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Sustainable Power Sector Development in Uzbekistan and Tajikistan

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Contents

Abstract

Sustainable development of the Uzbek and Tajik power sectors offers attractive opportunities for both countries, i.e. in terms of improved security of electricity supply and increased use of renewable energy sources, along with reduced greenhouse gas emissions and air pollution. Moreover, potential economic benefits arise from enhanced bilateral electricity trade. This report summarises the critical factors, affecting the envisaged development. The present status of the power sectors is discussed, including generation and consumption characteristics, and legal frameworks. Technical deficiencies are addressed, together with anticipating legislation, fostering modernisation of power system assets. Renewable energy potential in both countries is considered, with focus on hydro, solar and wind energy. Policies towards increased use of this potential are presented. Emphasis is given to ongoing and planned investments in electricity generation and transmission infrastructures, towards more efficient and cleaner power systems, and enhanced electricity trade between both countries.

1 Introduction

Historically, energy security has been primarily addressed in terms of global geopolitics. The main energy policy goal of import-dependent countries has been to secure supply of fossil fuel - oil and gas - at affordable prices (Jigang, W., Webb, P., 2020). Along with increasing electrification of societies, the specific concern of security of electricity supply has become more prominent. In its strict definition, i.e. within the boundaries of the power system, this concept refers to the capability to withstand disturbances or contingencies, with minimum acceptable service disruption (Fulli, G., 2016). Given the international engagement towards green transitions and massive use of renewable energy, security of electricity supply has become increasingly pertinent and complex, with many variables playing a role. In itself, substantial introduction of renewables in the energy mix leads to additional sources and suppliers, including from decentralised generation, with an inherent positive impact on security of supply. At first sight, the aspect of increased self-sufficiency offers an additional advantage, by allowing each country to have direct access to its 'own' renewable resources, without geopolitical barriers. On the other hand, security concerns arise from the intermittent nature of renewable energy sources (RES). Smart electricity systems are required to effectively restore the supply-demand balance at all times. Energy storage systems and electricity interconnections are key solutions in this context, allowing for respectively storing or transferring extra power and making it available at other times or other places, with occurring shortages. In addition, other types of power plants have a potential role in addressing variability in future electricity systems. For example, innovative gas-fired facilities, with short start-up time, high ramp rate and low minimum load, are suitable to cover peak load (Ministry of Economic Affairs of the Netherlands, 2016). Although lacking political consensus, also advanced nuclear power offers opportunities, i.e. by providing both baseload capacity and built-in flexibility (International Energy Agency, 2019).

Against this background, it has become technically challenging for individual countries to engage in a clean energy transition and secure electricity supply at the same time, while acting unilaterally in isolation from its neighbours. In general, countries do not dispose of all the necessary assets to guarantee security of electricity supply at all times, given the variability of modern power systems (Jigang, W., Webb, P., 2020). Interconnection of national transmission systems is required, along with coupled electricity markets and streamlined regulatory frameworks, allowing for electricity trade in a regional context. The European Union (EU) has been an obvious trendsetter in this respect, with its integrated electricity market, offering a cost-effective way to ensure secure and affordable supplies to its citizens, while pursuing ambitious targets for renewable energy. Physical integration of the electricity infrastructure between member states (MS) has been imposed, with targets for interconnection of installed electricity production (Steinbacher, K., et al., 2019).

Central Asia is a major emerging energy player in the world. Kazakhstan, Turkmenistan and Uzbekistan are fossil fuel-rich countries, with large reserves of natural gas, coal and crude oil. Given the local abundance of these energy resources, these countries have largely opted for energy self-sufficiency, including for electricity generation. Kyrgyzstan and Tajikistan are mountainous countries that own huge water resources, of which only a small fraction is used for hydropower. Both countries depend on energy imports, given the seasonal and weather variations of this power source. During the Soviet era, the five republics were interconnected through the Central Asian Power System (CAPS). The CAPS enabled a coordinated approach to security of electricity supply by making the best use of the hydropower potential in Tajikistan and Kyrgyzstan (in summer) and the fossil fuel resources in Kazakhstan, Turkmenistan and Uzbekistan (in winter). Since the disintegration of the USSR in 1991, energy collaboration has progressively deteriorated, with an associated decline of the CAPS. These developments have seriously jeopardised security of electricity supply, especially in Tajikistan and Kyrgyzstan, during winter (Boute, A., 2015).

In particular, a very problematic energy relationship has grown in the post-Soviet era between the states of Tajikistan and Uzbekistan. With political and ethnic conflicts at the background, the harsh competition between water for electricity generation (in Tajikistan) and water for irrigation of agricultural activities (downstream in Uzbekistan) has led to serious energy-related tensions between both countries. In addition, the withdrawal of Uzbekistan from the CAPS in 2009 practically isolated Tajikistan, not only from Uzbekistan, but also from Turkmenistan and Kazakhstan. This development placed a substantial burden on Tajikistan, making it unable to import sufficient power during winter months, when hydropower generation drops below demand. Moreover, Tajikistan could no longer export significant shares of its hydropower surplus in summer (Asian Development Bank, 2014). Although this cumbersome situation has generally been considered from the viewpoint of the dramatic energy crises in Tajikistan, the discontinued electricity trade has also resulted in a range of missed opportunities for its Uzbek neighbour, both economically and environmentally.

Along with political developments in Uzbekistan, the Uzbek-Tajik relationship has improved since 2018 and Tajikistan has resumed supplying Uzbekistan with electricity during summer. In the opposite direction, Tajikistan has substantially increased its electricity imports in winter. Moreover, Tajikistan has restarted importing natural gas from Uzbekistan (The Diplomat, 2018). As such, 2018 marked the onset of renewed energy collaboration between both countries, offering future opportunities for beneficial trade and enhanced security of supply. In addition, the considerable potential of renewable energy in Uzbekistan and Tajikistan (mainly hydro and solar) gives scope for sustainable energy transitions (Eshchanov, B., et al., 2019) (Eshchanov, B., 2019). However, optimal generation, transmission and trade of 'green electricity' will require significant upgrades of current power sectors.

