IRENA
International Renewable Energy Agency

RENEWABLES READINESS ASSESSMENT

THE KYRGYZ REPUBLIC

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About IRENA

The International Renewable Energy Agency (IRENA) serves as the principal platform for international co-operation, a centre of excellence, a repository of policy, technology, resource and financial knowledge, and a driver of action on the ground to advance the transformation of the global energy system. An intergovernmental organisation established in 2011, IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energy access, energy security and low-carbon economic growth and prosperity. www.irena.org

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This report was prepared by under the guidance of Gürbüz Gönül, Binu Parthan and Prasoon Agarwal (IRENA) and authored by Arslan Khalid (consultant) and Tatiana Vedeneva (consultant).

FOREWORDS

The Kyrgyz Republic, like many countries in Central Asia and around the world, is striving to overcome the enduring challenges posed by the COVID-19 pandemic. As efforts to secure a comprehensive socio-economic recovery continue, there is a need to focus on far-reaching measures that can help build a more resilient and diversified economy, improve the energy sector's viability, attract investments in clean energy projects and propel the country towards its climate goals.

The Kyrgyz Republic relies on large hydropower installations for its electricity needs. However, the demand in end use sectors (e.g. heating and transportation) is predominantly addressed through oil, coal and natural gas. Overall, the energy sector is central to the socio-economic development of the Republic.

As the country continues to develop, the social, environmental, resource and climate concerns linked to energy consumption are set to intensify. Rising fossil fuel imports are adding to the financial burdens of an energy sector undermined by ageing infrastructure and low revenues. The transition to renewable energy is therefore a key imperative for decision-makers of the country.

This Renewables Readiness Assessment (RRA) presents a strong case for a greater share of renewables in the broader energy sector (especially in transport and heating), coupled with diversification toward dynamic technologies such as solar PV, wind and small hydro in the power sector. It identifies twelve concrete actions to help the Government in addressing energy challenges, developing a more diverse energy sector and improving the livelihoods of its citizens.

Decision-makers in the Kyrgyz Republic are aware of the promising potential of renewables. The announcement of a more ambitious NDC, and ongoing reforms in renewable energy-related laws and regulations, signify their clear intent to achieve a sustainable energy future.

I sincerely appreciate the leadership and support provided by the Ministry of Energy and Industry of the Kyrgyz Republic in the preparation of this RRA, and the insights of the other partners that broadened the perspective of the assessment. IRENA looks forward to working with all of these stakeholders to transform these recommendations into practical, on-the-ground initiatives.

Francesco La Camera
Director-General
International Renewable Energy Agency

This renewables readiness assessment (RRA) represents an important step toward establishing a secure, modern, diversified and clean energy system in the Kyrgyz Republic. This report, prepared by IRENA in collaboration with the Ministry of Energy of the Kyrgyz Republic, reflects the unwavering resolve of the Cabinet of Ministers to identify a trajectory for sustainable national growth in line with international climate commitments, and the natural and environmental resources of the country.

Having set a goal to reduce greenhouse gas emissions by 44% by 2030 and to achieve carbon neutrality by 2050, Kyrgyzstan recognises that renewables – primarily hydropower – will be the driver of zero-carbon policies, given their enormous potential in the country.

The Kyrgyz Republic has significant potential across all renewable energy technologies, with hydropower being the most promising. The Cabinet of Ministers of the Kyrgyz Republic is pursuing several initiatives to convert this potential into tangible and significant renewables use. In this context, the President of the Kyrgyz Republic, Sadyr Zhaparov, signed the Law on Renewable Energy Sources, which was then adopted by the Jogorku Kenesh [Supreme Council] of the Kyrgyz Republic.

The Law covers regulation of relations linked to the use of renewables; the key principles of national renewable energy policies; and economic, organisational and legal mechanisms in the field of renewables. It aims to improve the attractiveness of the renewables sector for investments, and the Ministry of Energy will continue to play a central role in championing cost-effective and reliable renewable technologies in the country.

The expediency of accelerated development of renewable energy sources in the Kyrgyz Republic stems from current electricity shortages and the need to include renewable energy in the economic development and fuel mix of the Republic. In this regard, a critical challenge today is the need to commission new capacities; namely both large and small facilities for the production of energy based on renewables.

