic of), Iraq and Syria. The country conducts continuous or interrupted power exchanges with these countries depending on geopolitical challenges, with the aim to ensure its energy security and contribute to regional energy cooperation.

8.2 Current situation in the electricity sector

8.2.1 Supply and demand balance

Despite having notable electricity generation capacities and significantly increasing its generation capacity between 2010-2022 (by 55 per cent), domestic electricity generation is not sufficient to meet the internal demand, and the country is still dependent on imports. Between 2010-2022, electricity consumption in Türkiye increased by 67 per cent due to population growth and industrial development, amounting to about 287 TWh in 2022 (figure 56). The losses in all dimensions (generation, transmission and distribution) constituted 16 per cent of the total electricity supply (Mehdi, 2023). The electricity consumption per capita in 2022 was 3.45 MWh, which was half of the OECD average for the same year (Türkiye, Ministry of Energy

Figure 56. Electricity supply, demand and trade in Türkiye, 2010-2022



Source: Türkiye, Ministry of Energy and Natural Resources, "Electricity", n.d.a. Available at https://enerji.gov.tr/infobank-energy-electricity
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and Natural Resources, n.d.a.; TEIAŞ, n.d.a). The overall access to electricity for population is 100 per cent (The World Bank, 2024).

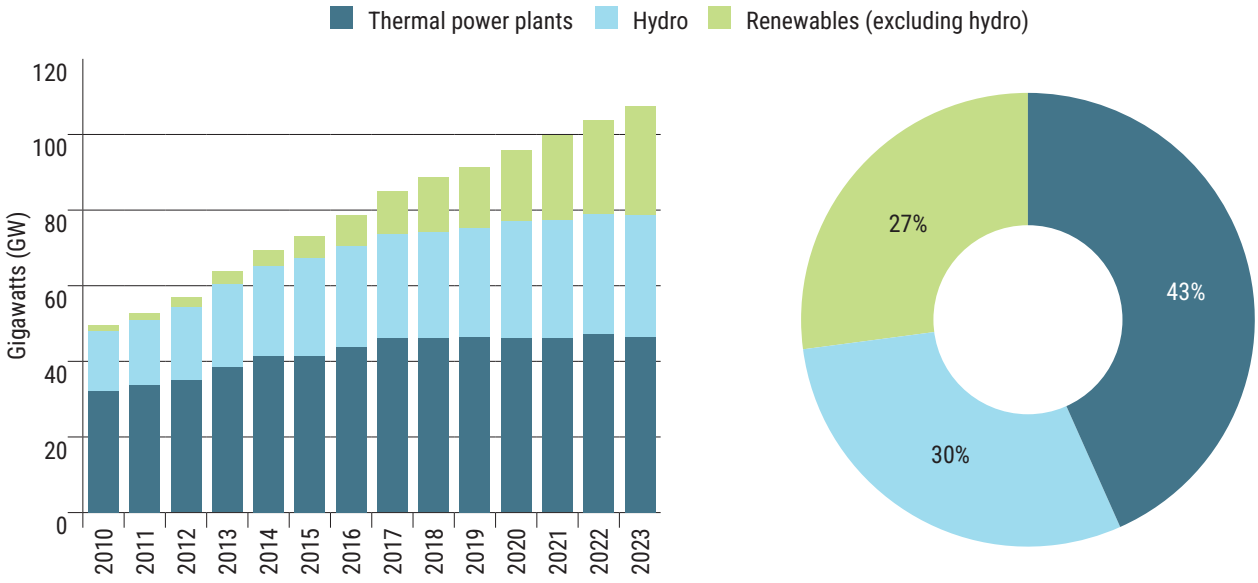
8.2.2 Capacity and generation

The electricity generation system in Türkiye has diverse patterns, ranging from various fuels to renewable energy sources. The country's total installed capacity has increased by a whopping 116 per cent in the period between 2010-2023 due to continuous market liberalization. As of the end of May 2024, Türkiye had a total installed capacity of over 110.340 gigawatts (GW): 46.84 GW of thermal, 32.18 GW of hydro and 31.23 of renewable energy power plants (wind, solar, geothermal and bioenergy) (Türkiye, Ministry of Energy and Natural Resources, n.d.a.). The state-owned generation company EÜAŞ is the main player in the generation sphere (20 per cent share), although its installed generation capacity has been decreasing since 2010 (Türkiye, Ministry of Energy and Natural Resources, n.d.a.). Thermal power plants are mainly dependent on the import of natural gas and coal. Some of these TPPs (22 per cent) utilize local lignite. As of May 2024, Türkiye had 763 hydraulic power plants, 69 coal power plants, 367 wind power plants, 63 geothermal power plants, 359 natural gas power plants, 23,730 solar and 474 other power plants.

Since the 2000s, the Turkish Government has been carrying out privatization to attract private investments and facilitate the procedures for private generation development (i.e., independent power producers). The share of IPPs increased from 44 per cent in 2010 to 67 per cent in 2023. Of the installed capacity of IPPs, 54 per cent is thermal, followed by hydro (22 per cent) and renewable energy (24 per cent). Furthermore, the Government is promoting renewable energy development through licensed and unlicensed mechanisms. Solar power dominates the unlicensed micro-scale renewable energy development (9.644 GW in 2023) (PwC Türkiye, 2023).

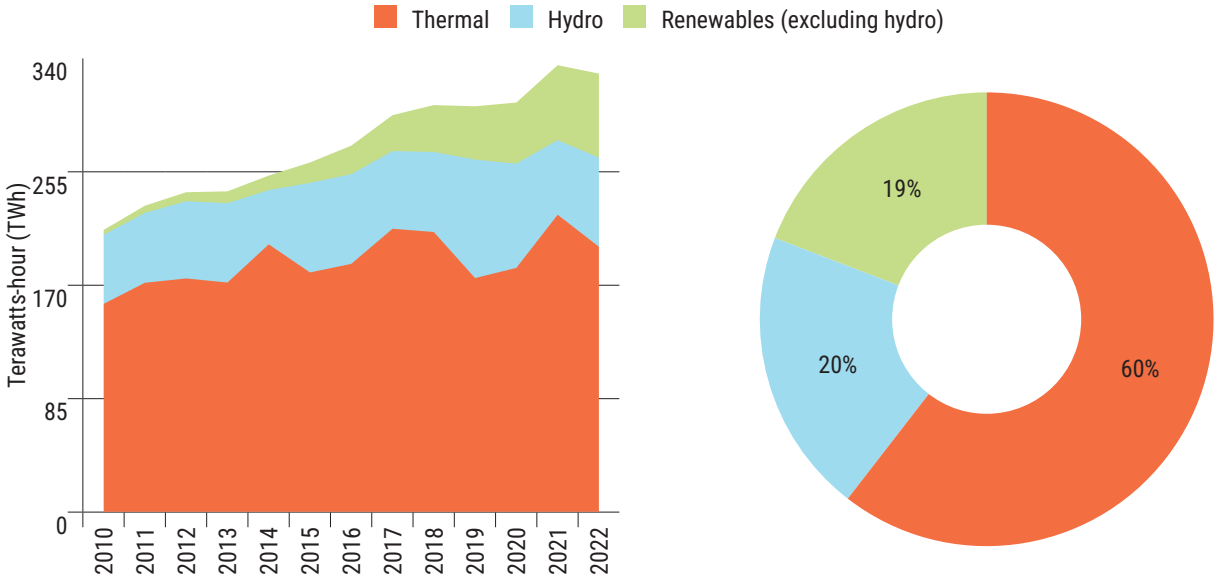
Approximately 58 per cent of electricity was produced by thermal power plants, 20 per cent by hydro power plants and 23 per cent from renewable energy plants in 2023 (figure 58). Imported coal dominates among fossil fuels in the thermal generation (22 per cent), followed

Figure 57. Electricity generation capacities trend in 2010-May 2024 (on the left), and breakdown by types in May 2024 (on the right)



Source: Türkiye, Ministry of Energy and Natural Resources, "Electricity", n.d.a. Available at https://enerji.gov.tr/infobank-energy-electricity; Turkish Electricity Transmission Corporation (TEIAŞ), "Power of Energy", n.d.a. Available at https://www.TEIAŞ.gov.tr/en-US

Figure 58. Electricity generation trend in 2010-2022 (TWh), and the breakdown by sources in 2022



Source: Türkiye, Ministry of Energy and Natural Resources, "Electricity", n.d.a. Available at https://enerji.gov.tr/infobank-energy-electricity; Turkish Electricity Transmission Corporation (TEIAŞ), "Power of Energy", n.d.a. Available at https://www.TEIAŞ.gov.tr/en-US

by imported natural gas (22 per cent) and local lignite (13 per cent).

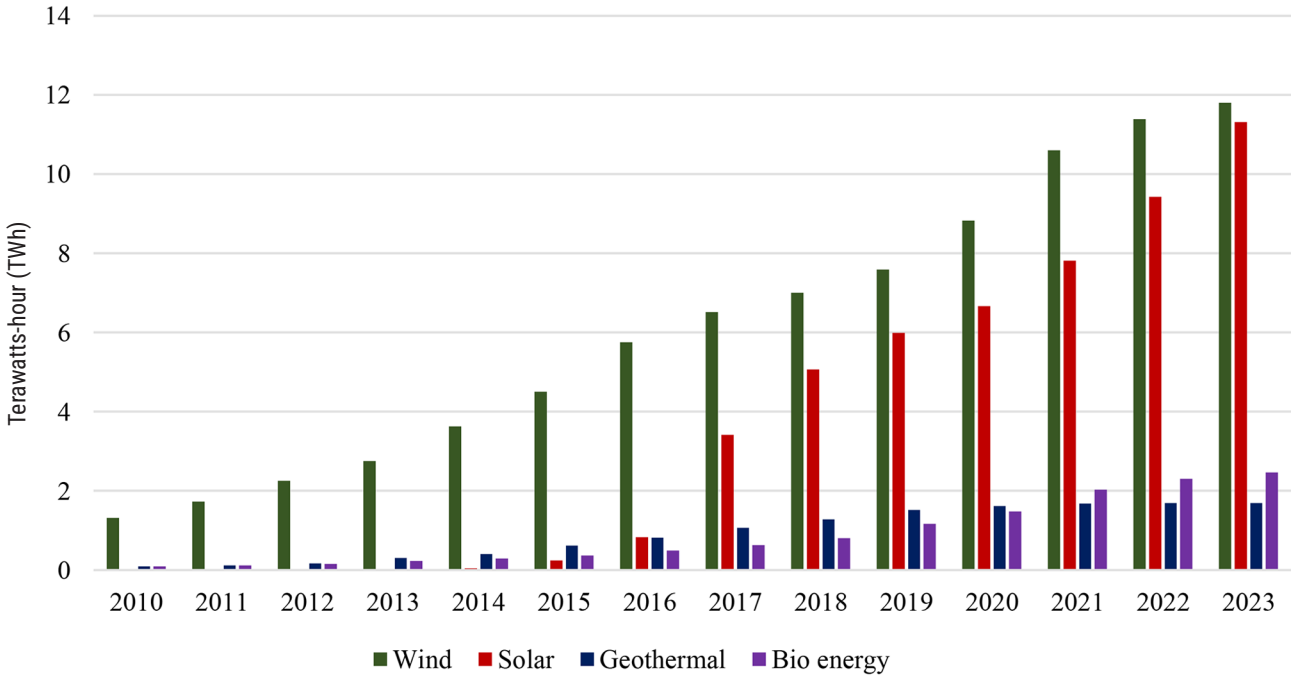
Hydropower is the second main generation source in the country. Although the hydropower generation capacity increased by 100 per cent between 2010-2022, the hydropower electricity generation increased only by 29 per cent in 2022 compared to 2010. This was due to fluctuating water resources owing to droughts in certain seasons.

Apart from fossil fuel and renewable energy plants, Türkiye has also prioritized the development of nuclear power plants (NPP) during the last two decades. It has already launched two nuclear power plant projects with foreign partners since 2010 as described below (Türkiye, Ministry of Energy and Natural Resources, 2022a; IEA, 2021; EIA, 2023):

- Akkuyu Nuclear Power Plant (4800 MW) – All the units are under construction and fresh nuclear fuel has reached the Akkuyu NPP site in April 2023 for the first reactor. The first unit is expected to be put into commercial operation by 2025 and other units in one-year intervals. The main equipment is from the Russian Federation, and the set sale price is 0.1235 USD/kWh.
- Sinop Nuclear Power Plant (4500 MW) – The expected equipment will be Japanese. The construction has not started, and no information is available on construction period.

Development of renewable energy commenced in Türkiye in early 2000s. The share of renewables (excluding hydro) in the total capacity and in the total generation in 2022 constituted 34 per cent and 27 per cent, respectively. Wind power plants have the highest share in the renewables (excluding hydro) (46 per cent), followed by solar (38 per cent), bioenergy (9 per cent) and geothermal energy (7 per cent). The Government has been undertaking a series of reforms in recent years to overcome technical and financial barriers to renewable energy development. In June 2021, the Green Certificate Market commenced in Türkiye with the aim to further promote renewables and reduce carbon emissions.

Figure 59. Electricity generation from renewable energy sources (excluding hydro) in Türkiye



Source: Türkiye, Ministry of Energy and Natural Resources, "Electricity", n.d.a. Available at https://enerji.gov.tr/infobank-energy-electricity; Turkish Electricity Transmission Corporation (TEIAŞ), "Power of Energy", n.d.a. Available at https://www.TEIAŞ.gov.tr/en-US

8.2.3 Imports and exports

Being an observer member of ENTSO-E (European Network of Transmission System Operators – Electricity), the power system in Türkiye is currently interconnected with the grids of Armenia, Azerbaijan (Nakhchivan AR), Bulgaria, Georgia, Greece, Iran (Islamic Republic of), Iraq and Syria. Türkiye had cross-border electricity transactions with all these countries between 2010-2022 to a certain extent, except with Armenia (the power flow between Türkiye and Armenia was suspended in early 1990s with the closure of borders between these countries). Figure 60 illustrates the cross-border transmission lines of Türkiye.