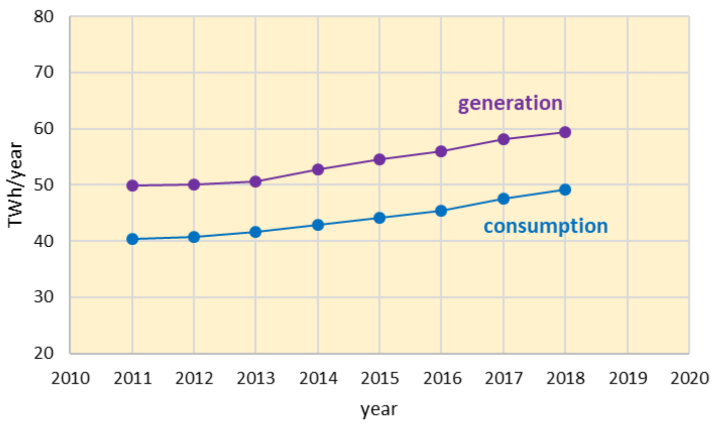
This report focusses on current trends and future opportunities for sustainable power sector development in Uzbekistan and Tajikistan, along with increased use of renewable energy. In Chapter 2, the current status of the power sectors of both nations is discussed, with emphasis on modernisation needs and related legislation. Chapter 3 addresses the renewable energy potential in Uzbekistan and Tajikistan, i.e. hydro, solar and wind. Policies and programmes towards increased exploitation of this potential are presented in Chapter 4. Chapters 5 and 6 present examples of ongoing and planned investments towards cleaner and more efficient power sector assets. Chapter 7 briefly discusses the context for enhanced electricity trade between both countries. Conclusions are presented in Chapter 8.

2 Power sector status

2.1 Uzbekistan

During the last decade, electricity generation in Uzbekistan has been steadily growing, with a total increase of about 20%. In 2018, the value of 60 TWh/year was reached. Simultaneously, electricity consumption has shown a comparable increase from approximately 40 TWh/year (2011) to almost 50 TWh/year (2018) (knoema, n.d.). 40% of this electric energy is consumed by industry, 25% by residential consumers and 20% by the agricultural sector (Energy Charter, 2018). For the coming years, the average growth in electricity demand is expected to be around 4% per year, primarily driven by industrial activity and steady growth in residential consumer demand. It is estimated that by 2030 electricity generation will have to reach levels, exceeding 100 TWh/year (CAREC, 2016). Substantial power system investments will be required to cope with this trend.

Figure 1. Electricity generation and consumption in Uzbekistan (2011-2018)



Data source: knoema, n.d.

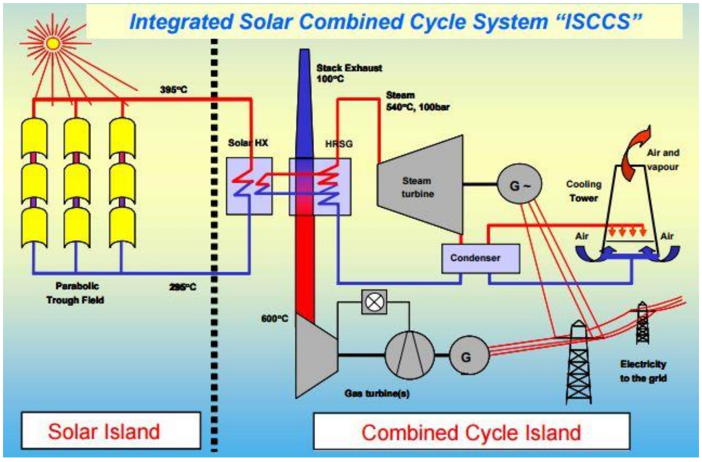
The installed capacity of all Uzbek power plants together currently exceeds 12.5 GW, which is sufficient to make the country fully energy-independent (Index Mundi Country Facts, 2018). Following Turkmenistan, Uzbekistan is the second largest of the Caspian gas producers and, hence, natural gas-fired thermal power plants are the country's main source of electricity, supplying approximately 85% of its total power. Remaining electricity is produced by hydropower stations and, to a less extent, from coal and oil (Export.gov, 2019).

Until recently, Uzbekistan's power sector was fully controlled by the Joint-Stock Company (JSC) Uzbekenergo, a state-owned power utility, which was tasked with providing electricity with a legally endowed monopoly and a vertically integrated supply chain, covering generation, transmission and distribution. Without a designated oversight body for the sector, Uzbekenergo undertook the combined functions of planning, investment, day-to-day system operation and regulation (Asian Development Bank, 2020). In 2019, three independent companies were created on the basis of JSC Uzbekenergo: JSC 'Thermal Power Plants', JSC 'National Electric Networks of Uzbekistan' and JSC 'Regional Electric Networks'. This reform was realised through the resolution 'On Strategy for Further Development and Reform of the Electricity Sector of the Republic of Uzbekistan' (GRATA International, 2019). Already in 2017, tariff reforms were initiated, based on the real cost of electricity generation, transmission and distribution. A cost recovery tariff strategy was designed, as well as a tariff structure with differentiated tariffs for classes of customers (Asian Development Bank, 2017).

Apart from Kazakhstan, Uzbekistan is the largest electricity producer in Central Asia and is a modest net exporter (1-2%). Beyond the limited effect of these exports, the apparent discrepancy between generation and consumption values - see **Figure 1** - is largely due to the outdated condition of the transmission and distribution systems of Uzbekistan. Transmission losses are officially reported at 18% and distribution losses at 14% (Energy Charter, 2018). An electricity demand-supply mismatch is prominent during the winter season, when there is an increased demand. Power cuts occur for two to six hours a day, both in small rural settlements and in big cities in the Ferghana Valley. This affects economic activity and delivery of social services (CAREC, 2016). The Uzbek thermal power plants, which mainly date from the 1960s and 1970s, represent an inefficient generating capacity, as they run on steam turbine technology with an average weight efficiency of only 33%, compared to 55% for advanced combined-cycle gas turbine (CCGT) technology. The overall power system efficiency is further undermined by the location of most power plants: about 70% of electricity generation occurs in the North, while over 90% of the gas production takes place in the South (Export.gov, 2019).