New renewables technologies are able to provide competitive energy supply, while reducing negative impacts on the environment and human health, bringing opportunities for universal access to inexpensive, reliable, sustainable and modern energy sources for various categories of consumers - one of the obligations of the Kyrgyz Republic under the United Nations Sustainable Development Goals (SDGs).

The Ministry of Energy of the Kyrgyz Republic acknowledges the valuable inputs provided by all stakeholders and the insights gained during the preparation of this renewables readiness assessment.

The RRA aims to achieve ambitious goals in green energy development, and I am confident that it represents a positive contribution to policy planning for the Kyrgyz Republic's energy sector.

The Ministry of Energy of the Kyrgyz Republic hopes that this cooperation with IRENA will mark the beginning of a significant evolution in the promotion of renewable energy development, supporting long-term planning and approaches as well as further beneficial co-operation.

H.E. Mr. Sultanbekov Sabyrbek
Vice-Minister of Energy of the Kyrgyz Republic

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ACRONYMS

USDc	US cent
EEU	Eurasian Economic Union
EHC	Energy Holding Company
FIP	feed-in premium
FIT	feed-in tariff
GDP	gross domestic product
GHG	greenhouse gas
GKPEN	State Committee on Industry, Energy and Subsoil Use
GoK	Government of the Kyrgyz Republic
GWh	gigawatt hour
HOB	heat-only boiler
HPP	hydropower plant
IEA	International Energy Agency
IMF	International Monetary Fund
INDC	Intended Nationally Determined Contribution
IPP	independent power producer
IRENA	International Renewable Energy Agency
JSC	joint-stock company
KGS	Kyrgyz Republic som
km	kilometre
kWh	kilowatt hour
LCOE	levelised cost of electricity
LUCF	land-use change and forestry
MOEI	Ministry of Energy and Industry
MtCO2e	metric tonnes of carbon dioxide equivalent
mtoe	million tonnes of oil equivalent
MWh	megawatt hour
NDC	Nationally Determined Contribution
NSC	National Statistical Committee
O&M	operation and maintenance
OECD	Organisation for Economic Co-operation and Development
PPA	power purchase agreement
PPP	public-private partnership
RRA	Renewables Readiness Assessment
SAEPF	State Agency for Environmental Protection and Forestry
SARFEC	State Agency for Regulation of the Fuel and Energy Complex
PV	photovoltaic
toe	tonnes of oil equivalent
TWh	terawatt hour
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
USD	US dollar
WRI	World Resources Institute

EXECUTIVE SUMMARY

The energy sector of the Kyrgyz Republic is central to the country's development and growth. As the population continues to increase, living standards improve and the economy grows, energy demand has been rising. Domestic consumption far exceeds local production, which leads to costly fuel imports, and makes the transition to clean energy a key imperative for decision making in the sector. Balancing the objectives of sustainable growth while addressing the challenges posed by climate change and energy sector dynamics is difficult. Cognisant of this, Kyrgyz decision makers are taking legislative strides towards a more sustainable energy sector, which can help address the rising demand through clean energy sources.

A relative economic boom from 2010 onwards boosted energy demand, with final energy consumption rising by about 54% in the 2010-2019 period. The main energy consumers include the residential, industry and transport sectors. Driven by improving living standards and rising demand for heating, energy consumption in the residential sector quadrupled between 2010 and 2019.

Demand for energy is addressed by oil products, electricity, coal, natural gas and heat. Oil products account for around 37% of the primary energy supply, followed by electricity (primarily hydropower) at 30% and coal at 26%. Since 2000, the energy mix has gradually shifted towards oil and coal as the production of hydropower has stagnated. Indeed, a very limited amount of hydroelectric capacity has been put into operation in recent decades. In addition to being used for heating, oil products are primarily used to address rising demand for transport fuel. Domestic coal is being utilised for exports and local consumption in heating and other sectors. The Kyrgyz Republic is among the most energy-intensive countries in the world, which gives rise to recurring energy shortages and reduces economic productivity and competitiveness (World Bank, 2017a).

