Policy brief

Understanding the climate and net-zero transition risks and opportunities in Tajikistan

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Key messages

Tajikistan is already experiencing climate change impacts. Climate change projections for the 2050s indicate seasonal and annual shifts in both temperatures and precipitation, as well as increases in the frequency and intensity of extreme events that will affect the country's energy systems. Melting glaciers and snowpack could impact the generation capacity of large-scale hydropower along some river reaches.

Hydropower remains the most cost-competitive source of energy in the country, and is a priority for investment. However, the country has significant untapped potential for solar and wind energy – solar could meet 10–20% of its energy demand. While solar PV and wind are still cost-intensive compared to hydropower and fossil fuels, costs have been declining.

Increasing the share of wind and solar PV offers co-benefits in terms of job creation, reducing emissions, reducing climate risk by diversifying generation portfolios and improving the viability of the energy sector. Nonetheless, doing so will require tackling many policy challenges which impede the transformation of the energy sector.

Tajikistan's future energy infrastructure must be designed with increasing demand, including that related to economic growth and diversification, climate change and other threats like cyber-attacks in mind. The country should conduct full semi-quantitative to quantitative all-hazards risk assessments to identify risks over the decades that the infrastructure will operate, and to understand the costs and benefits of mitigation.

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This brief summarises Kyrgyzstan-specific findings and recommendations from the reports *Opportunities and co-benefits of transitioning to a net-zero economy in Kyrgyzstan, Tajikistan and Uzbekistan*, and *Managing climate risks to protect net-zero energy goals*. The authors would like to thank Farukh Kasimov, Sardor Koshnazarov and Azamat Usubaliev for contributing to the research, as well as UNDP and members of the respective national ministries and agencies for their comments.

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Acronyms

HPP	hydropower plant
LCOE	levelised cost of electricity
RCP	representative concentration pathway
R&D	research and development
RE	renewable energy
TPP	thermal power plant

1 Recommendations

This brief summarises Tajikistan-specific findings and recommendations from the reports *Opportunities and co-benefits of transitioning to a net-zero economy in Kyrgyzstan, Tajikistan* and *Uzbekistan, and Managing climate risks to protect net-zero energy goals*. Key recommendations as ways forward for transitioning to a net-zero economy and protecting infrastructure investments are highlighted below, and followed by the synopsis.

1. A comprehensive set of measures is needed to support the development of non-conventional renewables – solar, wind and small-scale hydro – with medium-term (2030) and long-term (2050) goals, complementing the *National Development Strategy 2030*.
2. Public and private investments can be prioritised in non-conventional renewable (RE) infrastructure by liberalising legal and regulatory frameworks to enable greater private sector participation.
3. Facilitation of skills development is needed to create a skilled workforce. Greater support of research and development in RE technologies and processes to ensure coherence with international standards is also critical.
4. Continue strengthening and promoting regional cooperation and rejuvenation of the electricity export market. Coordinated efforts should be made to establish a dedicated regional cooperation mechanism for RE investments and trade.
5. Energy infrastructure must be designed with climate change, increasing demand and other threats like cyber-attacks in mind. Full semi-quantitative to quantitative all-hazards risk assessments should be conducted to identify risks over the decades that the infrastructure will operate, and to understand the costs and benefits of mitigation.
6. Energy sector all-hazards risk assessments require data: the network of automated weather stations, river gauges and glacier monitoring stations should continue to be strengthened, and the Agency for Hydrometeorology should consider joining Coordinated Regional Downscaling Experiment (CORDEX) for high-resolution climate models.

2 Energy sector

Tajikistan is a mountainous country; glaciers and snowpack in the Pamir and Alay contribute to the flows of the Vakhsh, Pyanj and Gant rivers, which are tributaries to the Amu Darya River. Agriculture is the primary employer. Water resources and demand strongly influence energy generation.

Hydropower (HPP) – from large-scale reservoir HPP such as Nurek and Rogun, to smaller run-of-river HPP – dominates the energy mix in Tajikistan at 93% of total installed generation capacity. Combined heat and power fossil-fuel thermal power plants (TPP) generate the next-largest share. However, if only non-conventional renewable energy sources like small HPP, solar and wind are considered, the installed renewable energy share falls to 2.54%.

Table 1 Installed generation capacity (MW)

Energy source	2017	2021
Gas TPP	318	318
Coal TPP	400	400
HPP	4495	5406

Source: Ministry of Energy and Water Resources, 2022

Generation and transmission infrastructure are ageing in Tajikistan, with HPPs larger than 1 MW capacity ranging in age from 4 to 86 years. Several repair and upgrading projects of existing HPP, transmission and distribution systems throughout the country are underway.