Above deficiencies call for modernisation and development programmes, aiming at a more efficient generation capacity and upgraded transmission and distribution systems (Export.gov, 2019). In 2015, a ‘Programme of Measures to Secure Structural Reforms, Modernisation and Diversification of Production for 2015-2019’ was adopted by presidential decree. This programme implied the modernisation of existing facilities, as well as the creation of more diversified installations, such as integrated solar combined cycle (ISCC) power plants - see **Figure 2** (Republic of Uzbekistan, 2015). In 2020, the Government of Uzbekistan approved the ‘Concept of Providing the Republic of Uzbekistan with Electric Energy for 2020-2030’. The concept stipulated an increase in the country’s generating capacity to 29.3 GW and electricity production to 120.8 kWh/year by 2030 (EU Political Report, 2021).

Figure 2. ISCC power plant schematic



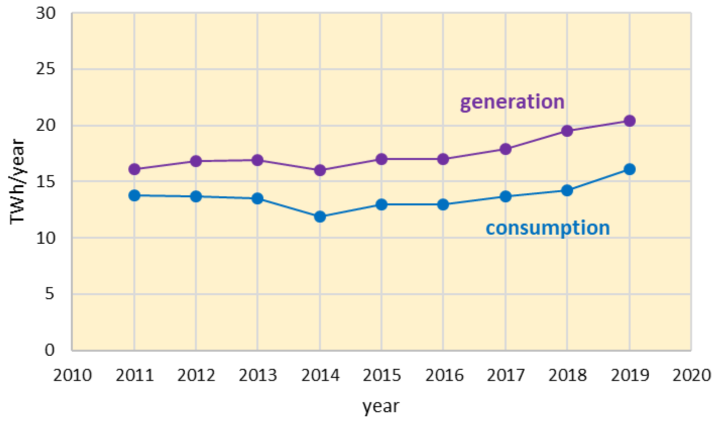
Source: Tunza Eco-generation, 2017

2.2 Tajikistan

Since 2014, electricity generation in Tajikistan has steadily increased, exceeding 20 TWh/year in 2019. Consumption has followed this trend, although at significantly lower levels. Differences of more than 25% are apparent - see **Figure 3** (knoema, n.d.b). The country’s largest energy-intensive consumer (26%) is the Tajik Aluminum Company (TALCO) (Akhrorova et al., 2014). The expected growth of Tajikistan's economy will involve a considerable increase in demand for electricity, requiring significant power system investments (Asian Development Bank, 2016).

As Tajikistan has abundant water resources, hydropower is the main source of electricity in the country. However, its theoretical potential of 527 TWh/year is only used for less than 5% (Eshanov et al., 2019). Tajikistan’s total installed electricity generation capacity is 6577 MW, including 5858 MW from hydropower plants (HPP) and 719 MW from coal-fired combined heat and power plants (CHPP). Apart from hydro, the country does practically not generate electricity from renewables (USA Department of Commerce, 2019).

Figure 3. Electricity generation and consumption in Tajikistan (2011-2019)



Data source : knoema, n.d.b

Tajikistan's power sector is still managed by a vertically integrated utility, owned by the government: Open Joint Stock Holding Company (OJSHC) Barqi Tojik. The company displays good technical expertise but suffers from weak operational and economic management systems and a worsening financial position. This has a negative impact on its critical functions of planning, implementing and supplying reliable power. Tajikistan's electricity prices were kept very low until 2007, and while they have gradually increased since then, they are still below the cost of supply. The below cost-recovery tariffs, combined with winter shortages, result in economic losses of around US$ 200 million a year. Also on the demand side, energy prices do not reflect the full cost of supply. The government should take steps to minimise the quasi-fiscal deficits of Barqi Tojik by addressing weaknesses in its billing and collection mechanisms (USA Department of Commerce, 2019). Although plans for the privatisation of OJSC Barki Tojik have been announced, no progress has been made in this direction. Privatisation of key HPPs has even been prohibited, by recognising them as objects of state and strategic importance (CABAR, 2021).

Although Tajikistan has traditionally been only a modest net electricity exporter (around 1 TWh/year), it significantly increased electricity exports in 2018, i.e. to Uzbekistan and Afghanistan – see paragraph 2.1 (Azernews, 2018). However, even with the increasing net exports, a significant discrepancy between domestic generation and consumption remains apparent. This is largely due to transmission and distribution system losses, which were estimated at 22% in 2015. Transmission losses (technical) accounted for 5% and distribution losses (technical and non-technical) for 17%. Moreover, the Tajik hydropower generation fleet requires substantial rehabilitation (Asian Development Bank, 2016). The poor state of Tajikistan's power sector contributes to frequent energy shortages, especially during the cold winters, affecting about 70% of its population. In the past, several severe energy crises have occured (OECD, 2016).

Already in 2002, the 'Law on Energy Saving' provided an initial step towards more efficient use of energy resources. The 'Energy Saving and Energy Efficiency Law' of 2013 introduced a legal and organisational framework for energy efficiency. The 'National Development Strategy for the Period up to 2030' (2016) aimed at assuring security and efficient use of energy by attracting foreign investment for energy projects. This strategy e.g. resulted in the construction of a second CHPP (400 MW) near the Tajik capital Dushanbe, which was completed in 2017 – see **Figure 4** (Bankwatch Network, 2018).