The power sector now has the challenging task of meeting the new level of electricity demand, which has increased by about 75% since 2010. The bulk of power generation (92%) is supplied by hydropower plants followed by small contributions from coal- and gas-fired power plants. The power sector also contributes to the socio-economic growth of the region through electricity trade. The dominant role of hydropower leads to strong interlinkages between irrigation and power, creating challenges for decision makers in the power and agricultural sectors. Ageing infrastructure, power sector entities' lack of financial viability, energy losses and limited new generation systems are other key challenges, which tend to reduce the quality and reliability of electricity.

A strong rationale for diversification

A more diverse Kyrgyz energy sector that relies on various renewable energy technologies, increased energy efficiency and accelerated electrification can help address rising energy demand while creating economic opportunities.

While large hydropower is set to retain its role as the backbone of the sector, the introduction of renewables such as solar photovoltaic (PV), wind, bioenergy and small hydropower can help meet demand and diversify the energy mix. The rationale for diversification towards renewables includes various social, economic and environmental factors.

Rising energy demand and energy imports: As energy consumption continues to rise, reliance on imported fossil fuels will increase. Excessive fossil fuel imports pose a significant burden on government budgets and could create energy security issues. Dependence on imported fossil fuels could also make the Kyrgyz Republic more vulnerable to volatility in international and regional fuel markets. Renewable energy technologies can help cater to domestic energy demand, thus helping to cut down the import bill.

Deteriorating infrastructure: The deterioration of energy sector infrastructure coupled with the financial crisis in the energy system will eventually lead either to a significant decrease in the quality of produced energy or to an increase in energy prices. Both of these impacts could increase demand for independent energy production and pave the way for the deployment of reliable renewable energy technologies.

Local air pollution: The Kyrgyz Republic is among those Central Asian nations most affected by diseases linked to indoor air pollution. In the winter months, the city of Bishkek regularly features among the top polluted cities in the world due to its air quality. Renewables could help replace fossil fuels (especially coal) in heating and power generation, thus reducing air pollution. Vehicular emissions can be reduced through greater adoption of public transport and the uptake of electric vehicles.

Mitigating climate change: The Kyrgyz Republic is vulnerable to the impacts of climate change, and national decision makers understand the importance of addressing this impending challenge. They are initiating mitigation and adaptation plans and programmes to ward off the impacts and to contribute to the international climate effort.

Declining renewable energy costs: Renewable energy technology prices, which are becoming increasingly competitive with fossil fuel alternatives, further strengthen the case for the uptake of non-hydro renewables. The levelised costs of solar PV and wind, for example, declined by 85% and 56%, respectively, between 2010 and 2020.

Short construction periods of renewables: The Kyrgyz Republic's rising energy demand needs to be met with rapid investments in sustainable and clean technologies. Renewables such as solar PV, wind and small hydropower tend to be modular and can be constructed in a very short time. In contrast, large hydropower projects tend to require longer construction times and can be susceptible to delays.

Seasonal variation in hydroelectricity generation: Hydropower in the Kyrgyz Republic is influenced by several factors such as seasonal variability of river flows, electricity demand and water demand for irrigation. An energy system that includes a diverse mix of complementary renewable energy technologies can be more resilient to seasonal variations.

Environmental impacts of hydropower: Large hydropower projects, just like many other large infrastructure projects, can have negative environmental and social impacts such as displacement, habitat destruction, loss of forest and disturbance to wildlife. A shift towards small hydropower projects can help avoid some of the impacts linked with large projects. Also, run-of-river hydropower installations can sidestep several of the impacts associated with reservoirs.

Abundant renewable energy resources: The country has significant renewable energy potential for solar, wind, bioenergy and hydropower. These resources can be utilised to create a diversified energy system that is sustainable from financial, social, climatic and environmental perspectives.

While the rationale for greater inclusion of renewables in the energy sector is clear, wide-scale deployment has been held back by several issues:

- Average power and heat tariffs are well below cost recovery, which holds back renewables at the retail level.
- Renewable energy targets have not been effective as they are not enforced by law, or backed by concrete policies.
- Renewable energy policies remain limited to the power sector, with little focus on heating and transport. Distributed generation policies such as net metering and wheeling are also not in place.
- Feed-in tariffs have not been successful in attracting investments, as the levels are low and the frameworks are not clear.
- Auctions/tenders have not been successful in the past.
- Permitting procedures require further clarification.
- Renewable energy capacity building is needed for public and private stakeholders.