As Tajikistan is more reliant on HPP, it has greater generation capacity between late spring and early autumn, when flows along the Vakhsh, Pyanj and Gant rivers are higher due to melting glaciers and snowpack. The country struggles to meet growing power demand, with recurring power deficits (electricity demand minus availability) reaching nearly 24% during the winter. Historically, Tajikistan relied on neighbours, such as Uzbekistan, to offset seasonal shortages through regional transmission grids under the Central Asian Power System. However, interconnections have been reduced, and winter and early-spring power outages are frequent. The CASA 1000 project will restrengthen regional connectedness.

Electricity demand is dominated by Tajik Aluminum Company (estimated at ~39% of total demand), irrigation pumping (predominantly April–September, around 23%) and residential use (19%) (ADB, 2017). Transmission and distribution losses are around 17%, and have increased due to ageing infrastructure and shifting demand (ibid.). Demand will increase due to economic diversification, population growth, and growing irrigation demand to offset increasing frequency and duration of drought, as acknowledged in the *National Strategy for Adaptation to Climate*

Change up to 2030; during heat waves, irrigation demand is estimated to increase by 25% (Peterson et al., 2021). The country is introducing multiple economic reforms, including new strategic goals for accelerated industrialisation, which will also impact future demand.

Table 2 Demand, historic and projected (TWh)

2000	2010	2022	2030
13.4	14.3	20.4	26.9

Source: Ministry of Energy and Water Resources (2022); IEA (2022)

Tajikistan has a series of laws governing the energy sector, with The Energy Law (2000) providing the overarching legislative framework and the energy sector's transition towards market competition. Energy security and efficient electricity use are one of four strategic priorities set out in the *National Development Strategy of the Republic of Tajikistan 2030*. The country continues to expand HPP planning, as well as diversifying its energy portfolio to construct solar and wind parks since *The Power Sector Development Master Plan* (2017). Small- and larger-scale solar parks, ranging from an installed capacity of 0.2–200 MW, are planned throughout Sughd, Khatlon and Gorno-Badakhshan.

3 Renewables potential

Levelised cost of electricity (LCOE) – the price at which the generated electricity should be sold for the system to break even at the end of its lifetime – continues to decrease for renewables globally, and RE is now competitive with conventional fossil-fuel electricity generation.

Hydropower is currently the cheapest energy in Tajikistan, with a LCOE of $15.4/MWh in 2020 (below the global average LCOE for hydropower of $44/MWh). However, only an estimated 6% of the historical HPP potential has been harnessed; future potential due to climate change impacts on glacial melt, warmer temperatures and shifting river hydrology in specific catchments remains to be calculated.

The government continues to prioritise investments in HPP, although the country has significant untapped potential for solar and wind energy. It has been estimated that solar could meet 10–20% of demand (ADB, n.d.). Solar PV and wind are still cost-intensive compared to hydropower and fossil fuels, although costs have been declining. In 2015, estimated utility-scale solar LCOE was $374/MWh; by 2021 it had reduced to $71/MWh (FCDO, 2015; Ministry of Energy and Water Resources, 2022; USAID, 2022). This trend of declining costs will continue, with solar and wind expected to become cost-competitive with fossil fuel and hydropower in the near future. According to estimates, scaling up the developments of renewables in Tajikistan would generate 10 TWh of exportable surplus in the country by 2030.

However, some key policy challenges are stalling the transition to a net-zero energy system. These include:

1. **Wind or solar power supply is not a priority.** The 2017 Master Plan does not consider wind and solar power. It is unclear which framework for renewable energy development is currently guiding the government approach.
2. **Lack of investment and private sector participation.** Public investment in RE (other than large-scale hydropower) has been minimal. Lack of incentives and legislative complexities around renewables investment remain a big constraint for private sector participation.
3. **Tajik energy sector operates at a loss.** Low tariffs, uncollected payments, and aged infrastructure all contribute to operating at a loss. Delaying reforms in this regard can undermine efforts to modernise Tajik energy generation and transmission infrastructure.
4. **Lack of skilled workforce.** Limited personnel for non-hydro renewable energy projects, in the absence of clear targets for scaling up these RE sources and programmes to train local workforce, can increase project costs.

4 Climate risks to energy infrastructure

Infrastructure investments need to be resilient to a number of rapidly changing threats related to climate change, increasing demand and cyber-attacks. The expected lifetime of solar PV installations – the current type of planned solar – is 25 to 40 years; for wind farms, it is around 20 years (NREL, 2022). Infrastructure built now or before 2030 will have to contend with projected changes in the 2050s. Hydropower and thermal power plants have longer lifetimes and must be prepared to handle the climate of 2100.