Figure 4. The Dushanbe-2 CHPP

Source: Asia-Plus Media Group, 2021

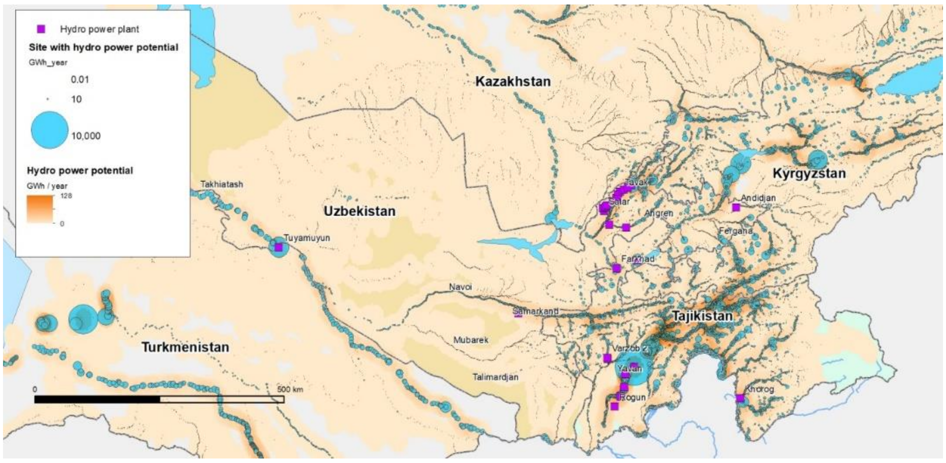
3 Renewable energy potential

3.1 Hydro

Within the Aral Sea basin, Uzbekistan and Tajikistan are entirely circumscribed by the two principal rivers flowing towards this sea: Syr Darya to the North and Amu Darya to the South. Syr Darya, which has its source in Kyrgyzstan, flows along a limited track in Uzbekistan and Tajikistan, but crosses one of the most densely populated and economically developed regions, the Fergana Valley, where the water is much needed for irrigation and electricity production. It is Amu Darya, with a much higher discharge and electricity generation potential, that has caused the dispute between the riverine countries on the best use of the water: electricity generation (Tajikistan) or irrigation for crops (Uzbekistan).

The regional hydro potential for electricity generation is among the largest in the world, due to the presence of a high orographic node, including the Hindukush Mountains, the Karakorum Mountains and the Alai Mountains. They meet in the centrally located Pamir High Altitude Plateau, from where rivers diverge in all directions. The high altitude creates favourable conditions for the existence of glaciers, which feed the rivers with large quantities of water, especially in the melting season (late spring - early summer). It is the abundance of water reserves, combined with the high elevation range that results in a great hydropower potential. However, as a result of climate change, the available water reserves caught in the glaciers will decrease, due to glacier melting without replenishing the reserves. The glacier area on the eastern Pamir Plateau decreased by 7.8% during 1978–1990 and 11.6% during 1990–2001, primarily due to increasing summer temperatures. These changes in glacier extent in eastern Pamir were determined from historical data and ASTER imagery. The ongoing trend will negatively affect future hydropower potential.

Figure 5. Hydropower potential in Tajikistan and Uzbekistan (and existing HPPs)



Tajikistan is covered for 93% by mountains, with more than half of the area being situated above 3000 m. Two individual rivers in Tajikistan stand out with exceptional hydropower potential: the Wakhsh river, with 48% of the total Tajik potential, and the Panj river, with 23% of the potential. While Wakhsh's potential has been partially tapped, Panj has remained practically untouched, without any major HPP. Wakhsh carries its 660 m^3/s average discharge through a deep and narrow valley, with a high gradient, which, along with easy accessibility, makes it suitable for the construction of dams and HPPs. Most of the water comes from snow and glacier melting and less from rainfall. Although basically unexploited, Panj owns a greater average discharge - 1000 m^3/s.

Uzbekistan's landscape is more diverse, stretching from the high altitudes in the East to the low-lying arid zones around the Aral Sea in the West. Most of the population is concentrated in the eastern half, with the highest share and densities in the Fergana Valley, where the capital Tashkent is located. The country relies massively on water sourcing from the mountains in the East, only partially on its territory, for its cotton-based agriculture sector. The most suitable river used for hydropower is Pskem, which represents 45% of the country's total potential.

Table 1. Hydropower potential in Tajikistan and Uzbekistan

	Gross theoretical potential (TWh/year)	Technically exploitable capability (TWh/year)
Tajikistan	527.0	317.0
Uzbekistan	88.5	27.4

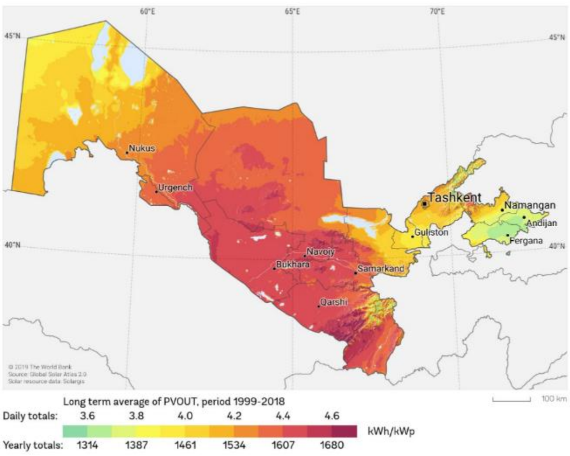
Source: Eshchanov, B., et al., 2019

3.2 Solar

In almost the entire Central Asian territory, solar insolation displays a high value, which translates into a high solar energy potential. This is mainly due to its location at the centre of the continent, far away from large bodies of water, acting as sources of evaporation. The predominantly anticyclonic conditions, coupled with low air humidity, ensure (in average) more than 2000 hours of sunshine per year, distributed along more than 250 sunny days.

Especially Uzbekistan can profit from abundant solar irradiance (1400-1800 kWh/m^2 per year). Rakhimov et al. (2017) present six ground weather stations that are spread over the country and display in between 315 and 345 clear sunny days per year ($\Sigma q_{\perp} \geq 1$ kWh/m^2.day).