Recommendations for the deployment of renewable energy

The Renewables Readiness Assessment presents a set of short- to medium-term recommended actions to address key challenges and support the country in moving towards a diversified and climate-friendly energy system.

Create a level playing field with energy tariff reforms

Well-designed tariff reforms in the energy sector can help generate revenue while lowering the barrier to market entry for distributed renewable energy technologies. To be sustainable, tariff reforms should be designed in a way to minimise the economic impact on low-income and marginalised parts of society.

Streamline the procedure for bringing renewable energy projects online

Permitting requirements and procedures should be streamlined under an overarching renewable energy law, implemented through concrete secondary regulations, which clearly articulate the process and identify responsible government entities. The design of the procedures should focus on simplicity, flexibility and transparency.

Improve the feed-in tariffs

The feed-in tariffs scheme should be revised and improved based on factors such as changing market conditions, competitive technology costs and clear resource assessments. The selection of an appropriate tariff is an extensive process that should be led by the government with active and diverse representation from all stakeholders. Feed-in tariffs need to be supported by a conducive policy and clear institutional responsibilities.

Implement auctions for large capacities

Auctions can be used to attract investment for relatively large-scale projects in hydropower, solar and wind. They need to be designed in a way that attracts developers, enhances competition and enables price discovery while ensuring project delivery.

Enact policies to decarbonise end-use sectors

The decarbonisation of the heating sector needs a multifaceted approach that includes renewables-based electrification, use of renewable heating (where available, solar thermal, biomass, geothermal) and investments in efficient district heating. In the transport sector, more efficient public transport, electric vehicles and support for alternative modes of transportation (*e.g.* bicycle and walking infrastructure) can help. The introduction of net metering, wheeling and other distributed generation policies can help unlock the small-scale market segment.

Improve renewable energy resource mapping

Zoning for solar PV and wind should be prioritised. An analysis of potential suitability, as conducted by the IRENA, identifies suitable zones for solar PV and wind, and can serve as an important initial step towards a complete zoning assessment. Follow-up studies could build on this exercise by performing detailed technical and economic analyses and ground-based measurements within the identified solar and wind zones.

Develop long-term energy scenarios

A detailed long-term planning exercise should be undertaken for energy demand in all sectors to identify the optimal energy mix. Scenario analyses that explore a host of different energy sector futures can be used to inform policy making. Energy sector planning needs to be complemented by reforms in the collection and reporting of energy statistics.

Establish comprehensive and ambitious renewable energy targets

Renewable energy targets should reflect the country's strong renewable energy potential, declining technology costs and rising energy demand. They are best backed by strong political commitment and legislation, to be defined at the level of the sector and further disaggregated by subsector.

Adopt a standard power purchase agreement

Design elements of renewable energy power purchase agreements (PPAs) should be devised in accordance with international best practices to de-risk investments and facilitate financing. This effort may be complemented by a thorough review of contractual project document templates for renewables along with the development of standardised PPAs.

Introduce public-private partnerships

To be successful, the introduction of public-private partnerships (PPPs) in the Kyrgyz energy sector must be backed by strong political will, capable institutions and conducive legislation. Fair risk-sharing criteria must be established. On the public side, there should be an absolute commitment to the long-term payment for energy production. On the private side, penalties should be levied if services are not delivered.

Enhance institutional capacities

The technical and co-ordination capabilities of public and private sector entities require improvement to facilitate renewable energy deployment. Topics to address include technology costs, grid integration issues, economic management and the introduction of flexibility mechanisms, regulatory aspects, policy design, etc.

Educate and train a skilled workforce

Investment in the education and training of workers such as engineers, technicians and other skilled personnel is very important. Universities, vocational training institutes and schools all have a role to play. Industry upgrade programmes, joint ventures and tax breaks can be used to strengthen local industrial capabilities.

1. INTRODUCTION

The Kyrgyz Republic is a landlocked, mountainous country in the northeast of Central Asia. The country borders Uzbekistan to the west, Kazakhstan to the north, China to the east and Tajikistan to the south. The total area of the country is approximately 200 000 square kilometres (km^2) (Energy Charter, 2018).