Türkiye was a net electricity importer between 2010-2022. In 2022, the country's electricity imports amounted to 6.44 TWh and was attributed to Azerbaijan, Bulgaria, Georgia and Greece. Exports amounted to 3.71 TWh and were channelled to Azerbaijan, Bulgaria, Georgia, Greece, Iraq and Syria (80 per cent of the total export) in the same year (figure 61 and figure 62). Table 39 below provides information on the cross-border transmission lines.

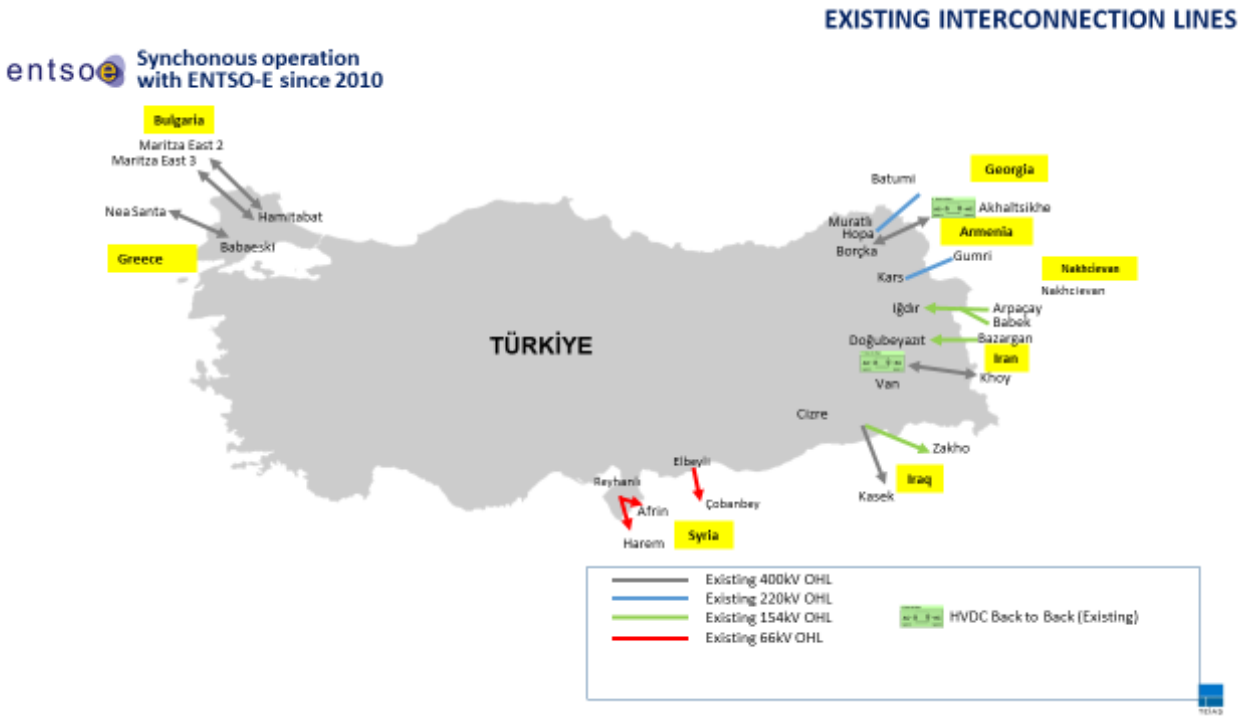
Figures 61 and 62 illustrate the volume of electricity exports to and imports from neighbouring countries in 2010-2022.

Table 39. Cross-border transmission lines in Türkiye

No.	Country	Transmission line	Voltage level (kV)
1.	Bulgaria	Hamitabat-Maritsa East (1st line)	400
2.	Bulgaria	Hamitabat-Maritsa East (2nd line)	400
3.	Greece	Babaeski-NeaSanta	400
4.	Georgia	Borchka-Akhaltsikhe	400
5.	Georgia	Hopa-Batumi	220
6.	Azerbaijan (Nakhchivan AR)	Ighdir-Arpachay	154
7.	Azerbaijan (Nakhchivan AR)	Aralik-Babek	154
8.	Iran (Islamic Republic of)	Doghubeyazit-Bazargan	154
9.	Iran (Islamic Republic of)	Van (Back-to-Back) – Khoy	400
10.	Iraq	Jizre-Kasek	400
11.	Iraq	Jizre-Zakho	154
12.	Syria	Reyhanli-Afrin	154*
13.	Syria	Reyhanli-Harem	154*
14.	Syria	Elbeyli-Chobanbey	154*
15.	Armenia	Qars-Gyumri	220

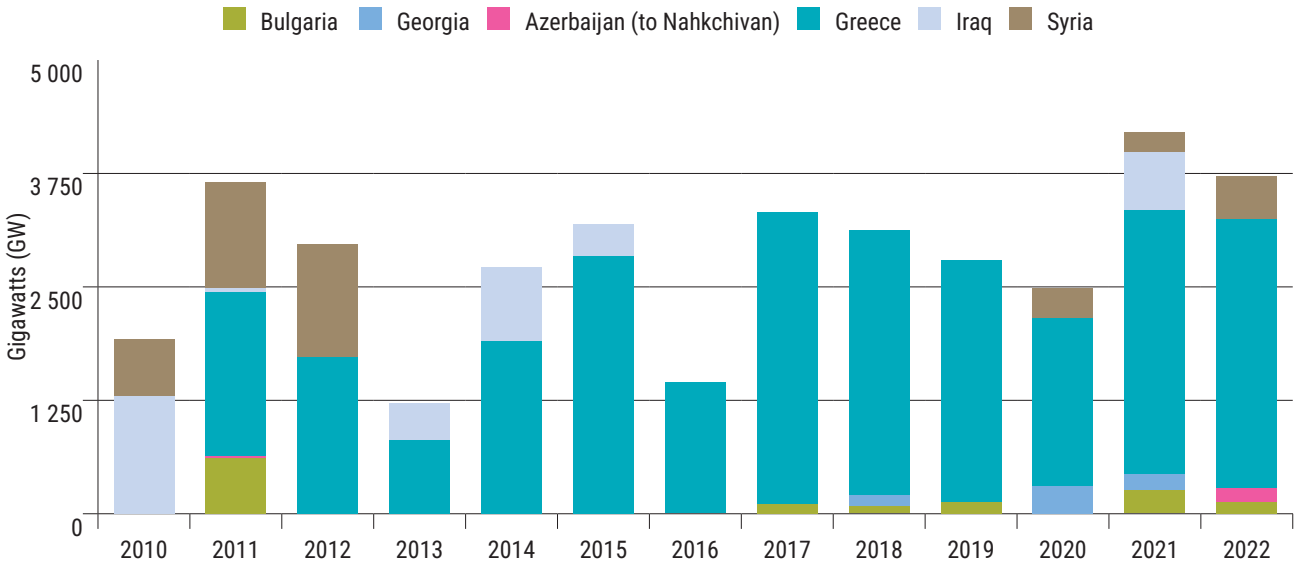
Source: Turkish Electricity Transmission Corporation (TEİAŞ), "Related Documents", n.d.b. Available at https://www.TEIAŞ.gov.tr/ilgili-dokumanlar
Note: * Operated at 66 kV voltage level.

Figure 60. Cross-border interconnections of Türkiye with this neighbours



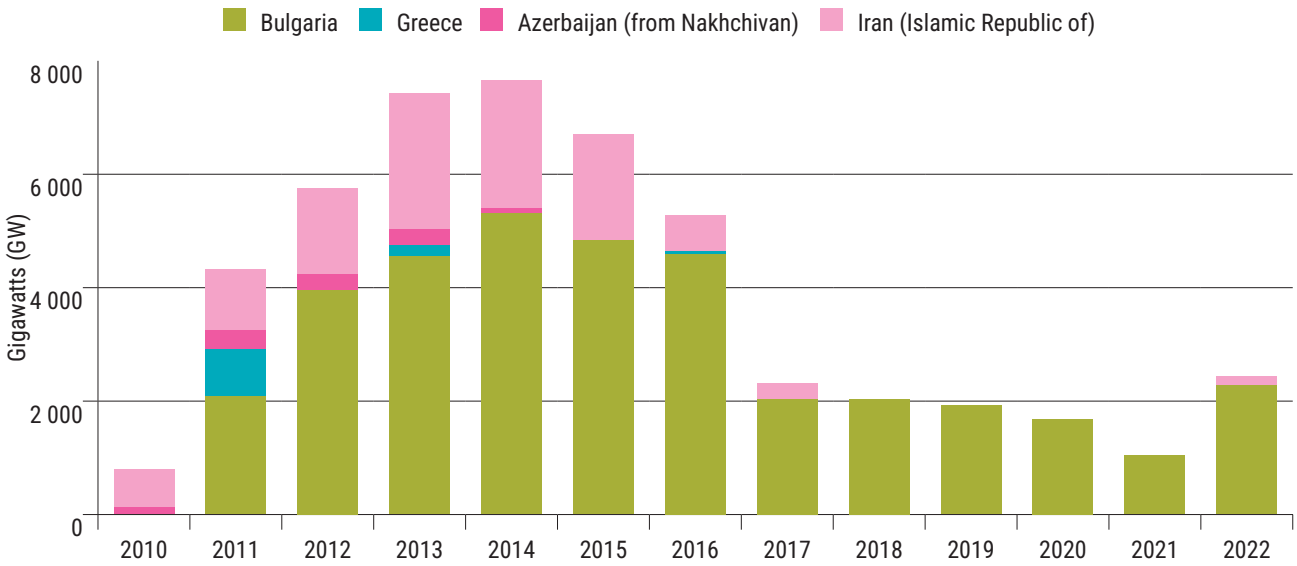
Source: International Energy Agency, "Turkey 2021: Energy Policy Review", 2021. Available at https://iea.blob.core.windows.net/assets/cc499a7b-b72a-466c-88de-d792a9daff44/Turkey_2021_Energy_Policy_Review.pdf
Disclaimer: The boundaries and names shown and the designations used in this map do not imply official endorsement or acceptance by the United Nations

Figure 61. Electricity exports in 2010-2022 (GWh)



Source: Türkiye, Ministry of Energy and Natural Resources, "Electricity", n.d.a. Available at https://enerji.gov.tr/infobank-energy-electricity; Turkish Electricity Transmission Corporation (TEIAŞ), "Power of Energy", n.d.a. Available at https://www.TEIAŞ.gov.tr/en-US

Figure 62. Electricity imports in 2010-2022 (GWh)



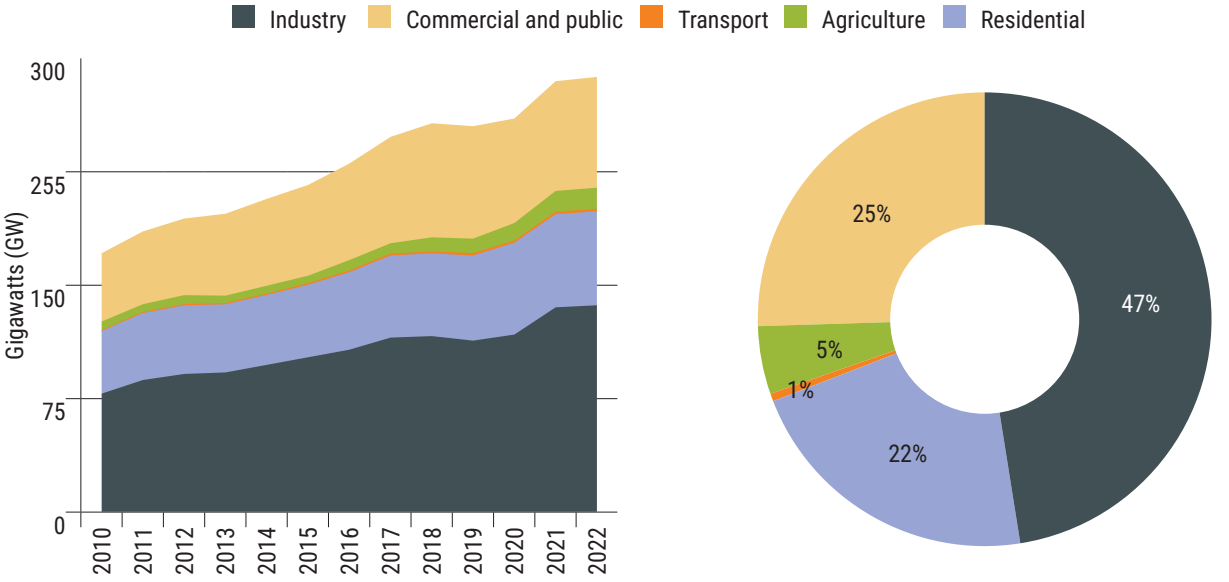
Source: Türkiye, Ministry of Energy and Natural Resources, "Electricity", n.d.a. Available at https://enerji.gov.tr/infobank-energy-electricity; Turkish Electricity Transmission Corporation (TEIAŞ), "Power of Energy", n.d.a. Available at https://www.TEIAŞ.gov.tr/en-US

8.2.4 Demand

The industrial sector had the highest share in electricity consumption in 2022 (47 per cent), followed by commercial and public services (25 per cent), the residential sector (22 per cent), agriculture (5 per cent) and transportation (1 per cent) (figure 63).

In terms of demand growth, in the period between 2010-2022, the transportation sector experienced remarkable growth (170 per cent), followed by agriculture, forestry and fishing (150 per cent), industry (75 per cent), commercial and public services (62 per cent), and the residential sector (50 per cent).