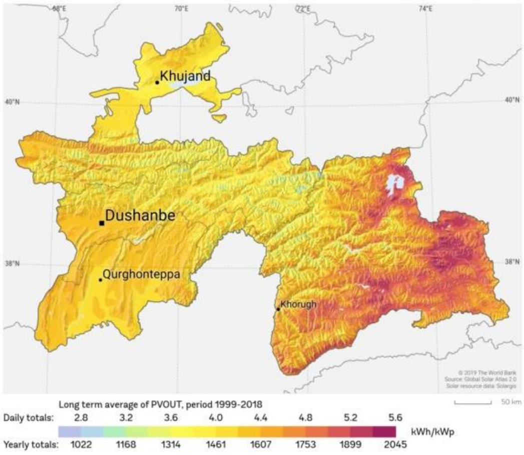
Figure 6. Photovoltaic power potential in Uzbekistan



Source: Solargis, 2020

In spite of its predominantly mountainous geography, also Tajikistan has a high solar energy potential. Although this potential is homogenously distributed, the orientation and exposition of valley slopes introduce a high variation in actual insolation. Hence, local factors largely influence the amount of the solar output.

Figure 7. Photovoltaic power potential in Tajikistan

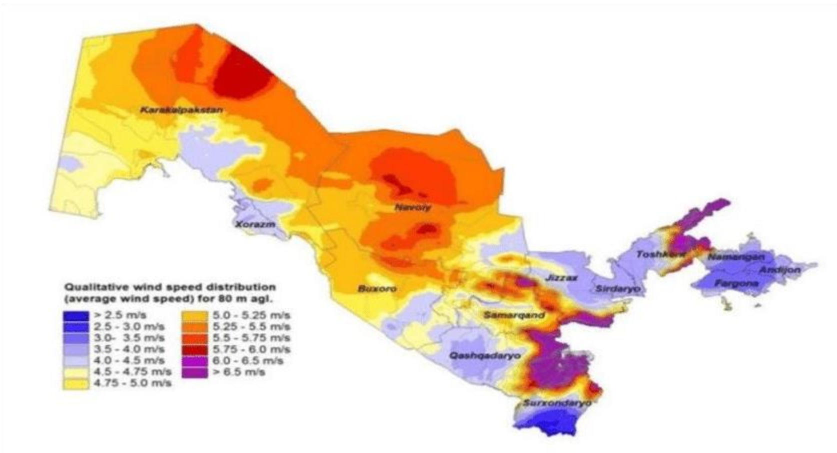


Source: Solargis, 2020b

3.3 Wind

Bahrami et al. (2019) present the hourly wind speed data of 17 different sites in Uzbekistan (10 m height) in a typical meteorological year. This study compares 15 different commercially available wind turbines and shows that the average annual wind speed, power density and energy production are in the range between 0.61-3.98 m/s, 1.74-88.55 W/m^2 and 15.27-775.72 kWh/m^2, respectively.

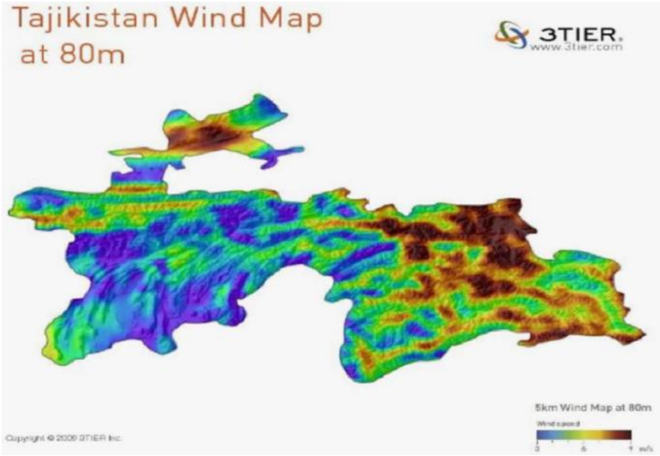
Figure 8. Wind speed distribution across the territory of Uzbekistan



Source : Zakhidov and Kremkov, 2015

In Tajikistan, the strongest winds are in highland areas, which exhibit a constant clash of cold mountain air with warm air from arid regions. The average annual wind speed in these areas reaches 3-6 m/s (United Nations Economic Commission for Europe, n.d.).

Figure 9. Wind speed distribution across the territory of Tajikistan



Source : 3TIER, 2009

Table 2. Solar and wind potential in Tajikistan and Uzbekistan

	Solar Photovoltaic (TWh/year)	Wind (TWh/year)
Tajikistan	410	146
Uzbekistan	1195	1185

Source: Laldjebaev, M., et al., 2021

4 Renewable energy policies

4.1 Uzbekistan

Uzbekistan is highly vulnerable to climate change, with important impacts on agriculture, water resources, human health and ecosystems. Uzbekistan's greenhouse gas (GHG) profile is largely dominated by emissions from the energy sector, which account for 192 $MtCO_2e$ or 90% of its total GHG emissions (2014). These emissions increased by 19% from 1990 to 2014 (United States Agency for International Development, 2019). In addition, air quality forms a concern in the Uzbek cities. For 2020, IQAir reports an average US air quality index of 29.9 for the capital Tashkent, with five months of the year rated 'unhealthy for sensitive groups' (IQAir, 2021).

Uzbekistan established a carbon intensity target aiming at a decrease of GHG emissions per unit of gross domestic product (GDP) of 10% by 2030, compared to the 2010 levels (United States Agency for International Development, 2019). Anticipating to the significant opportunities offered by RES, the Uzbek president signed in 2017 a resolution 'On the Programme of Measures for Further Development of Renewable Energy, Improving Energy Efficiency in Economic and Social Spheres for 2017-2021'. The Uzbek leader approved targets for further development of renewable energy, envisaging an increase of the share of RES in generating capacity to 19.7% by 2025. This includes hydropower (15.8%), solar energy (2.3%), and also wind energy (1.6%) (UZ Daily, 2017). In line with this, the 'Resolution on Further Development of Renewable Energy and Energy Efficiency for 2017-2025 in Uzbekistan' set following increases in absolute capacity values: hydropower from 60.7 MW to 1.24 GW, solar Photovoltaic (PV) from 100 to 450 MW, and onshore wind from 0 to 302 MW (International Energy Agency, 2017). The president of Uzbekistan has already approved the implementation of 810 projects for the development of renewable energy in the period up to 2025 (UZ Daily, 2017). Moreover, the Senate of the Republic of Uzbekistan approved in 2019 the 'Law on Using of Renewable Energy Resources'. In accordance with this law, renewable energy resources are the energy of solar, wind, geothermal origin, natural movement of water flows and biomass, which are naturally restored in the environment. They are referred to as 'Soft Energy' (SE). The Ministry of Energy is appointed as the specially authorised state body for using SE resources. Producers of SE are offered following benefits:

- exemption from payment of corporate property tax on the SE production units and corporate land tax on the land plots occupied by these units (with a nominal capacity of 0.1 MW or more) for a period of 10 years;
- exemption from payment of Value Added Tax (VAT) in terms of volume of energy that will be sold to the state power company;
- operators of SE units are exempt from payment of all types of taxes for a period of 5 years from the date of the state registration (Azizov & Partners, 2019).