About 80% of the country is mountainous; the rest is valleys and basins. The climate is continental, with strongly defined seasons. The rugged topography, with large differences in altitude, determines the variety of climatic conditions and temperatures in different regions of the country. The annual average sunshine level, at 2 100-2 900 hours/year, is similar to that of Türkiye and Greece (Energy Charter, 2018).

The country is divided into nine administrative areas, including seven provinces and the two main cities of Bishkek and Osh (Figure 1.1). Bishkek is the national capital and the largest city with a population exceeding 1 million people (1 074 000 people in 2020). Osh (322 000 people), Jalal-Abad (123 000) and Karakol (84 000) are other major cities (NSC, 2021).

The republic has significant water resources. It is the only Central Asian country where almost all the water resources originate within national borders. The Kyrgyz Republic's lakes, glaciers and rivers are a significant part of the country's hydrological resources. The republic's 1 923 lakes and reservoirs hold more than 1 745 cubic kilometres (km^3) of water, most of which is stored in lake Issyk-Kul. Glaciers are estimated to hold 760 km^3 of water, but this water source has been decreasing in recent decades. There are more than 25 000 rivers, of which 73 are more than 50 km in length, and the remaining are smaller. Irrigated farming accounts for around 90% of water consumption, followed by industrial purposes (6%), household use (3%) and other uses (1%) (DWRLI, 2021; Mamatkanov, Bazhanova and Romanovsky, 2006; Ratnaweera *et al.*, 2013).

Figure 1.1 Administrative regions of the Kyrgyz Republic

Source: UN Geospatial (2011).

Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply the expression of any opinion on the part of IRENA concerning the status of any region, country, territory, city or area, or of its authorities, or concerning the delimitation of frontiers or boundaries.

1.1 Socio-economic conditions

The population of the Kyrgyz Republic stood at around 6.6 million people at the beginning of 2021. One-third of the resident population (34%) lived in urban settlements with the remaining living in rural areas. The population density averaged 33 people/km^2. The average life expectancy was 68 years for the male population and 76 years for the female population. The inflation rate was 5% in 2019, and the unemployment rate in the country amounted to 5.5% (NSC, 2021; World Bank, 2020).

The poverty level in the country was 25% in 2020, which is the second highest in the Central Asia region after Tajikistan (NSC, 2021; World Bank, 2021). Around 1.3 million people lived below the poverty line in 2019, of which 74% were residents of rural settlements. While a fourth of the country's population was poor, 58% were considered vulnerable (with per capita income less than USD 5.5/day). Concerns about poverty have direct implications for the energy sector, particularly when it comes to tariff setting. The current social safety net is not adequate to mitigate the potential impacts of a tariff increase on the poor (IMF, 2019; NSC, 2021).

An unstable political situation and low level of economic development are considered to be contributing factors to the three political crises of 2005, 2010 and 2020. Increases in electricity tariffs and the obscure privatisation processes of energy companies have also contributed to social unrest and instability in the Kyrgyz Republic in recent decades. The affordability and reliability of the energy supply remain very sensitive issues (Energy Charter, 2018; Mallinson, 2020).

The gross domestic product (GDP) in 2020 amounted to Kyrgyz Republic soms (KGS) 601 billion (USD 7 billion),[1] following a contraction of 8.4% from 2019 due to social unrest, a financial crisis and the COVID-19 pandemic. Over the past couple decades, GDP growth averaged at around 4.45%, compared to 6.5% in the other Caucasus and Central Asia[2] countries and 5.3% in emerging market developing economies[3] (IMF, 2019; World Bank, 2021). In response to the pandemic, the Government of the Kyrgyz Republic (GoK) introduced several socio-economic measures to encourage economic growth in a more sustainable and climate-friendly direction (UNFCCC, 2021).

National estimates show that between 2010 and 2020 GDP increased from USD 920 to USD 1 231 per capita (NSC, 2021). The International Monetary Fund (IMF) estimated it at USD 1 330 in 2022. Income per capita has lagged behind that of comparator countries over the last couple decades. Meanwhile, the income gap with emerging market countries has been increasing. In 2019, the IMF estimated that at its forecasted growth rate (3.8% on average over 2020-2023), GDP per capita in the Kyrgyz Republic would require 23 years to reach middle-income GDP per capita levels (USD 2 370). Achieving this benchmark may become more difficult due to the COVID-19–related economic slowdown (IMF, 2019; SAEPF, 2020).