Figure 63. Electricity consumption by consumer groups in 2010-2022 (GWh) and the breakdown of consumption by categories in 2022



Source: Türkiye, Ministry of Energy and Natural Resources, "Electricity", n.d.a. Available at https://enerji.gov.tr/infobank-energy-electricity; Turkish Electricity Transmission Corporation (TEIAŞ), "Power of Energy", n.d.a. Available at https://www.TEIAŞ.gov.tr/en-US; PwC Türkiye, "Overview of Turkish Electricity Market", September 2023. Available at https://www.pwc.com.tr/tr/sektorler/enerji/2024/overview-of-the-turkish-electricity-market-2023.pdf

8.3 Electricity market regulation

8.3.1 Power market structure

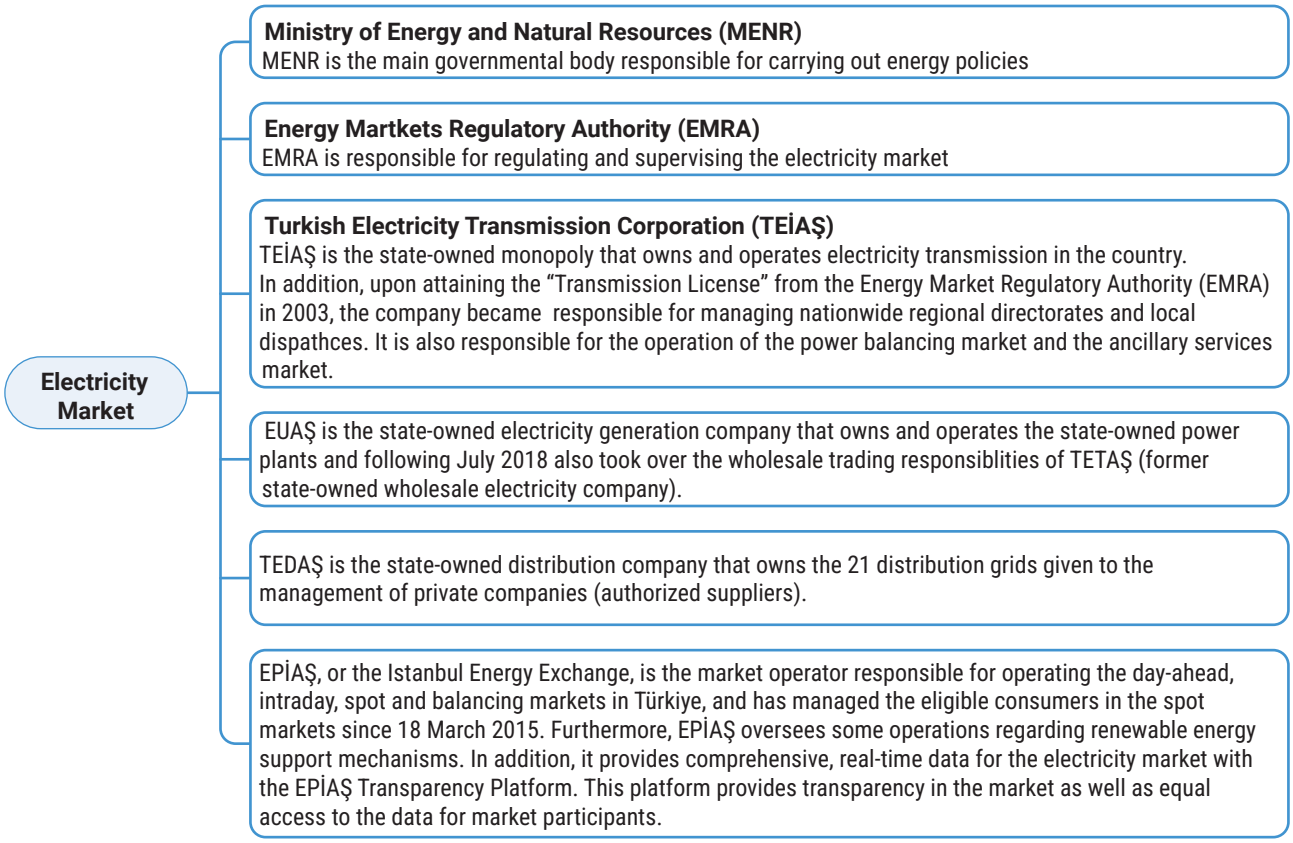
As a result of large-scale market liberalization and privatization efforts launched by the Turkish Government since the 2000s, the Government's involvement in the electricity sector has shrunk due to partial ownership (20 per cent) in generation, full ownership in transmission/dispatching and partial involvement in wholesale and distribution activities.

Figure 64 illustrates the agencies and companies that are the key state-owned institutions involved in the electricity market

There are 17 independent power producers generating electricity that have an installed capacity exceeding 1 GW, and thousands of licensed and unlicensed (up to 50 kW) private generators. The electricity supply/retail activities in the distribution grids are provided by 21 private companies managing the grids in 21 relevant regions. There are also over 150 private wholesale companies.

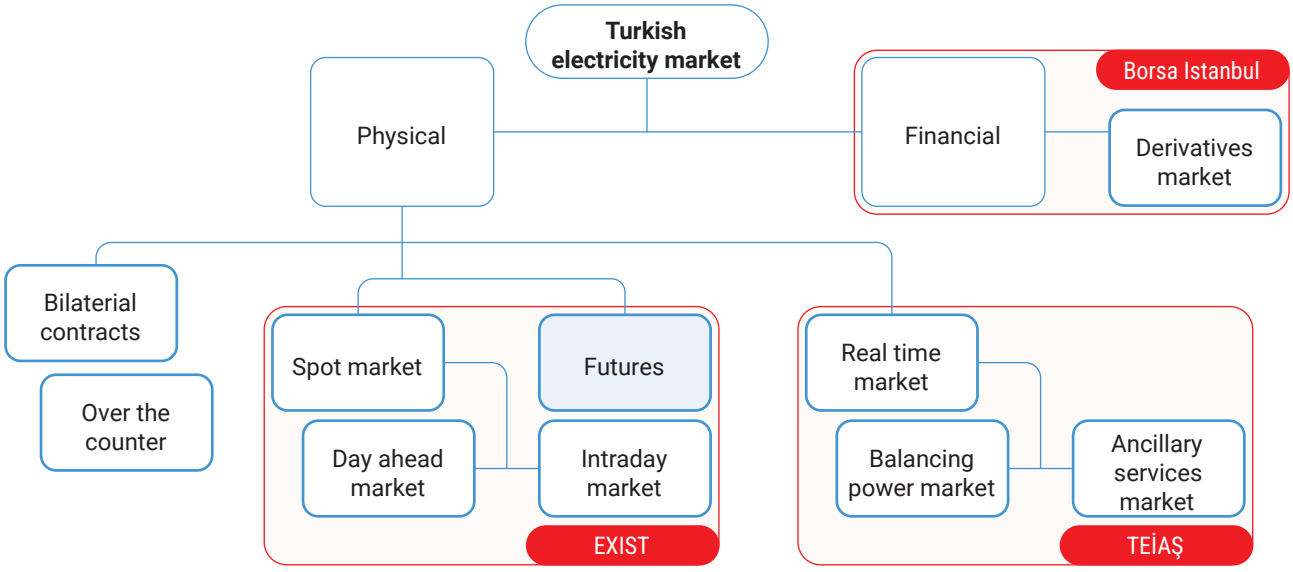
The EPIAŞ-run Istanbul Energy Exchange (EXIST) handles 47 per cent of the electricity trade in the country, the rest being covered by biliteral agreements. Figure 65 depicts the electricity market schematically for physical and financial operations. The sections separated with red lines illustrate the various trading instruments of electricity as a commodity in wholesale and financial products.

Figure 64. State-owned institutions and companies in the electricity market in Türkiye



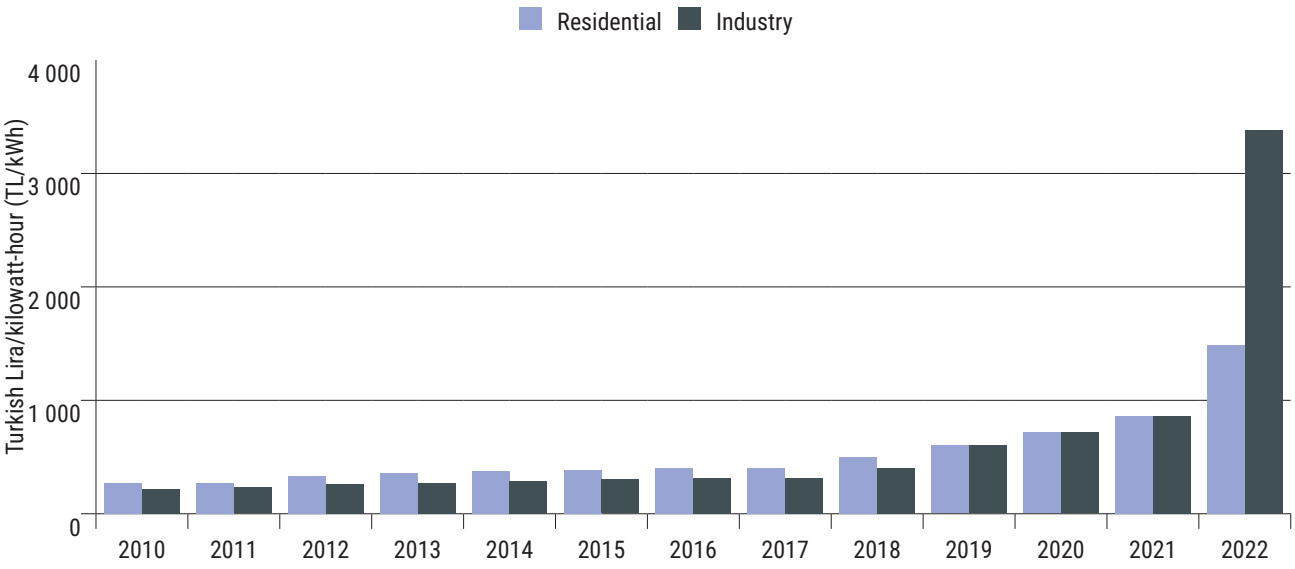
Source: Türkiye, Ministry of Energy and Natural Resources, "Home page", n.d.b. Available at https://enerji.gov.tr/homepage; Türkiye, Energy Market Regulatory Authority, "Home page", n.d. Available at https://www.epdk.gov.tr/Home/En; Türkiye, The Electricity Generation Corporation, "Home page", n.d. Available at https://www.euas.gov.tr/en-US; Turkish Electricity Transmission Corporation (TEIAŞ), "Power of Energy", n.d.a. Available at https://www.TEIAŞ.gov.tr/en-US; EPIAS https://www.epias.com.tr/en/

Figure 65. Electricity market operations in Türkiye



Source: International Energy Agency (IEA), "Turkey 2021: Energy Policy Review", 2021. Available at https://iea.blob.core.windows.net/assets/cc499a7b-b72a-466c-88de-d792a9daff44/Turkey_2021_Energy_Policy_Review.pdf

Figure 66. The trend of electricity prices in Turkish Lira



Source: International Energy Agency, "Data and Statistics", n.d. Available at https://www.iea.org/data-and-statistics

8.3.2 Tariffs

Wholesale electricity prices in Türkiye are deregulated and in cost-recovery levels as a result of EXIST and bilateral transactions. Transmission tariffs are set by TEIAŞ on an annual basis for each of the 14 transmission regions using Investment Cost Related Pricing methodology, and then approved by EMRA prior to application. Distribution tariffs are also set by EMRA for each distribution region by differentiating the load profiles of the five consumer groups: industrial, commercial, residential, agriculture and irrigation, and lighting (IEA, 2021). In general, retail tariffs have noticeably increased since 2022 due to volatility of energy prices in the international markets and depreciation of the Turkish Lira. However, the Government is trying to maintain residential tariffs amidst the economic challenges. The tariffs for relevant consumer groups in 2022 according to the exchange rates are:

- Residential – 0.0895 USD/kWh
- Industrial – 0.2 USD/kWh

8.3.3 Market reform

The reforms in the electricity market in Türkiye commenced in the 1970s with the establishment of the Turkish Electricity Administration (TEK). The reforms picked up pace between 1980 and 2023, with significant strides toward the creation of a complete electricity market and with the aim to reduce government involvement and attract private investments. Efforts include:

- Unbundling of TEK to independent generation, transmission and distribution companies;
- Enacting the Turkish Electricity Market Law;
- Establishing the Energy Regulatory Authority;
- Establishing the Organized Electricity Market;
- Introducing BOT (Build-Operate-Transfer), TOR (Transfer-Operating-Rights) and BOO (Build-Operate-Own) schemes for IPPs;

- Introducing renewable energy support mechanisms (feed-in-tariffs, tax incentives, auctions, unlicensed electricity for micro scales) for renewable energy developers;
- Introducing EXIST for Day-Ahead and Intra-Day electricity sales transactions;
- Introducing the Green Tariff (in the context of Green Certificate Market).

8.4 Plans and measures for electricity sector development

8.4.1 National goals and plans

The most recent strategic policy document that outlines future prospects for the electricity sector is the Türkiye National Energy Plan was announced by the Ministry of Energy and Natural Resources in 2022 (Türkiye, Ministry of Energy and Natural Resources, 2022b; IEA, 2024). This document sets forth projections and expectations for generation and consumption of electricity, however, does not provide any insight on electricity export-import balance. Furthermore, in 2023, the Ministry announced the Hydrogen Technologies Strategy and Roadmap that provides insights on future hydrogen development in the country. Table 40 documents the key points of the road map.