As such, the above incentives, which only focus on tax exemptions, are not sufficient to boost diversification of energy generation in Uzbekistan. Genuine political motivation is required to fully abandon state-subsidised electricity prices and create enhanced legal frameworks for foreign private-sector investments. The latter should fix the requirements and conditions of connecting to the grid and selling the energy produced by independent (renewable) power producers (Central Asian Bureau for Analytical Reporting, 2019).

4.2 Tajikistan

Also Tajikistan is highly susceptible to climate change. According to documentation compiled by the United Nations Framework Convention on Climate Change, temperatures in Tajikistan will rise from 1.8°C to 2.9°C by 2050. These projections will negatively affect water resources, the agricultural sector, transport infrastructure and public health (OCHA reliefweb, 2017). GHG emissions have increased during the last decade, reaching 15.2 $MtCO_2e$ in 2018 (macrotrends, 2021). The average US air quality index for 2020 in the capital Dushanbe is reported at 30.9, with six months being 'unhealthy for sensitive groups' (IQAir, 2021).

Already during the first decade of this century, a series of laws were adopted by the Parliament of the Republic, including elements on renewable energy system development. The amendment of 2007 of the Law of the Republic of Tajikistan ‘On Energy’ (2000) specified incentives to promote alternative energy sources and provided the introduction of a ‘green tariff’ for selling electricity generated from RES. The Resolution ‘A Long-Term Programme of Building a Cascade of Small Hydropower Plants 2009-2020’ (2009) addressed the development of hydropower resources of small rivers and related infrastructure, including the development of a feasibility study for the construction of small hydropower plants (SHPP). The Law of the Republic of Tajikistan ‘On the Use of Renewable Energy Sources’ (2010) regulated the activities in the field of RES, including the principles and objectives of policies in the field of renewable energy. It identified ways of integrating RES in the power system, as well as organisational, research, engineering and regulatory activities aimed at increasing the use of RES (United Nations Economic Commission for Europe, n.d.). Within the ‘Sustainable Energy for All’ framework (2013), Tajikistan introduced a target of a 20% increase of electricity production from RES by 2030. This involved the establishment of a National Trust Fund on Renewable Energy and Energy Efficiency. Interestingly, regional cooperation and partnership in the energy sector was also brought forward as a related task (United Nations Development Programme, 2016).

RES development in Tajikistan is still challenging, although the Tajik authorities have undertaken general reform efforts to open up the economy and introduce market-based mechanisms. Business registration has been streamlined, the burden of licensing and inspections has been addressed, and the taxation and competition regimes have been improved (UNCTAD, 2016).

5 Investments in power generation assets

5.1 Hydropower

Through a decree issued in 2017, Uzbekistan expressed its intention to invest about US$ 2.65 billion in hydropower development during the period 2017-2025. This decree involved plans for the development of 18 new hydropower projects and the modernisation of 14 existing plants. Target parameters within the decree specified an increase of the share of HPPs in electricity generation from 12.7% to 15.8%. Included in the development plans were two new HPPs on the Pskem River in the Bostanlyk district: the 404 MW Pskem and the 240 MW Mullalak plants (Hydro Review, 2017). In 2020, six HPP modernisation (adding 7.5 MW) and construction (adding 64 MW) projects were commissioned, capable of producing 541 GWh of electricity per year. The Kamchik hydropower project (26.5 MW) and the Zarchob small hydropower chain on the Tupalang river (37.4 MW) were commissioned, offering a combined annual average output of 177 GWh. The country also established an ambitious national energy strategy to double hydropower electricity generation by 2030, involving seven large plants with 1.2 GW of hydropower capacity. Investments in the Uzbek hydropower sector are heavily supported by international and foreign financing organisations, e.g. the Asian Development Bank (ADB) and the French Development Agency (FDA) (International Hydropower Association, 2020).

Tajikistan is pursuing efforts to harness its vast hydro resources to address electricity shortages in winter and ensure security of power supply in the long term. The government has prioritised eight projects with a combined capacity of 6 GW, including the 3.6 GW Rogun hydro project, which is currently under construction. Two turbines (1.2 GW) are already installed and producing electricity. The dam and the fully operational power plant are planned to be completed in 2032, producing an expected yearly electricity output of 13.1 TWh. The largest hydropower stations presently in operation are Nurek (3 GW), Baipaza (600 MW), Golovnaya (250 MW) and Qairokkum (126 MW), which are all subject of big modernisation programmes. More specifically, the Nurek HPP has entered a project of rehabilitation in two phases: the first until the end of 2022 and the second until the end of 2030. Efficiency and safety of three generating units of the power plant are enhanced and their generating capacity is restored. Also in Tajikistan, investements in hydropower are substantially underpinned by international financing organisation, e.g. the European Bank for Reconstruction and Development (EBRD) and the Green Climate Fund (GCF) (Andritz, 2021).