The country has considerable economic potential based on its resources, including pastures (48%) and arable land (7% of the country) along with substantial forests and minerals (World Bank, 2020).

According to data for 2019 (Figure 1.2), trade accounts for about 18% of GDP, followed by the industrial sector at 14%. The basis of industry is the country's largest gold deposit at Kumtor. The agriculture sector accounts for 12% of GDP, the construction sector for about 10%, transport 4%, while other services make up the rest. Energy generation, transmission, distribution and supply account for about 2.3% of GDP (NSC, 2021).

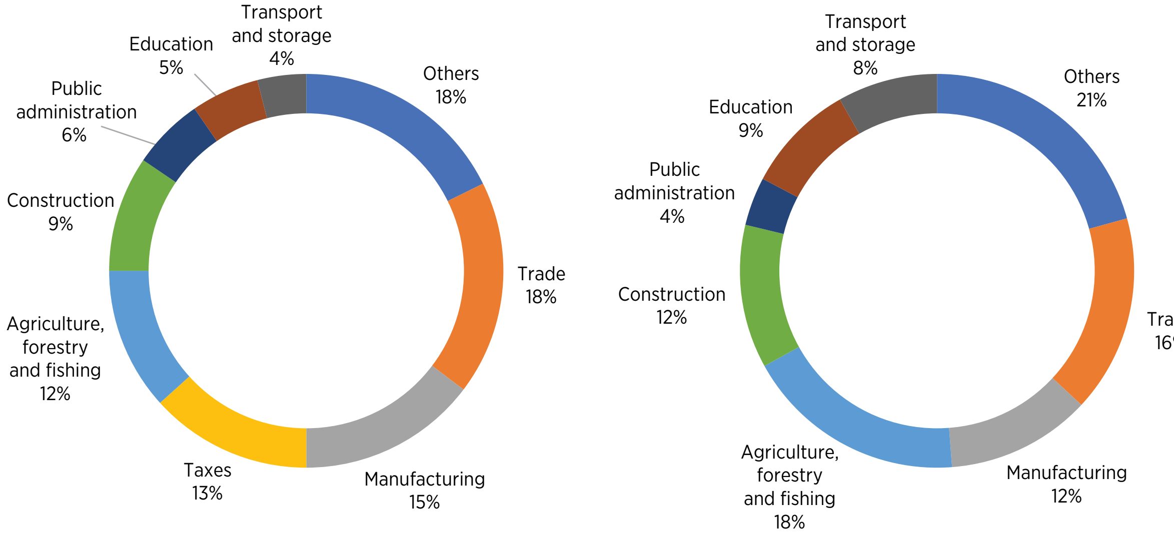
The two largest sectors contributing to the country's GDP - domestic trade and industry - employ about 16% and 12%, respectively, of the working population. The agriculture sector employs the largest share of the working population, at 18%, though this sector is only the third largest in terms of its contribution to GDP. The significant differences between these sectors in employment and their contribution to GDP is explained by the presence of a large informal economy in the agriculture sector and the comparatively low income of informal workers. The added value received as a result of hidden and informal production (excluding agriculture) is estimated at 23.4% of GDP. The electricity, gas and steam generation, transmission, distribution and supply subsectors employ 1.3% of the total working population of the country, or about 13% of industrial workers (Energy Charter, 2018; NSC, 2021).

1 *USD 1 = KGS 84.8 (as of 30 January 2021).*

2 *Armenia, Georgia, the Kyrgyz Republic and Tajikistan are oil importers, while Azerbaijan, Kazakhstan, Turkmenistan and Uzbekistan are oil exporters.*

3 *Emerging market developing economies include 154 countries.*

Figure 1.2 Comparison of GDP components (left) and structure of the Kyrgyz labour market (right), 2019 (%)



Source: NSC (2021).

Note: GDP = gross domestic product.

The country's economy relies on three highly volatile sources of revenue including mineral resources, remittances and foreign aid, and loans. Around 31% of the country's GDP in 2020 was through remittances. The Kyrgyz Republic is rich in mineral resources but has negligible oil and natural gas, which it imports. Substantial deposits of coal, gold, uranium, antimony and other valuable metals are included in its mineral reserves (World Bank, 2021).