8.4.2 Current measures for the development of lower-carbon energy

In October 2021, Türkiye ratified the Paris Agreement and subsequently announced its commitment to achieve an economy with Net Zero Greenhouse Gas emissions by 2053. The National Energy Plan highlights the Ministry's expectations on targets that need to be met until 2035 to secure net zero GHG emissions by 2053. The Nationally Determined Contributions of Türkiye highlights the vision

Table 40. Prospects per segments for Türkiye

Segment	Projections and expectations
Generation	Period by 2035 • The total installed capacity will increase to 189.6 GW by 2035. The share of renewable energy sources will increase by 64.7 per cent by 2035. Hydropower plants will reach an installed capacity of 35.1. Wind power installed capacity will increase to 29.6 GW and solar power installed capacity will increase to 52.9 GW. • The share of renewable energy sources in electricity generation will increase by 54.8 per cent by 2035. • Electricity generation in coal-fired plants will continue to decrease. • Battery capacity is expected to increase through intermittent renewable energy sources to 7.5 GW by 2035. • Electrolyzer capacity for hydrogen production will increase to 5 GW by 2035. Period of 2035-2053 • Nuclear energy will reach a share of 30 per cent (42-47 GW) in 2053. • The share of fossil resources will increase by 20.8 per cent by 2053. The share of coal will fall to 3.6 per cent, and the share of oil and natural gas will fall to 5.6 per cent and 11.7 per cent, respectively. • The share of renewable energy sources in the installed capacity will reach 69.1 per cent by 2053.
Consumption	• Annual electricity consumption is projected to surpass 500 TWh and the industry and service sectors are expected to constitute more than 50 per cent of the total consumption. • The share of transportation sector in electricity consumption is expected to increase to 6 per cent in 2035. • Industry will retain dominance in the consumption, followed by services and residential sectors.

Source: Türkiye, Ministry of Energy and Natural Resources, *Türkiye National Energy Plan*. Available at https://enerji.gov.tr/Media/Dizin/EIGM/tr/Raporlar/TUEP/T%C3%BCrkiye_National_Energy_Plan.pdf; International Energy Agency (IEA), "Hydrogen Technologies Strategy and Roadmap", 30 January 2024. Available at https://www.iea.org/policies/17216-hydrogen-technologies-strategy-and-road map

to reduce the greenhouse gas emissions by 41 per cent by 2030 compared to a baseline.

To further support the renewable energy development in the country, the Government is conducting the following steps:

- The renewable power plants operational since July 2021 will continue benefiting from feed-in-tariffs until 2030;
- Since 2023, EMRA has started issuing licenses for electricity storage capacities. Applicants that receive licenses to establish an electrical storage facility will have the license to build and operate a wind (minimum 20 MW) or solar power plant (minimum 10 MW and maximum 250 MW) with the same capacity of the storage facility;
- Since 2022, EMRA has started issuing licenses for the electrical vehicle charging stations;
- Continue fostering unlicensed electricity generation (up to 5 MW) by EMRA that focuses on renewable energy development.

8.4.3 Key challenges and issues in lower-carbon energy development

Despite the well-developed and functional electricity market, Türkiye faces challenges for low-carbon development. These include:

- Lack of support systems to ensure that dispatchable renewables generation react to short-term issues and that local content requirements and import duties do not impede system cost savings;
- Arduous licensing procedure (including a high number of permits required) which discourages more investments to renewable energy development;
- Limited operations of the Green Certificate Market;
- Lack of development in renewable energy in order to expand exports of green energy.

8.4.4 Plans for cross-border power trade development

Among the ECO member states, Türkiye is expanding electricity trading initiatives with Azerbaijan and Iran (Islamic Republic of). On January 2024, the Iranian Electricity Transmission Operator IGMC and TEIAŞ signed the Operational Agreement on 400-kV Van Back-to-Back – Khoy Interconnection Line (TEIAŞ, 2024).

Türkiye will serve as a buyer and transit country in the export of Azerbaijani green electricity to Europe (Azerbaijan – Türkiye – Europe Energy Hub and Green Energy Export to Europe initiatives) (for more information, see the chapter on Azerbaijan) (Ashirov, 2023; Azernews, 2023).

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9 Turkmenistan

9.1 Summary

The power system in Turkmenistan is profitable, with an estimated power generation capacity utilization factor at 46 per cent. The generation capacity is based on 13 large natural gas power plants which use the country's own resources. Renewable power capacity is very low, despite the high potential for solar and wind generation.

The country is 100 per cent grid electrified. The electric power industry (generation and grids) is under state management and the country does not have an unbundled electricity market. Domestic electricity prices are regulated and export prices are subject to bilateral agreements. Turkmenistan is interested in and is actively implementing projects to expand electricity exports to other countries.

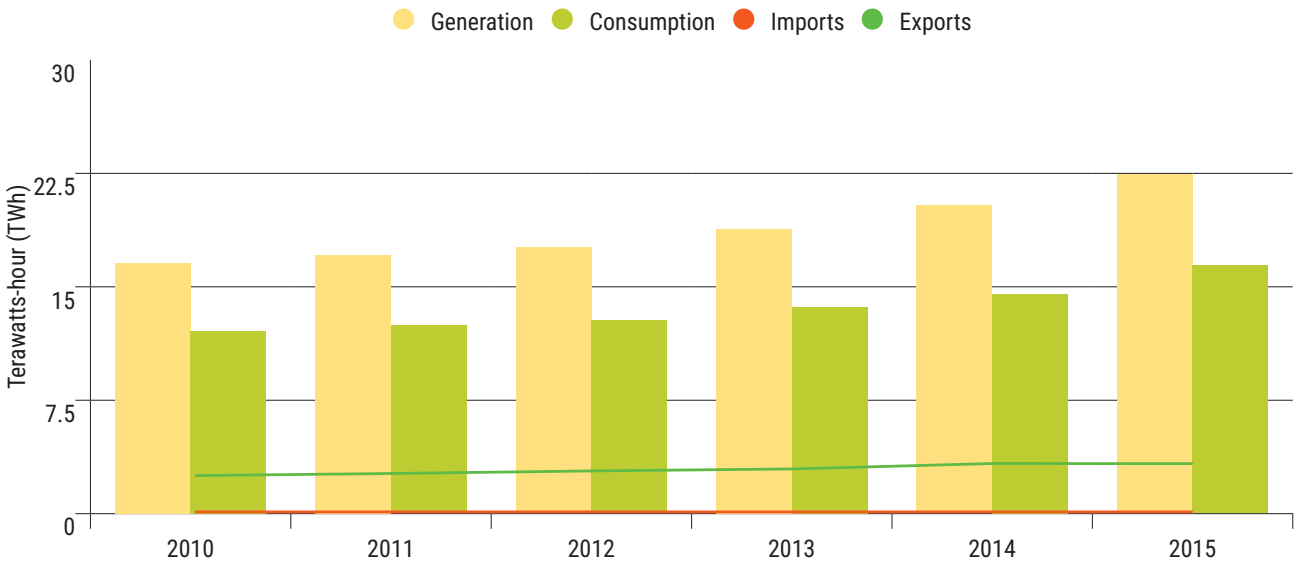
9.2 Current situation in the electricity sector

9.2.1 Supply and demand balance

The energy system in Turkmenistan is profitable. In 2021, electricity consumption per capita was about 2,592 kWh/person (55 per cent increase from 2000 to 2021 (IEA, 2023)). The entire population has access to electricity (100 per cent).

Since 2016, full data on the electricity balance has not been published, hence only individual indicators are available for analysis (see below).

Figure 67. Electricity supply, demand and trade in Turkmenistan, 2010-2022



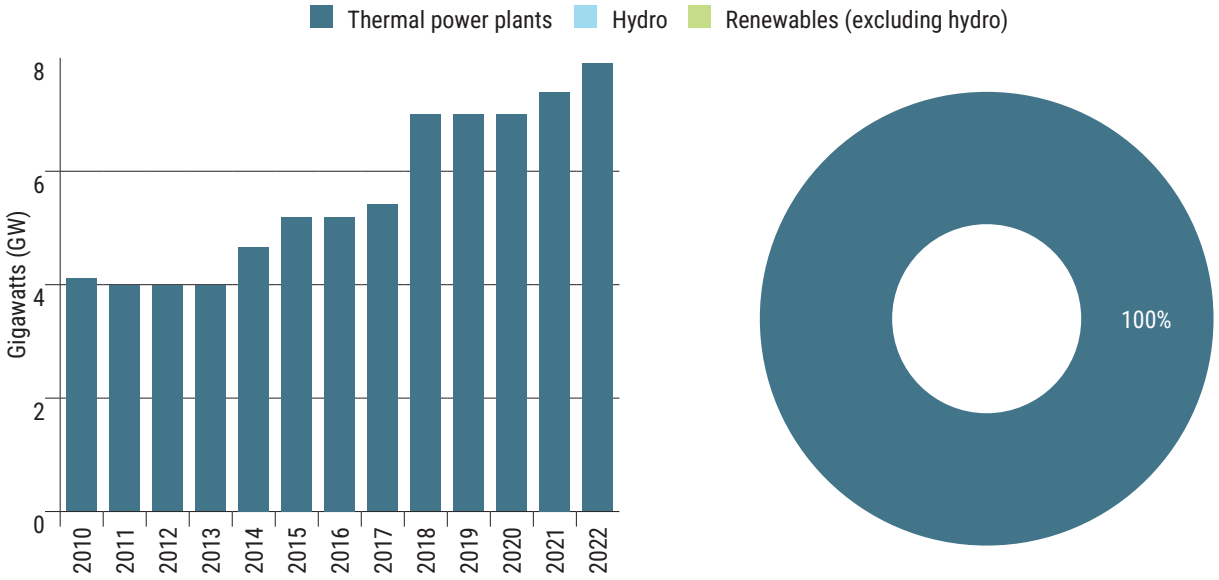
Source: United States Energy Information Administration (EIA), "Turkmenistan", n.d. Available at https://www.eia.gov/international/data/country/TKM

9.2.2 Capacity and generation

In 2022, the capacity of electric power plants in Turkmenistan was 7.9 GW, which is 1.9 times higher as compared to 2010. Between 2010-2022, the increase in energy capacity came only from thermal power plants (TPP) due to new construction and upgrade.

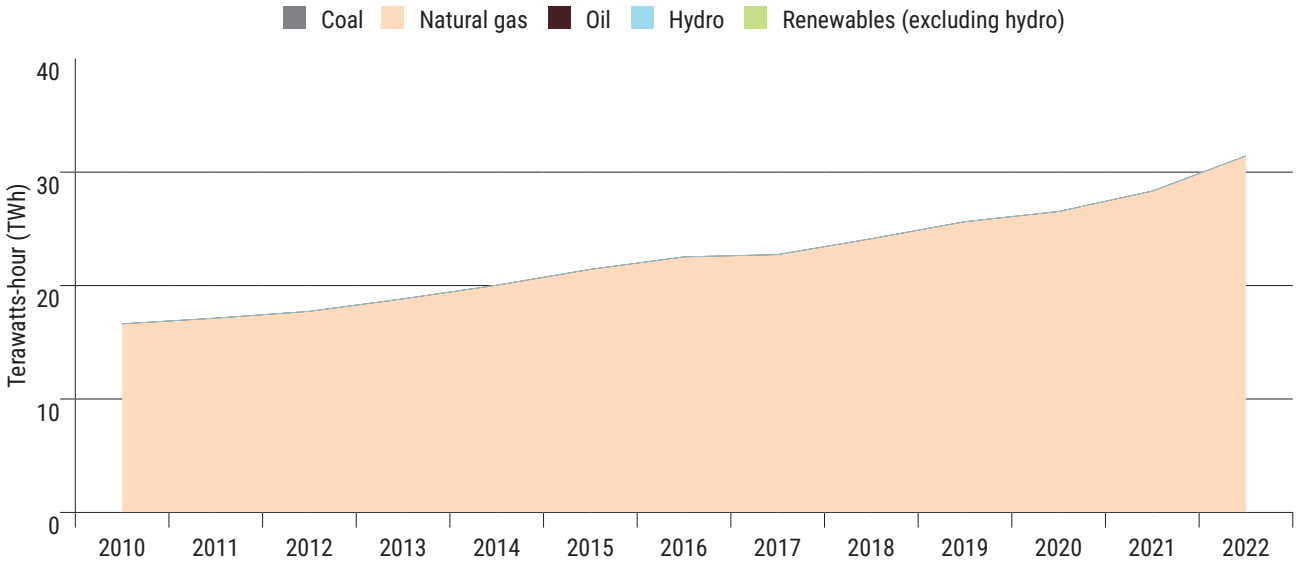
The structure of energy capacity is dominated by TPPs (13 large units) that run on natural gas with a share close to 100 per cent in 2022.

Figure 68. Electricity capacity in Turkmenistan, 2010-2022 (left) and by source, 2022 (right)



Source: CIS Electric Power Council, "Electric Power Industry of Turkmenistan (2010-2015)", n.d. Available at http://energo-cis.ru/wyswyg/file/ news/%D0%AD%D0%BD%D0%B5%D1%80%D0%B3%D0%BE%D1%81%D0%B8%D1%81%D1%82%D0%B5%D0%BC%D0%B0_%D0%A2%D1%83%D1%80%D0%BA%D0%BC%D0%B5%D0%BD%D0%B8%D1%81%D1%82%D0%B0%D0%BD%D0%B0.pdf (Translated in English); International Renewable Energy Agency (IRENA), "Energy Profile: Turkmenistan", 2024. Available at https://www.irena.org/-/media/Files/IRENA/Agency/Statistics/Statistical_Profiles/Asia/Turkmenistan_Asia_RE_SP.pdf

Figure 69. Electricity generation by source, 2010-2022



Source: Interstate Statistical Committee of the Commonwealth of Independent States, "Home page", n.d. Available at https://new.cisstat.org/web/eng/cis-stat-home; United States Energy Information Administration (EIA), "Turkmenistan: Data – Hydrocarbon Gas Liquids", n.d. Available at https://www.eia.gov/international/data/country/TKM

The rest is covered by one small-capacity hydropower plant. However, there is a high potential for solar and wind generation.