Figure 10. Location of Nurek and Rogun dams on Vakhs river

Source: ENR, 2016

5.2 Solar power

Solar energy development in Uzbekistan largely exceeds the related policy targets. In 2019, the Government of the Republic of Uzbekistan and the International Finance Corporation (IFC) signed an agreement to attract consulting services towards increasing the capacity of the Scaling Solar projects to 1 GW of PV plants. The Scaling Solar programme is a World Bank (WB) instrument that fosters procurement and development of large-scale solar projects with private financing. Both the 'Solar Scaling 1' (one plant of 100 MW) and the 'Solar Scaling 2' (two plants of 200 MW each) projects were awarded to Masdar Clean Energy. 'Scaling Solar 3' (three plants of 500 MW in total) is currently subject of a preliminary study. Additional opportunities for investments in Uzbek PV power plants arise from collaboration with the ADB. This includes the projects 'Sherabad 1' (200 MW) and 'Sherabad 2' (300 MW). Moreover, bilateral contracts have been signed, e.g. with the French Total Eren company, for a 100 MW PV plant (Asadov, 2021).

Figure 11. Location of 'Solar Scaling 2' PV plants

Source: Asadov, 2021

Along with challenging geographic conditions and a less favourable investment climate, solar energy in Tajikistan is largely unexploited. Nevertheless, initial developments are currently apparent, like the 220 kW Murghob solar power plant (SPP), which was completed in 2020 with the support of USAID. The Murghob plant increases daytime electricity by 50% for 6000 inhabitants, living at an altitude of 3600 m. This project shows how Tajikistan can take advantage of solar energy opportunities in remote and isolated areas, with foreign support (Tajinvest, 2020).

5.3 Wind power

In line with recent solar power development, also wind power in Uzbekistan is currently subject of substantial investment initiatives. With the support of the EBRD, the 'Wind Farm 1' (100 MW) and the 'Wind Farm 2' (200 MW) projects have been initiated, with 'Wind Farm 1' currently in the competitive bidding phase. Moreover, bilateral contracts have been concluded with ACWA Power (1 GW plant) and Masdar (500 MW plant) (Asadov, 2021). Masdar has recently tripled the capacity of the project in the Navoi region up to 1.5 GW (Institute for Energy Economics and Financial Analysis, 2021).

Figure 12. Location of Masdar wind power plant

Source: Asadov, 2021

In Tajikistan, wind power is still in its infancy, with some underperforming wind farm projects in non-windy areas (Asia-Plus Media Group, 2009).

5.4 Gas power

In line with Uzbekistan's ambitious power system programmes - see paragraph 2.1 - outdated gas-fired power plants are being modernised or replaced by advanced installations. In this respect, Uzbekistan has been successful in attracting foreign investors, mostly with the support of international financing organisations.

For example, supported by an EBRD loan, a 1.5 GW CCGT power plant, with an efficiency of more than 60%, will be constructed in the Sirdarya region. Along with this, the old, inefficient and polluting Sirdarya thermal power plant (1.2 GW) will be shut down. The overall project is expected to result in a total system-wide saving of 2.6 million tonnes of CO_2 (European Bank for Reconstruction and Development, 2021). Turkey's Cengiz Energy is establishing a CCGT plant near Tashkent. This 240 MW plant will produce approximately 2 TWh of electricity per year, meeting the energy needs of 120 thousand households (Anadolu Agency, 2020). Recently, Uzbekistan's Ministry of Energy has signed a deal with the Dutch-registered company Stone City Energy for another CCGT power plant. This 1.6 GW plant will be constructed in the Surkhandarya region and is expected to come online by the end of 2024 (Power Technology, 2021).

Figure 13. Sirdarya CCGT power plant outlook

Source: Power Technology, 2021

5.5 Nuclear power

Uzbekistan is the world's seventh largest uranium producer but it does currently not operate any nuclear power plant (NPP). Nevertheless, in September 2018 the governments of Uzbekistan and Russia signed an agreement on cooperation in the construction of NPPs. In August 2020, however, Uzbekistan declared that it was not yet ready to sign the actual contract (New Europe, 2020). The initial plan was that the Russian state nuclear corporation Rosatom would construct a NPP, including two third-generation 'water-water energetic reactors' (VVER 1200) in the Jizzakh region, near Lake Tuzkan (Kun.uz, 2021). The reactors, which would cover up to 20% of Uzbekistan's electricity needs, would be built, using a loan provided from the Russian state budget. They were planned to be commissioned in 2028 and 2030, respectively (World Nuclear News, 2019). Negotiations between both countries were continuing during 2021.

6 Electricity transmission system investments

6.1 Uzbekistan

Modernisation of the Uzbek electricity transmission system has taken place within the context of the Central Asia Regional Economic Cooperation (CAREC) programme, of which Uzbekistan is a key member. As an example, a project, co-funded by the WB, aims at modernisation and upgrade of transmission substations. This project, which should be completed by the end of 2022, is improving the performance of the Uzbek power sector by rehabilitating 22 high-priority substations in the Tashkent City and 10 additional regions of the country, reducing technical losses, and operational and maintenance costs (CAREC, 2016b). Recently, the WB's Board of Executive Directors has approved the 'Electricity Sector Transformation and Resilient Transmission Project'. This project will be underpinned by a credit from the International Development Association (IDA), and a loan from the GCF. Among other activities, it will include the construction of a new 500 kV transmission substation and associated transmission lines in 11 regions of Uzbekistan. Moreover, the project will introduce modern digital and telecommunication technologies, and solutions to improve the process of monitoring, control, and operation of the power transmission system (The World Bank, 2021). The ADB is working with Uzbekistan to improve the reliability of the power transmission network in the northwest regions of Karakalpakstan and Khorezm. The project is building a more than 360 km-long 220 kV transmission line, as well as upgrading and expanding three key substations (Asian Development Bank, 2021).

6.2 Tajikistan

Already one decade ago, Tajikistan was supported within the CAREC programme in terms of transmission line (double-circuit 220 kV) and substation investments, with main objective to enhance its electricity export and import capacity (CAREC, 2015). Also the CASA-1000 programme, which is co-funded by the WB, invests in the Tajik electricity transmission system, both in high voltage alternating current (HVAC) and high voltage direct current (HVDC) systems (CASA-1000, 2021). Although oriented towards electricity trade with Afghanistan and Pakistan, the programme offers clear benefits for the local population, which is living in villages along the transmission lines, funded by CASA-1000 (The World Bank, 2019). Presently, the ADB is helping Tajikistan to expand and modernise its electricity transmission system. This project includes the construction of two new 220 kV transmission lines, totalling 140 km, and the rehabilitation of various substations (Asian Development Bank, 2021b). In addition, the ADB will build a 90 km transmission line connecting the Panjakent and Ayni regions to meet rising demand for power (Asian Development Bank, 2021c).