This reliance leads to vulnerability to external economic shocks. Economic growth in the past decade has been driven mainly by the service sector, including trade, while the contribution of the industrial sector has been fluctuating given the strong presence of natural resource processing activities (Rovenskaya *et al.*, 2018).

1.2 Renewables Readiness Assessment

A transition towards renewable energy in all energy sector applications can help address energy demand while creating economic opportunities and position the Kyrgyz Republic as a global example for sustainable growth and well-being. The Renewables Readiness Assessment (RRA) aims to support the GoK in this transition. The RRA was initiated by the Ministry of Energy and Industry (MOEI) in 2021 in co-operation with the IRENA, to support the country's efforts in enabling the greater adoption of various renewable energy technologies in the energy sector.

IRENA developed the RRA as a tool for carrying out a comprehensive evaluation of the conditions for renewable energy deployment in a particular country. The RRA is a country-led, consultative process. It provides a venue for multi-stakeholder dialogue to identify challenges to renewable energy deployment and to devise solutions to existing barriers. Short- and medium-term recommendations are presented to governments to guide the formation of new policies or the reform of existing policies to establish a more conducive enabling environment for renewable energy. The RRA also consolidates existing efforts and mobilises resources for priority action. Since 2011, the RRA methodology has been used to conduct more than 30 country assessments, often resulting in extensive stakeholder engagement and improvements in policies and institutional frameworks (IRENA, 2013, 2022).

The RRA of the Kyrgyz Republic provides a rigorous assessment of ground conditions, including the enabling environment and the potential for growth of the renewable energy market. The assessment determines that there is a strong case for diversification of the country's power mix towards medium-sized and small hydropower, and towards renewables in end-use energy sectors such as transport and heating. Finally, to help the Kyrgyz Republic accelerate the deployment of renewables, it provides a range of recommendations including policy measures and initiatives, rooted in extensive analysis and stakeholder input.

The RRA has been enriched through the guidance and inputs of the MOEI, the United Nations Development Programme (UNDP) and other stakeholders. An initial expert consultation workshop, co-organised by the MOEI, IRENA and the UNDP in April 2021, helped lay the foundations of the RRA. The findings and recommendations of the RRA were discussed in a validation workshop co-organised by IRENA, the MOEI and the UNDP in February 2022.

The RRA included three special objectives: contributing inputs to the Nationally Determined Contributions (NDCs) process; an assessment of the potential of wind and solar photovoltaic (PV); and capacity building in the setting of renewable energy targets. IRENA prepared an NDC note in January 2021 to contribute to the NDC updating efforts of the UNDP and the GoK. A detailed assessment of the solar and wind energy potential of the country has been added to the RRA. Finally, an activity to build capacity in setting renewable energy targets was carried out in March 2022.