The reliability of power supply is low (ADB, 2018), with no reserve capacity. This is due to a lack of technical modernization of grids. Nonetheless, the process to modernize is underway (including the support of the Asian Development Bank).

The power system of Turkmenistan is synchronized with the power system of Iran (Islamic Republic of). Turkmenistan exited the Unified Power System of Central Asia in 2003 and several power plants operate in "island" mode with Uzbekistan.

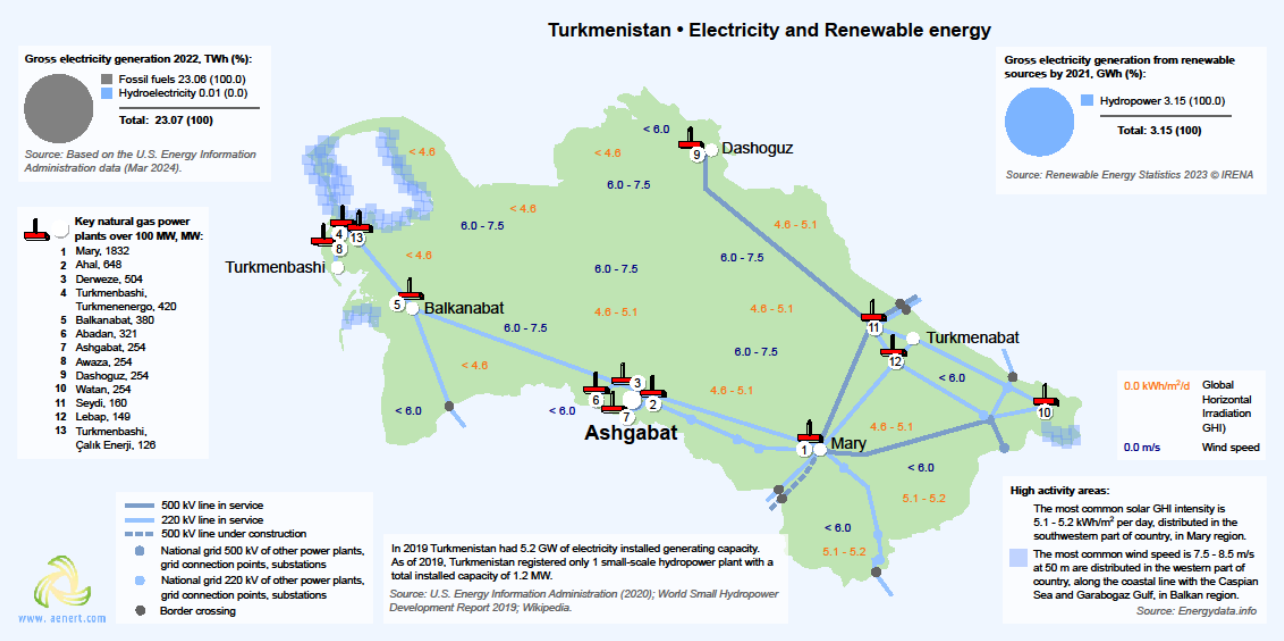
Table 41. Cross-border electricity trade of Turkmenistan, billion kWh, 2019-2023

Country	2019	2020	2021	2022	2023
Exports					
Uzbekistan	0.66	3.20	4.21	4.53	4.02
Kyrgyzstan (via Uzbekistan)			0.50	2.11	1.90*
Iran (Islamic Republic of)	1.11*	1.21*	1.14*	0.89*	1.74*
Afghanistan	0.69	0.73	1.08	1.47	1.42

Source: CDC Energia, "Cooperation within the framework of the Central Asian Unified Power System", April 2024. Available at https://www.carecprogram.org/uploads/CDC-presentation-Dr-Shamshiev-ESCC-2024-ENG.pdf; National Statistical Committee of the Kyrgyz Republic, Foreign and mutual trade of the Kyrgyz Republic in goods (Translated in English). Available at https://www.stat.gov.kg/ru/publications/vneshnyaya-i-vzaimnaya-torgovlya-tovarami-kyrgyzskoj-respubliki/; ORIENT, "Turkmenistan is expanding its electricity supply network to Afghanistan: routes and projects", 4 March 2024b. Available at https://orient.tm/en/post/69366/turkmenistan-expanding-its-electricity-supply-network-afghanistan-routes-and-projects; International Trade Centre (ITC), "Trade Map", 2019. Available at https://www.trademap.org/Country_SelProductCountry_ TS.aspx?nvpm=1%7c795%7c%7c%7c%7c2716%7c%7c%7c%4%7c1%7c2%7c2%7c2%7c1%7c%7c2%7c1%7c1

Note: * estimated

Figure 70. Electricity transmission network of Turkmenistan



Source: Advanced Energy Technologies (Aenert), "Turkmenistan: Electricity and Renewable Energy", 2024. Available at https://aenert.com/fileadmin/default/templates/images/Turkmenistan/2024_map/aenert_map_Turkmen_el_ren24.pdf

Disclaimer: The boundaries and names shown and the designations used in this map do not imply official endorsement or acceptance by the United Nations.

9.2.3 Imports and exports

The electric power system of Turkmenistan is connected with Afghanistan (500 kV (used as 220 kV), 110kV)), Iran (Islamic Republic of) (220 kV), and Uzbekistan (through 500 kV and 220 kV lines).

Cross-border transmission capacity of Turkmenistan is at 2622 MW: 216 MW with Afghanistan and 460 MW with Iran (Islamic Republic of) (Moore Afghanistan, 2017), and 1946 MW with Uzbekistan (ECE, 2024).

Turkmenistan is an exporter of electricity and electricity exports amounted to 9 billion kWh in 2023.

9.2.4 Demand

Electricity supply to the domestic market in 2015 amounted to 19 billion kWh (an increase of 36 per cent compared to 2010). About 3 billion kWh (15 per cent) were registered as losses. The structure of final electricity consumption is dominated by the industry sector (36 per cent in 2015) and agriculture (32 per cent).

9.3 Electricity market regulation

Electric power industry (generation and grids) is under state management.

Electricity prices (tariffs) in Turkmenistan are regulated by the President's Act and prices are set for consumers of different groups (categories).

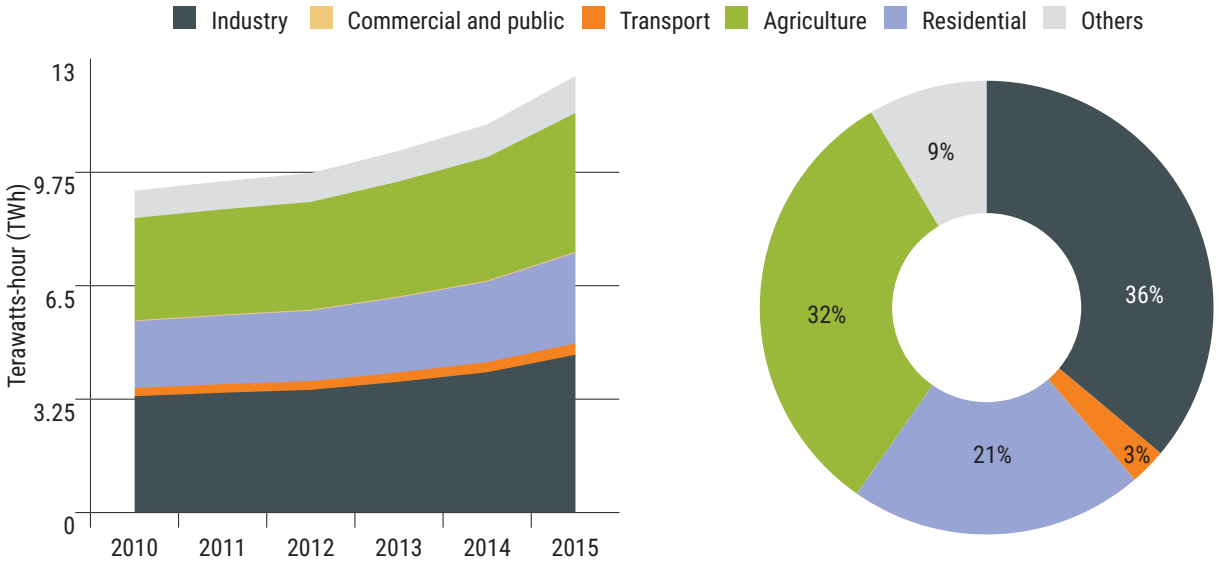
9.4 Plans and prospects for the development of the electric power industry

9.4.1 National goals and plans

In order to increase the energy potential of Turkmenistan and introduce environmentally friendly technologies, six plants are due to be conversed to cogeneration. Additionally, two more combined power plants are planned to be built (Turkmenistan, 2022) together with a solar-wind power plant with the capacity of 10 MW (Turkmenistan, 2019b).

By 2028, the total volume of electricity production is expected to increase to

Figure 71. Electricity consumption by sector, 2010-2015 (left) and 2015 (right)



Source: International Energy Agency (IEA), "Turkmenistan", n.d. Available at https://www.iea.org/countries/turkmenistan/electricity#how-is-electricity-used-in-turkmenistan

Table 42. Electricity prices in Turkmenistan (from November 2017)

Consumer's category	Price* (excl. VAT), USD/kWh
Budget–funded and equivalent legal entities	0.00946
State–owned self-supporting legal entities	0.01794
Non-state-owned legal entities and individuals engaged in entrepreneurship	
Foreign citizens who have a document issued in accordance with the legislation of Turkmenistan granting the right to reside in the territory of Turkmenistan	0.00620
For stateless persons and refugees	
Legal entities established in accordance with the legislation of foreign countries, carrying out their activities through a representative office and branch registered in Turkmenistan	3.58000
Diplomatic missions accredited in Turkmenistan, consular offices of foreign states and permanent missions to interstate, intergovernmental, international organizations of these states, as well as for interstate, intergovernmental, international organizations, their branches and permanent missions in Turkmenistan	0.00946
Citizens of Turkmenistan who are not engaged in entrepreneurial activities (consumed above the free limits 35 kWh***)	0.00714**

Source: Embassy of Turkmenistan, "New tariffs for utilities, communications and transport services will be introduced from November 1, 2017", n.d.. Available at https://uk.tmembassy.gov.tm/en/news/6355
Note: * calculated at the exchange rate USD/TMT in April 2024.
** including VAT.
*** cancelled since 2019 (Chronicles of Turkmenistan, 2018).

37.5 billion kilowatt-hours, which is a 22.5 per cent increase in volume as compared to 2022 (Turkmenistan, 2019a). Moreover, 3,631 kilometres of power lines are to be laid to ensure that 100 per cent of the population has access to inexpensive, reliable and modern energy supply.

9.4.2 Current measures for the development of lower-carbon energy

The Nationally Determined Contribution of Turkmenistan sets a target for 20 per cent reduction in its greenhouse gas emissions in 2030 under the business-as-usual scenario, relative to 2010 emissions. The development of the National Mitigation Plan (NPM) is planned only for 2023-2029.

The National Strategy of Turkmenistan on Climate Change outlines the main policy directions for a consistent transition to an economy with the lowest greenhouse gas emissions (UNDP, n.d). This includes energy efficiency and energy saving; rational use of natural gas and petroleum products; and expansion of the use of renewable energy sources. In the electric power sector, strengthening of economic and financial incentives is expected, together with developing a national system of pricing and tariffing.

The National Strategy for the Development of Renewable Energy in Turkmenistan until 2030 has also been adopted.

Another relevant area of development of alternative energy sources is hydrogen energy, which has high energy efficiency. In 2022, the country developed a road map for the development of international cooperation in hydrogen energy of Turkmenistan for 2022–2023.

At the end of 2020, Turkmenistan adopted the Programme for the Development of Energy Diplomacy in Turkmenistan 2021–2025, which aimed at increasing cooperation with international organizations in the field of energy.

In June 2023, a road map for the development of international cooperation aimed at studying the issue of access to the Global Methane Commitment for 2023–2024, as well as an action plan for its implementation, was approved.

9.4.3 Key challenges and issues in lower-carbon energy development

The natural and climatic conditions of Turkmenistan are favourable for the increased use of renewable energy sources (wind and solar energy). However, the abundance of available fossil fuels is slowing the progress toward the development of renewable energy sources. There are very high energy subsidies leading to free access to energy, which is not conducive to energy savings. Turkmenistan has one of the most difficult business environments in the region (ECE, 2022). Though the investment climate is improving, it is still limited by non-transparent regulations (Radovanović, 2021).

9.4.5 Plans for cross-border power trade development

Turkmenistan plans to increase its electricity exports (ORIENT, 2024a) and is making plans to expand cross-border power transmission lines (Neftegaz, 2022).

In addition to expanding exports to current partners, Turkmenistan is interested in exporting electricity to the markets of the Caucasus (via Iran (Islamic Republic of)), South Asia (via Afghanistan) (Internet Portal CIS, 2023) and Kazakhstan (via Uzbekistan) (Informburo, 2024). The possibility of supplying electricity through third countries to Türkiye is also being discussed (Neftegaz, 2023).

To ensure, among other things, exports and market connectivity, the Asian Development Bank (ADB) is financing a project to build ring trunk power lines throughout the country (ADB, 2024).