High-resolution climate change projections for the 2050s indicate shifts in both temperatures and precipitation on a seasonal and annual basis, as well as in the frequency and intensity of extreme events. Mean annual maximum temperatures are projected to increase by 1.8°–2.2°C by the 2050s across Tajikistan, Uzbekistan, and Kyrgyzstan, under Representative Concentration Pathway (RCP) 2.6 and RCP4.5, with increases of up to 4.0°C for the Pamir-Alay and eastern Pamirs.[1] The country will experience warming days and nights in all seasons, with greater warming during the winter (January–March). Extreme heat waves and droughts could extend over a multi-country area, which would have cascading regional consequences for energy demand for irrigation pumping and for transmission grid stability. The intensity and frequency of 24-hour extreme rainfall events is projected to increase. Warming temperatures and potential precipitation shifts will impact glaciers and river discharges (see Opitz-Stapleton et al., 2022).

Climate risks to energy infrastructure result from the combination of vulnerability (e.g. specific operational requirements for water, sensitivities to temperature or demand loads during extreme heat), exposure (e.g. the location of the infrastructure in a hazard-prone area) and shifts in the frequency, intensity, duration and location of climate hazards. Climate risks have to be considered not only to individual infrastructure, but also for the energy system as a whole. Some climate risks to HPP, solar and wind projects in Tajikistan are outlined in Table 3.

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1 RCP2.6 is a lower-emission scenario that is in line with Paris Agreement goals of no more than 2°C. RCP4.5 is in line with the emission totals of current NDC pledges and would amount to mean global warming greater than 3°C.

Table 3 Climate risks to energy systems*

Hazard	Risks
Higher day and night temperatures accelerate glacier/snow melt and change river flow: increases of 1.6°–2.7°C in winter and 1.1°–5°C in summer over Pamir	Direct risks: shifts in peak flow from late to early summer; sediment increases; potential flash floods due to rain-on-snow events in spring for low- to mid-elevations Cascading risks: HPP reservoirs lose storage to sedimentation and generation declines; shifting hydrology requires changing HPP operations; generation and transmission damaged by rockslide
Decrease annual precipitation of up to -8% over eastern Gorno-Badakhshan and -5% over southern Sughd. Decreases more significant in summer	Direct risks: hydrological, agricultural and socioeconomic impacts; impacts may be magnified by concurrent heat wave; water availability and quality decline Cascading risks: energy demand for irrigation pumping increases; generation declines; load shedding; socioeconomic impacts
Extreme rainfall events: 1-in-100-year 24-hour precipitation events becoming 1-in-20-year events in parts of GBAO and southern Sughd	Direct risks: flooding, particularly in late winter and spring; increased sedimentation in rivers and reservoirs Cascading risks: normal operating levels on HPP reservoirs held lower for flood routing, reducing downstream water availability; storage maximum capacity of smaller reservoirs breached by excess runoff; infrastructure damage

*This is a summary. See full report, Opitz-Stapleton et al. (2022)

5 Co-benefits of transition

There are a number of benefits that arise from transitioning to a net-zero economy. The estimates used below for potential job creation and the economic value of potential benefits are from Jacobson et al. (2017) and IRENA statistics. More details are available in Panwar et al. (2022).

1. **Meeting future demand:** Scaling up the use of renewable energy will help offset increases in energy demand as Tajikistan's economy grows and diversifies, though greater energy efficiency will also be necessary. Using additional non-conventional renewable energy capacities will also diversify the current energy mix and support the move toward a more sustainable energy supply.
2. **Job creation:** Transitioning to a net-zero economy could stimulate economic output and create employment. The RE sector is expected to create 38 million jobs by 2030 and 43 million jobs by 2050 globally. The energy sector (generation, transmission, distribution) in Tajikistan currently accounts for 1.2% of the country's total recorded jobs. In a full (100% RE) transition scenario, RE could generate over 6,000 jobs by 2050 in Tajikistan. This would add an average of nearly $0.3 billion to the Tajik economy.
3. **Reducing energy sector costs:** Conventional energy production is costly; switching to RE could generate savings in the long term considering a declining trend in the cost of RE. Tajikistan is projected to avoid up to $5 billion in carbon-based energy production costs per year by 2050 if it transitions to 100% RE.
4. **Investment opportunities:** A stable and reliable electricity supply, which is a prerequisite in attracting private investments, could create a better business environment and improve investor confidence in Tajikistan.
5. **Emissions reductions and commitments:** Increased use of RE sources can substantially reduce CO_2 emissions. Electrification and RE sources alone could deliver up to a 75% reduction in global energy-related emissions. By using HPP as a primary source of electricity, Tajikistan has avoided an estimated 8.64 million tonnes of CO_2 per year.
6. **Health benefits:** Transition to 100% RE could avoid an estimated 7,000 deaths per year by 2050. The marginal co-benefits of avoided mortality could be $50–380 per tonne of CO_2 (West et al., 2013; Vandyck et al., 2018).

Achieving these co-benefits and protecting energy investments will require additional steps on the part of the government, investors and energy companies, and cooperation with other countries on the regional grids. Some of these recommendations are outlined at the start of this brief. Full recommendations can be found in both reports.

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