6.3 Cross-border interconnections

As discussed above, Tajikistan was practically isolated from the CAPS in 2009, jeopardising electricity trade, not only with Uzbekistan, but also with Turkmenistan and Kazakhstan. In 2018, along with an improved political relationship, Uzbekistan and Tajikistan signed a power trade agreement to restart mutual electricity trade. Accordingly, at the end of 2018, the ADB approved a grant to reconnect Tajikistan's electricity system to the CAPS, through interconnection with the Uzbek system. This project, which was conceived under CAREC, is expected to be completed in 2022 and covers the installation and upgrade of modern relay protection equipment for synchronising Tajikistan's and Uzbekistan's electricity systems, the expansion of interconnection points, and the reinforcement of Tajikistan's capacity for stable parallel operation (Asian Development Bank, 2018). The proposed project involves the modernisation of equipment and systems at eight 220 kV and two 500 kV interconnection points, as well as the establishment of two new 500 kV cross-border interconnections (CAREC, 2015b).

7 Opportunities from sustainable electricity trade between both countries

Recent investments in hydropower and cross-border trading capacity have enhanced Tajikistan's electricity export potential towards Uzbekistan. Two features play a supporting role in the export trade. First, demand patterns in Uzbekistan are complementary to Tajikistan's seasonal generation profile of summer surpluses and winter shortages. Second, the average cost of current electricity generation (mainly from gas) in Uzbekistan (almost US$ 50 / MWh) is substantially higher than the marginal cost of generation (from hydro) in Tajikistan (average estimated at US$ 6 / MWh) (International Energy Agency, 2021). Tajikistan can take advantage of this opportunity because of the cost-recovery market policy in Uzbekistan, which is progressively implemented - see paragraph 2.1. At the same time, also Uzbekistan can profit from this trade, i.e. by adding 'cheap and clean' hydropower imports to its own renewable energy generation, gradually replacing power from gas.

Oppositely, for the winter months, Uzbekistan can develop a more sustainable electricity export towards Tajikistan. Apart from (limited) power from available RES, this can involve power from advanced CCGT plants and - potentially - from third-generation NPPs. Beyond offering economic and environmental benefits, this export trade would contribute to a pursued leading position in the region, along with the ambition to be a modern country, promoting and implementing ambitious sustainable energy policies.

The bidirectional power trade should go along with a minimum level of power system and market harmonisation, along with political agreements between both countries. However, it does not require the same domestic market structures.

Increased use of renewable energy would further expand economic opportunities for Tajikistan, by delivering ancillary services. In particular, this country could significantly increase the volume of activated frequency restoration reserve (FRR) in the power systems, providing a significant income in addition to the seasonal exports (International Energy Agency, 2021).

8 Conclusions

Following decades of extremely poor development, Uzbekistan and Tajikistan are currently modernising their power sectors towards more efficient and cleaner assets. Related efforts are underpinned by policies towards sustainable power system development, which take into account substantial potential for hydro-, solar and wind power. Accordingly, international financing organistations and foreign private investors have discovered an improving investment climate in both countries, including for electricity generation and transmission facilities. Through regional development programmes, also electricity interconnections between Uzbekistan and Tajikistan are subject of significant upgrades.

In the coming decade, above developments should contribute to a sustainable energy collaboration between both countries, which should be largely based on renewable energy, complemented with power from advanced gas and (potentially) nuclear plants. Herein, Tajikistan should primarily profit from enhanced energy security during winter and increased trade of hydropower during summer, with additional income from provided ancillary services. On the other hand, the collaboration should help Uzbekistan in implementing its ambitious energy policies, through importing and exporting electricity from sustainable energy sources, along with attractive environmetal and economic benefits.

Within the framework of its strategies on Asia and Central Asia, the EU supports energy connectivity in and with Central Asia (European Commission, 2018). The EU Global Gateway initiative will support investments in quality infrastructures, underpinning energy transitions, renewable energy use, regional energy integration, etc. (European Commission, 2021). The NDICI - Global Europe instrument will be available to financially support the Central Asian region and its countries during the period 2021-2027, including in the field of fighting climate change. This implies 'promoting access to and increasing cooperation on sustainable energy' (European Commission, 2021b). The EU - Central Asia Economic Forum of November 2021 included an important agenda point on 'transition to a green recovery'. The joint press release confirmed all critical factors towards sustainable power system development, which are addressed in this report. This includes 'generation of clean and climate neutral renewable energy' and 'intra-regional trade in sustainably generated electricity' (European External Action Service, 2021). Accordingly, the EU confirmed its engagement to support the Central Asian states in the given fields.

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List of abbreviations and definitions

ADB	Asian Development Bank
CAPS	Central Asian Power System
CAREC	Central Asia Regional Economic Cooperation
CCGT	Combined Cycle Gas Turbine
CHPP	Combined Heat and Power Plant
EBRD	European Bank for Reconstruction and Development
EU	European Union
FDA	French Development Agency
FRR	Frequency Restoration Reserve
GCF	Green Climate Fund
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HPP	Hydropower Plant
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
IDA	International Development Association
IFC	International Finance Corporation
ISCC	Integrated Solar Combined Cycle
JSC	Joint-Stock Company
MS	Member State
OJSHC	Open Joint Stock Holding Company
PCI	Project of Common Interest
PV	Photovoltaic
RES	Renewable Energy Sources
SE	Soft Energy
SHPP	Small Hydropower Plant
SPP	Solar Power Plant
TALCO	Tajik Aluminum Company
VAT	Value Added Tax
VVER	Water-Water Energetic Reactor
WB	World Bank

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