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10 The Republic of Uzbekistan

10.1 Summary

The consumption of electricity has rapidly increased in Uzbekistan, mainly due to industrial development and population growth. Trade in electricity with neighbouring countries is the basis of the country's energy security. In recent years, a reform of the electricity market has been implemented, which aims at developing competition and increasing efficiency. The main priorities for energy development are: expanding the use of low-carbon energy sources, primarily renewable energy sources and nuclear energy; increasing energy efficiency; and reducing losses in the transmission and distribution of electricity. In 2023, ambitious goals were approved to increase the volume of renewable energy to 25 GW by 2030. Expanding cross-border trade in electricity with Afghanistan and Tajikistan, through the development of an electricity grid, is also an important task in the energy sector.

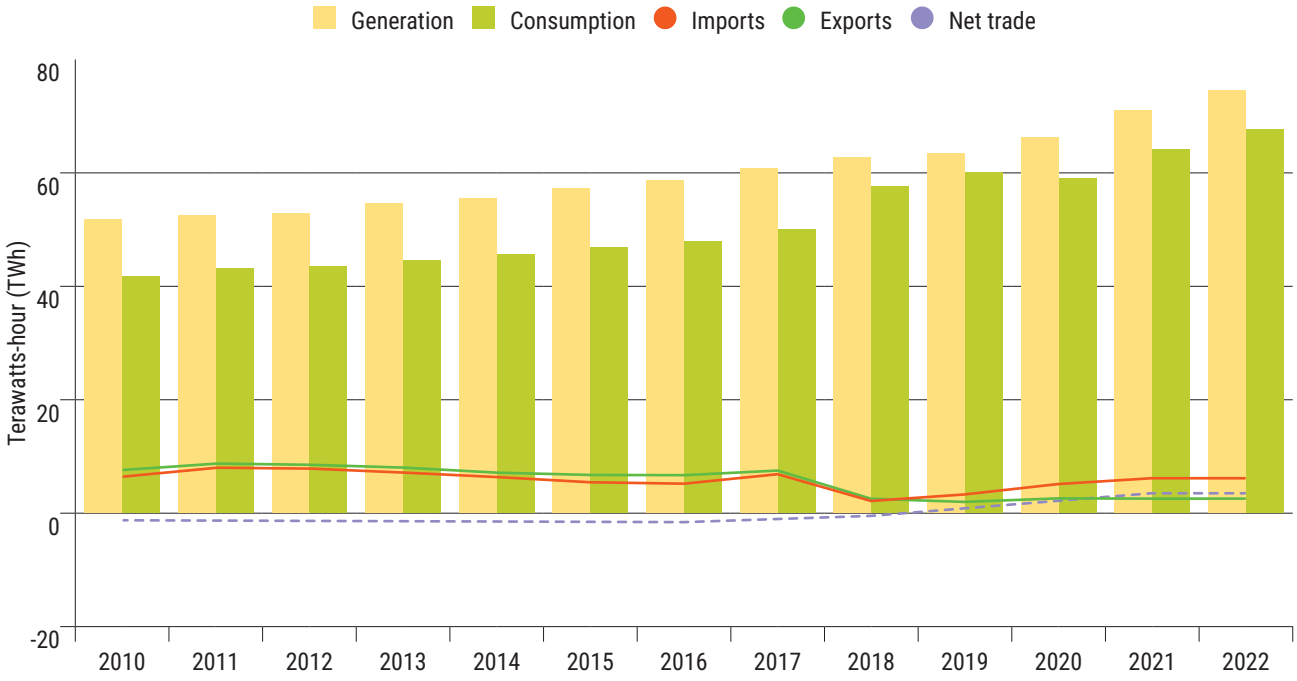
10.2 Current situation in the electricity sector

10.2.1 Supply and demand balance

Over the past 10 years, Uzbekistan has been characterized by high growth rates in electricity demand. This growth is mainly due to economic development and population growth. The increase in electricity demand was covered by domestic production, while net electricity imports fell.

In 2022, electricity consumption per capita in Uzbekistan was about 1900 kWh/person, which is almost half of the global average

Figure 72. Electricity supply, demand and trade in Uzbekistan, 2010-2022



Source: United States Energy Information Administration (EIA) "Uzbekistan: Data", n.d. Available at https://www.eia.gov/international/data/country/UZB/electricity/electricity-capacity?pd=2&p=0000000000000000000007vo7&u=0&f=A&v=mapbubble&a=-&i=none&vo=value&t=C&g=none&l=249--241&s=315532800000&e=1640995200000&

(about 3,400 kWh/person). Electrification of final consumption in Uzbekistan will require the development of national energy in the future.

10.2.2 Capacity and generation

Between 2010-2023, the main increase in energy capacity came from thermal power plants (TPP) running on natural gas.

TPPs dominate the structure of energy capacity in Uzbekistan, having a share of 86 per cent in 2022. In the same year, the capacity of TPP was 14.6 GW, up by 48 per cent from 2010 levels.

Hydropower is the second source of energy. Between 2010-2022, the growth in hydropower capacity was only 15 per cent, and its share in the energy mix fell from 15 per cent in 2010 to 12 per cent in 2022.

Alternative renewable energy sources (excluding hydropower) did not receive widespread development in Uzbekistan until 2022. In 2022, the share of renewable energy sources in energy capacity was only 2 per cent and was represented by solar power plants.

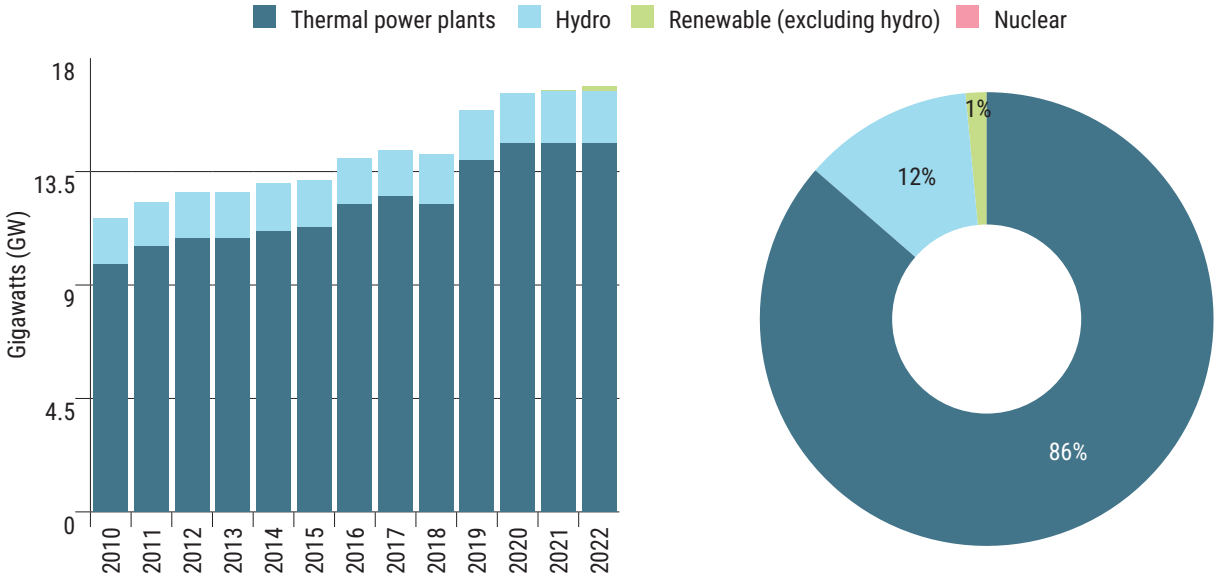
In 2022, the development of solar energy began and its capacity at the end of the year amounted to 0.3 GW (about 2 per cent of total capacity) (EIA, n.d.).

In 2023, seven solar and wind power plants were launched with a total capacity of 2600 MW (at the beginning of 2024, solar and wind power plants accounted for over 10 per cent of total power capacity) (President of the Republic of Uzbekistan, 2023). As of the end of 2023, the installed capacity of power plants in Uzbekistan was about 20 GW (BMI, 2024).

Natural gas dominated the electricity generation mix with 88 per cent in 2022, and its share has grown between 2010-2022. This was achieved through the commissioning of new capacities of TPP.

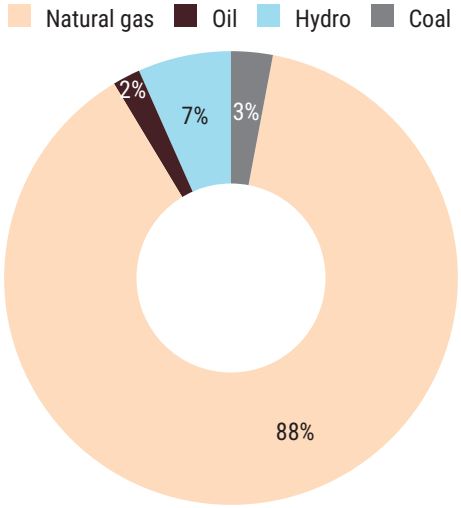
The Government is pursuing a policy of diversifying energy sources by increasing the use of renewable ones, as well as the developing nuclear power plants and coal-fired

Figure 73. Electricity capacity in Uzbekistan, 2010-2022 (left) and by source, 2022 (right)



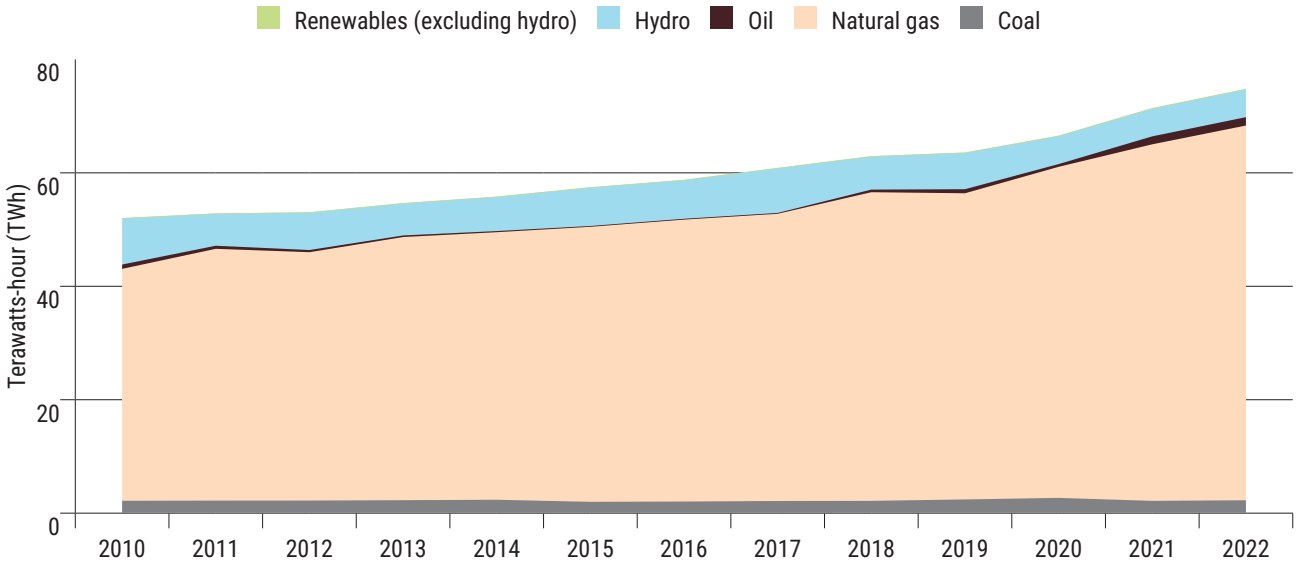
Source: United States Energy Information Administration (EIA), "Uzbekistan: Data", n.d. Available at https://www.eia.gov/international/data/country/UZB/electricity/electricity-capacity?pd=2&p=0000000000000000000007vo7&u=0&f=A&v=mapbubble&a=-&i=none&vo=value&t=C&g=none&l=249--241&s=315532800000&e=1640995200000&

Figure 74. Electricity generation by source, 2022



Source: United States Energy Information Administration (EIA), "Uzbekistan: Data", n.d. Available at https://www.eia.gov/international/data/country/UZB/electricity/electricity-capacity?pd=2&p=0000000000000000000007vo7&u=0&f=A&v=mapbubble&a=-&i=none&vo=value&t=C&g=none&l=249--241&s=315532800000&e=1640995200000&

Figure 75. Electricity generation by source, 2010-2022



Source: United States Energy Information Administration (EIA), "Uzbekistan: Data", n.d. Available at https://www.eia.gov/international/data/country/UZB/electricity/electricity-capacity?pd=2&p=0000000000000000000007vo7&u=0&f=A&v=mapbubble&a=-&i=none&vo=value&t=C&g=none&l=249--241&s=315532800000&e=1640995200000&

power plants. As of 2022, the average age of thermal power plants was 42 years and 46 years for large hydropower plants (IEA, 2022).

10.2.3 Imports, exports, transit

The electric power system of Uzbekistan connects to other countries of Central Asia and the Russian Federation (through 220 kV and 500 kV lines), as well as to Afghanistan (by 220 kV lines).

Table 43. Cross-border electricity trade of Uzbekistan, billion kWh, 2021-2023

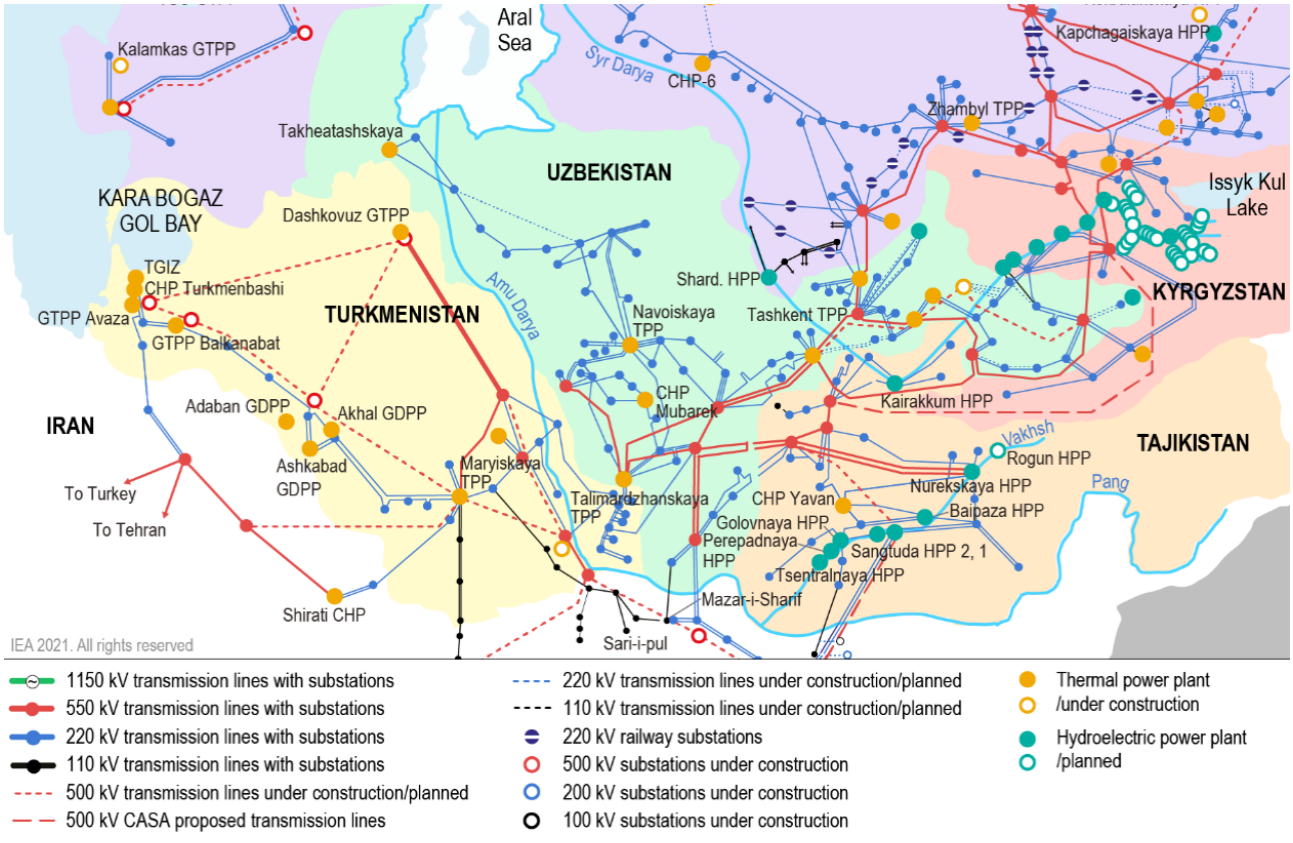
Country	2021	2022	2023
Imports			
Turkmenistan	4.21	4.53	4.02
Tajikistan	1.15	0.84	0.91
Exports			
Afghanistan	2.15	1.43	1.82
Net trade	-3.21	-3.94	-3.10

Source: CDC Energia, "Cooperation within the framework of the Central Asian Unified Power System", April 2024. Available at https://www.carecprogram.org/uploads/CDC-presentation-Dr-Shamshiev-ESCC-2024-ENG.pdf

Cross-border capacity is at 4150 MW or 25 per cent of the country's installed capacity: 450 MW with Afghanistan, 1000 MW with Kazakhstan, 1000 MW with Kyrgyzstan, 850 MW with Tajikistan and 850 MW with Turkmenistan (IEA, 2022).

Uzbekistan is a net importer of electricity. In 2023, electricity imports amounted to 4.9 billion kWh, mainly from Tajikistan and Turkmenistan, and exports amounted to 1.8 billion kWh, mainly to Afghanistan. Uzbekistan has traditionally exported gas-fired

Figure 76. Electricity transmission network of Uzbekistan



Source: International Energy Agency (IEA), "Uzbekistan 2022: Energy Policy Review" (Paris 2022). Available at https://www.iea.org/reports/uzbekistan-2022

Disclaimer: The boundaries and names shown and the designations used in this map do not imply official endorsement or acceptance by the United Nations.

Table 44. Interstate transmission lines

No.	Country	Name of substations at the beginning and end of the transmission line	Voltage (kV)	Total length (km)	Length in the country (km)	Capacity (MVA)
1.	Uzbekistan – Kazakhstan	Tashkent – Chimkent	500	111.6	12.7	1 645
2.	Uzbekistan – Turkmenistan	Serdar – Karakul	500	369.4	58.5	1 645
3.	Uzbekistan – Tajikistan	Regar – Guzor	500	163.0	141.0	1 645
4.	Uzbekistan – Turkmenistan	Karakul – Chorzhui	220	67.4	44.4	301
5.	Uzbekistan – Afghanistan	Surkhon – Noibobod	220	150.0	43.3	449
6.	Uzbekistan – Afghanistan	Surkhon – Noibobod	220	150.1	43.2	449
7.	Uzbekistan – Tajikistan	Regar – Denov	220	49.3	27.88	301
8.	Uzbekistan – Tajikistan	Regar – Gulcha	220	47.95	28.45	301
9.	Uzbekistan – Kyrgyzstan	Lochin – Datka	500	92.7	54.8	1 645
10.	Uzbekistan – Kyrgyzstan	Kristall – Yuldu	220	64.5	46.6	301
11.	Uzbekistan – Kyrgyzstan	Toroboev – Lochin	220	87.6	52.0	218
12.	Uzbekistan – Kyrgyzstan	Foton – Fozilmon	220	59.3	35.9	218
13.	Uzbekistan – Kazakhstan	Feruza – Mactaaral	110	37.2	15.2	72
14.	Uzbekistan – Kazakhstan	Tashkent TPP – Chimkent	220	117.4	14.58	342
15.	Uzbekistan – Kazakhstan	Tashkent TPP – Dzhilga	220	110.5	12.7	342

Source: United Nations Economic Commission for Europe (ECE), "Energy connectivity in Central Asia: An inventory of existing national energy systems", 2024. Available at https://unece.org/sites/default/files/2024-02/EN_Energy%20Connectivity%20in%20Central%20Asia_V2.pdf

electricity in winter months and imported hydropower during summer.

In 2020, the Government of Uzbekistan signed a ten-year agreement with the Afghanistan Government for electricity export, including the construction of a 500 kV interconnection line, which could help increase the net electricity exports from Uzbekistan (IEA, 2022).

10.2.4 Demand

Electricity supply for the domestic market in 2021 amounted to 75 billion kWh (an increase of 48 per cent compared to 2010). About 11 billion kWh (14 per cent) were losses. The structure of final electricity consumption is dominated by the industrial sector (36 per cent in 2021), followed by the residential sector (28 per cent) and agriculture (17 per cent). Between 2010-2021, the largest increase in electricity demand was from the industrial sector (increase of 46 per cent), followed by the residential sector (increase of 35 per cent), and the commercial sector (increase of 34 per cent).

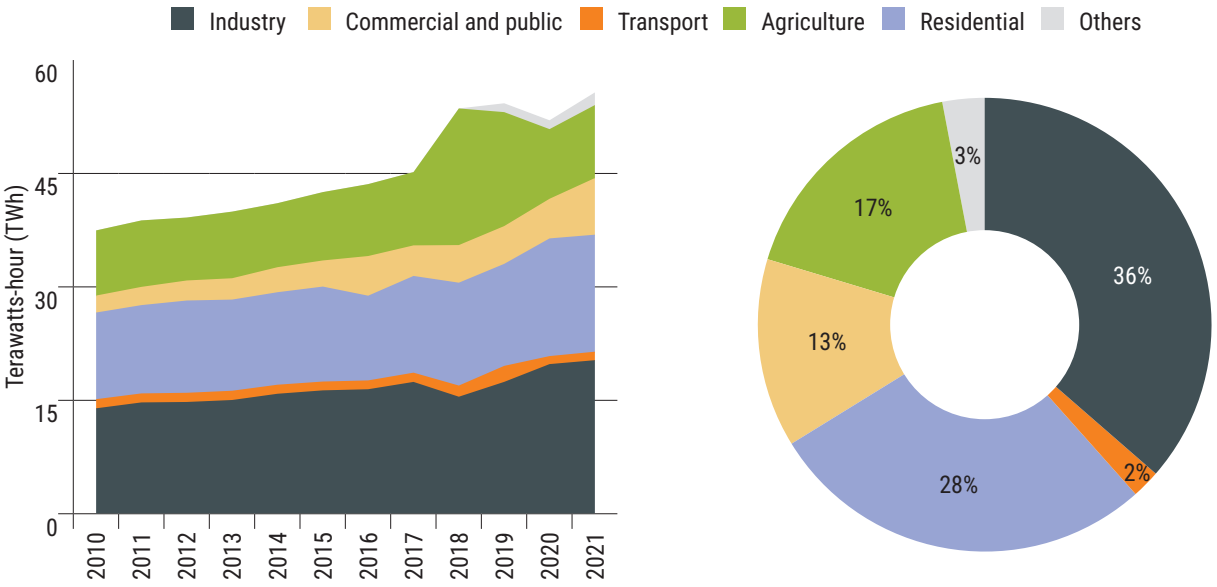
10.3 Electricity market regulation

10.3.1 Power market structure

Uzbekistan is implementing electricity market reform within the framework of the Electricity Supply Security Concept for 2020-2030, which was adopted in 2020 (Uzbekistan, Ministry of Energy, 2024).

The vertically-integrated state monopoly, Uzbekenergo, was divided into three separate companies responsible for the generation, transmission and distribution of electricity. Electricity producers (TPP and Uzbekhydroenergo) sell electricity to a single buyer, the National Electricity Grid of Uzbekistan JSC, at prices that should cover

Figure 77. Electricity consumption by sector, 2010-2021 (left) and 2021 (right)



Source: International Energy Agency (IEA), "Uzbekistan 2022: Energy Policy Review" (Paris 2022). Available at https://www.iea.org/reports/uzbekistan-2022

production costs. The National Electricity Grid of Uzbekistan JSC sells electricity to regional electric networks, which in turn sell electricity to all consumers at fixed tariffs, including industrial consumers.

Projects in hydropower, solar energy and wind energy sectors are actively developing in Uzbekistan.

In the field of hydropower, the operator of hydropower plants and new projects is Uzbekhydroenergo JSC, created in 2017 by separating from Uzbekenergo JS. The state has set goals for the development of hydropower, which involves the construction of large, medium and small hydropower plants by 2030.

Projects in solar and wind energy are implemented by private companies with the involvement of foreign investors and financing from international financial institutions (IFC, ADB, EBRD).

10.3.2 Tariffs

Electricity prices and tariffs in Uzbekistan are regulated by The Interdepartmental Tariff Commission under the Cabinet of Ministers. The Government plans to deregulate consumer prices for electricity. In 2022, the Government decided to transit to market relations (creation of a wholesale market) from 2026.

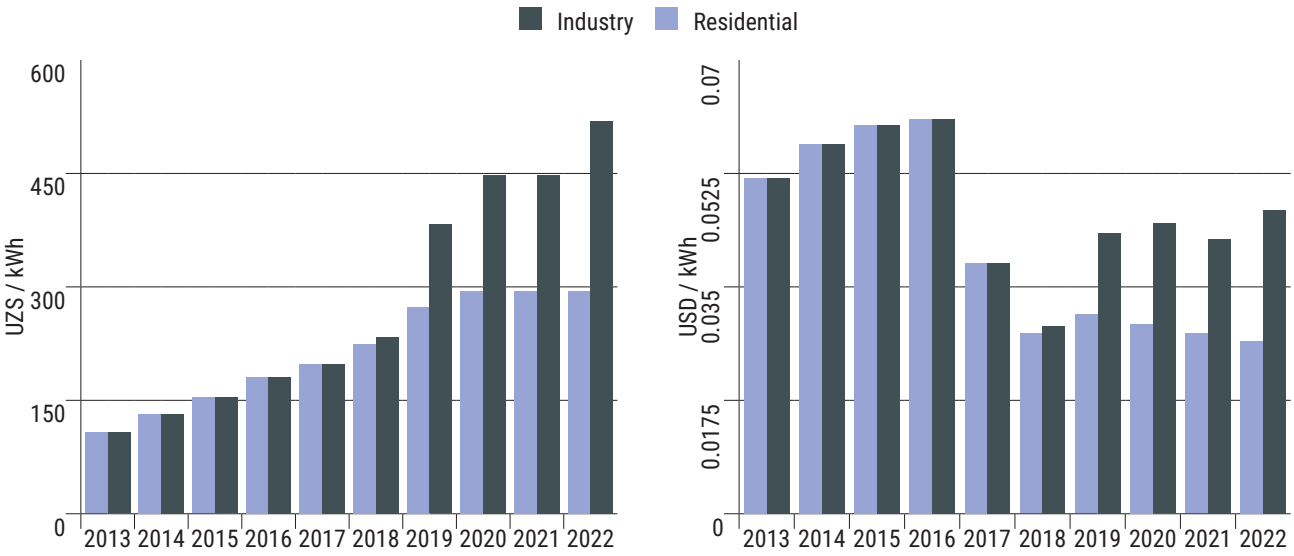
Tariffs for electricity producers and for the transmission and distribution of electricity are set using a cost-plus approach now.

The tariff system in the electric power industry includes a group of regulated and unregulated tariffs.

Regulated tariffs include tariffs for electricity and heat from power plants, surcharges for the distribution and sale of electricity, and electricity tariffs for various consumer groups.

Unregulated tariffs include tariffs for the sale and purchase of electricity in accordance with international agreements, including transit through the national grid.

Figure 78. Electricity tariffs in Uzbekistan, 2013-2022



Source: International Energy Agency (IEA), "Energy Prices", 2023. Available at https://www.iea.org/data-and-statistics/data-product/energy-prices#overview

10.3.3 Market reforms

Creating a competitive market is a critical part of the power market reforms of the electric market. Uzbekistan is poised to launch a free, wholesale electricity market by 2026 (President of the Republic of Uzbekistan, 2023). It mandates the creation of a legal framework, the development of market infrastructure, the digitization of the energy system at every level, and the implementation of an intelligent real-time control system (SCADA) with minimal human intervention.

10.4 Plans and measures for electricity sector development

10.4.1 National goals and plans

In 2020, the strategic document, namely the Electricity Supply Security Concept for 2020-2030 was adopted (Uzbekistan, Ministry of Energy, 2024). The main goal of the country's energy development is to meet the growing domestic demand for electricity.

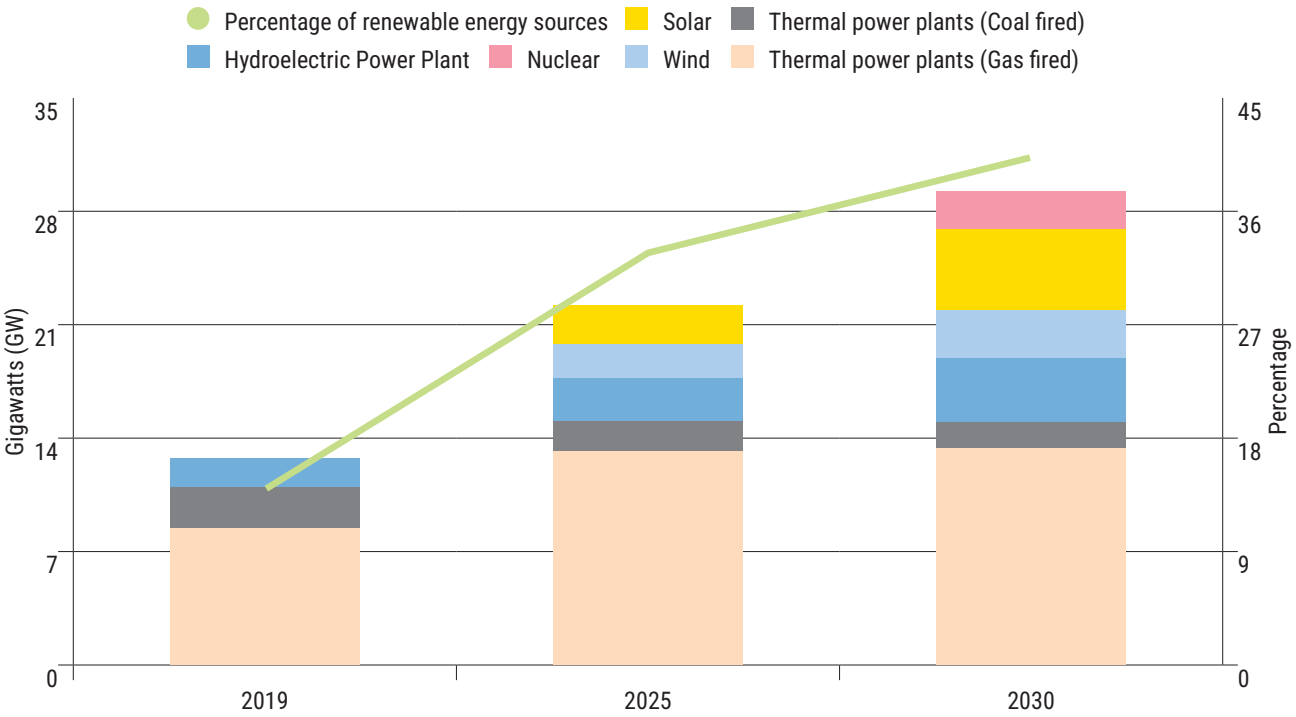
By 2030, the following results are expected to be achieved:

- Increase the installed capacity of power plants to 29.3 GW;
- Develop renewable energy sources and nuclear energy: 5 GW solar, 3 GW wind, 2.4 GW nuclear power plants;
- Double the production of electricity as compared to 2020, to 120.8 billion kWh;
- Reduce the use of natural gas in the electricity sector;
- Privatize most of the generating capacities, except hydropower and nuclear power plants

By 2030, the share of renewable energy sources in the total installed energy capacity of the country is expected to increase to 40 per cent (a three-time increase since 2019), with an increase of 26.1 per cent in electricity generation, including 10.8 per cent in hydropower plants, 8.2 per cent in solar, and 7.1 per cent in wind.

In 2023, the Uzbekistan-2030 strategy was adopted (Uzbekistan 2030, n.d.). The document defined goals for the development of green energy by 2030, including increasing the share

Figure 79. Electricity capacity structure by 2030



Source: Uzbekistan, Ministry of Energy, *Concept Note for ensuring electricity supply in Uzbekistan in 2020-2030* (2024). Available at https://minenergy.uz/en/lists/view/28

of renewable energy to 25 GW, or 40 per cent of total electricity demand.

Uzbekistan has substantial solar and wind power potential that could help the country become a renewable energy exporter. Technical potential for solar power generation is several times higher than the country's entire primary energy supply, ranging from 177 million tons of oil equivalent (Mtoe) to 265 Mtoe) (IEA, 2022). Official sources quote 360 Mtoe of gross technical potential of wind power generation (IEA, 2022).

In terms of developing electrical networks, the Electricity Supply Security Concept for 2020-2030 includes the following activities:

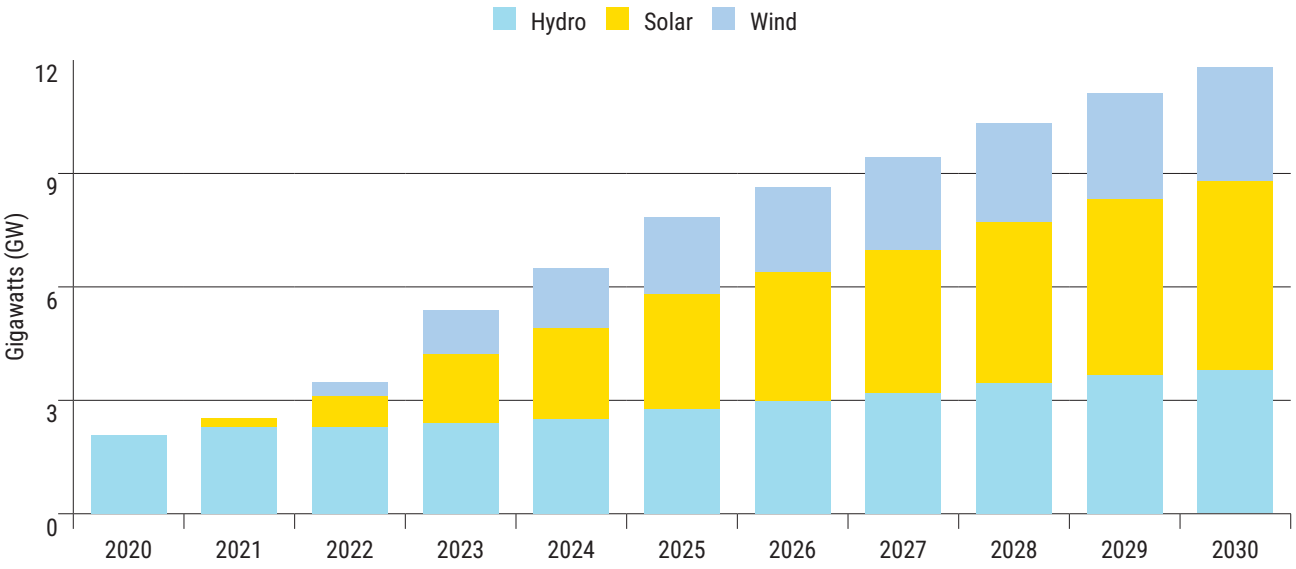
- Connect the entire power system with 500 kV power lines by 2025;
- Construct a 200 km long 500kV TL from Surkhon-500 SS (Uzbekistan) to Puli-Khumri SS (Afghanistan);
- Construct a 63 km long 500kV TL from Guzar SS (Republic of Uzbekistan) to Regar SS (Tajikistan).

According to the indicators of SDG 7 (Affordable and clean energy), Uzbekistan is in a good position in terms of population access to electricity (100 per cent in 2021 compared to the global average of 91 per cent) and clean energy sources for cooking (83 per cent in 2020 compared to the global average of 71 per cent). However, the share of renewable energy sources in final energy consumption in Uzbekistan is much lower compared to the world average.

10.4.2 Current measures for the development of lower-carbon energy

In 2019, The Law on the Use of Renewable Energy Sources was adopted, which set the legislative framework for the accelerated development of renewable energy sources.

Figure 80. Renewables-based generation structure by 2030

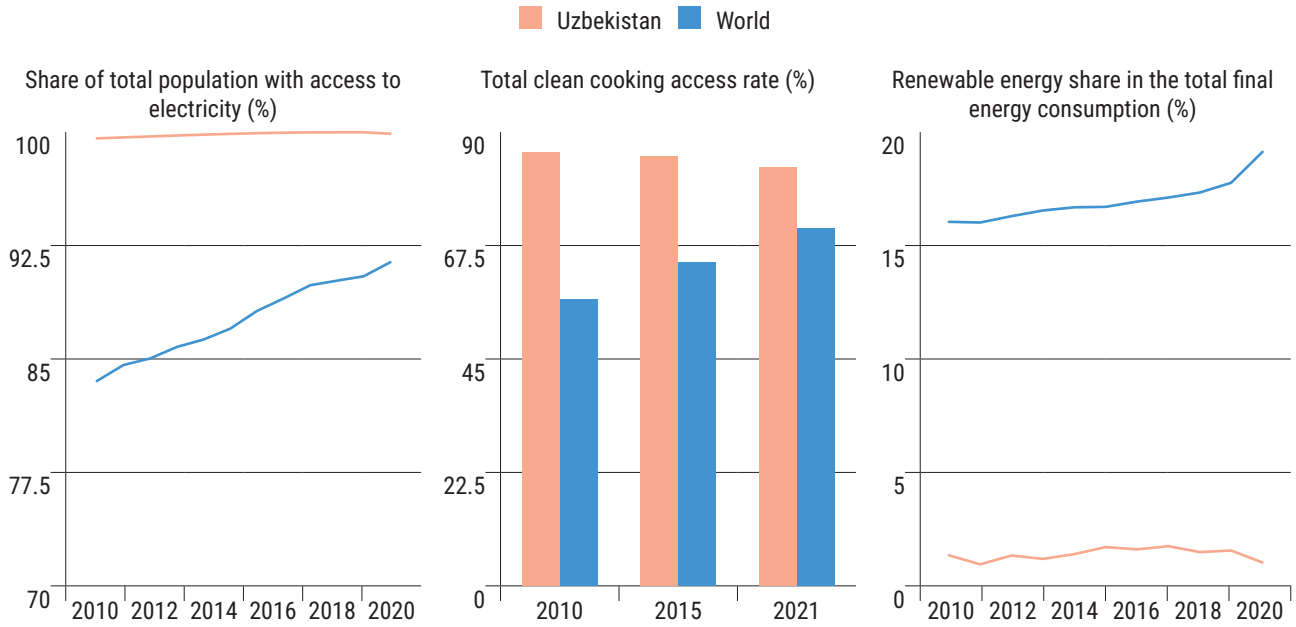


Source: Uzbekistan, Ministry of Energy, *Concept Note for ensuring electricity supply in Uzbekistan in 2020-2030* (2024). Available at https://minenergy.uz/en/lists/view/28

The law defined benefits for producers and consumers of renewable energy sources:

- Exemption from property tax and land tax for capacities over 100 kW for 10 years from the date of commissioning;
- The right to conclude direct energy purchase and sale agreements with consumers;
- Manufacturers of equipment for renewable energy sources are exempt from all types of taxes;

Figure 81. Sustainable Development Goal (SDG) 7 for energy in Uzbekistan, 2010-2021



Source: International Renewable Energy Agency (IRENA), "Tracking SDG7: The Energy Progress Report 2023", 2023. Available at https://www.irena.org/Publications/2023/Jun/Tracking-SDG7-2023

- Uzbekistan uses the PPP mechanism when implementing renewable energy projects. The state guarantees preferential conditions for private investors, including in terms of financing, taxes and land allocation. Feed-in tariffs are not used in Uzbekistan; the size of the renewable energy tariff is determined on a competitive basis.

10.4.3 Key challenges and issues in lower-carbon energy development

In recent years, Uzbekistan has become a leader in the development of renewable energy sources in Central Asia. The Government can improve the investment climate in the renewable energy sector by carrying out additional reforms in the energy sector, including through the creation of an independent energy regulator and optimization of regulation.

Further development of RES will require coordination with conventional energy through careful consideration of technical and economic possibilities and consequences.

10.4.5 Plans for cross-border power trade development

Uzbekistan can benefit from developing cooperation with neighbouring countries, primarily Kyrgyzstan and Tajikistan, in expanding trade in electricity, as well as in terms of construction of regulating hydropower plants in these countries. Potential positive outcomes for Uzbekistan include the use of low-carbon electricity and balancing the energy system of the entire region.

Uzbekistan has already taken steps in this direction by negotiating the construction of two HPPs on the Zeravshan river in Tajikistan. Strengthening of the unified power system of Central Asia will allow for cross-border trade to support system flexibility and diversification of the generation sources and efficient use of border rivers (IEA, 2022).

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