Yurt camping in Kyrgyzstan
© Dave Primov / Envato.com

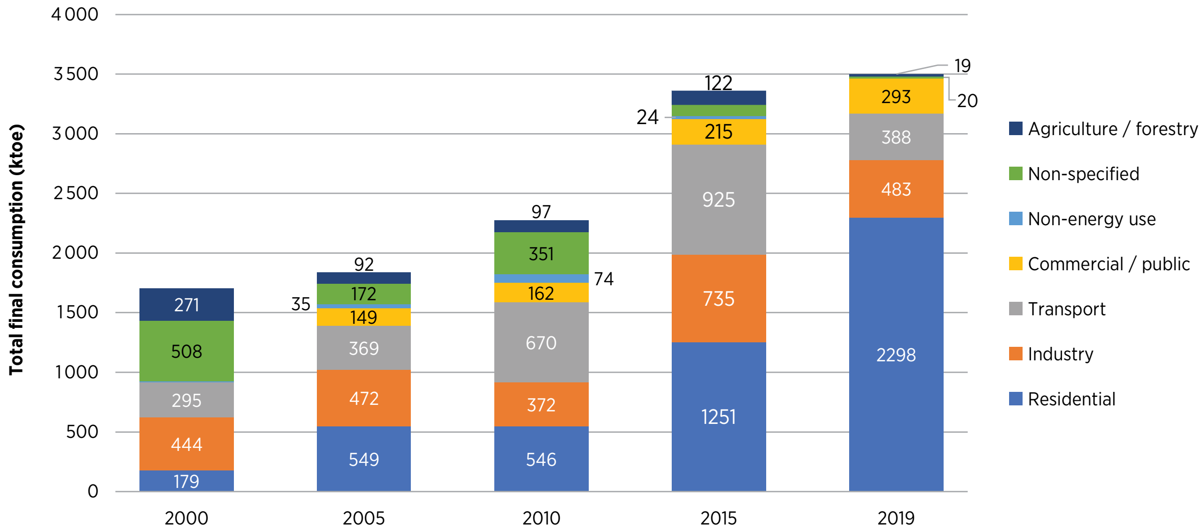
2. ENERGY SECTOR CONTEXT

The energy sector has played an important role in the socio-economic development of the Kyrgyz Republic. As the Kyrgyz population continues to increase and the economy grows, energy consumption has been increasing. Kyrgyz energy consumption far exceeds domestic production, which leads to costly fuel imports, and makes the transition towards clean fuels a key imperative for decision making in the sector.

2.1 Energy consumption and production

The 2000-2010 decade was characterised by an economic crisis and social unrest, which slowed growth in energy demand. A relative boom in economic growth from 2010 onwards has boosted energy demand. Final energy consumption increased by 33% in the 2000-2010 decade compared to growth of 54% in the 2010-2019 period. Total final consumption stood at 3.5 million tonnes of oil equivalent (mtoe) in 2019 (Figure 2.1).

Figure 2.1 Total final energy consumption by sector, various years



Source: IEA (2020b).

Note: ktoe = kilotonne of oil equivalent.

The main energy consumers include the residential, industry and transport sectors, representing 66%, 14% and 11% of consumption, respectively. They are followed by the commercial/public sector,[4] agriculture/forestry and non-energy use, all with much smaller shares of consumption. Consumption in the industry and transport sectors has undergone significant fluctuations, some of which could be explained through changes in levels of economic activity, while others could be due to statistical methodologies.[5] The energy consumed by the residential sector, however, has grown consistently and rapidly, tripling during the 2000-2010 period and more than quadrupling between 2010 and 2019. This increase can be attributed to improving living standards coupled with the rising demand for heating.

Final energy consumption is composed of oil products, electricity, coal, natural gas and heat. Oil products account for around 40% of consumption, followed by electricity at 30%. Coal, heat and natural gas account for 16%, 8% and 4%, respectively, of final demand.

[4] *Includes energy supplied for construction, installation and drilling works and for communal and cultural needs.*

[5] *In 2019, for instance, new legislation restricted fuel imports to only those for private use. Thus, despite similar or greater demand from the transport sector, consumption fell dramatically and the bulk of it shifted to the residential sector (according to IEA data).*

The fuel mix seen in final demand (Figure 2.2) has undergone a significant shift since 2000 when electricity was the dominant contributor with 41%, followed by oil products at 24% and coal at 12%. A very limited amount of hydroelectric capacity was put into operation in recent decades, while the consumption of coal and mazut (heavy fuel oil) increased for heat generation. Consequently, coal's market share increased to 16% in 2019 due to the availability of relatively cheap local coal reserves while that of electricity declined to 30%. Shares of natural gas also decreased slightly from 10% to 8% between 2000 and 2019 due to reduced availability and higher prices. Simultaneously, the share of oil products in final consumption increased to 41% by 2019 due to the country's growing vehicle fleet. Another negative trend is the smaller share of heat energy in final consumption (14% to 4%), revealing that the country did not fully utilise the potential of its two combined heat and power plants in Bishkek and Osh and the district heating systems in other small cities (Energy Charter, 2018; IEA, 2020b).

The shift towards oil is also evident in the mix of the total primary energy supply. As Figure 2.3 shows, the energy supplied by hydropower stagnated at around 1.1 mtoe, while that from oil and coal more than doubled. Consequently, the share of hydropower declined from 43% to 30% between 2000 and 2019, whereas that of oil increased from 16% to 37%. The share of coal supply also increased from 18% to 26% due to domestic consumption and rising exports to neighbouring countries (China, Uzbekistan and Tajikistan).

Overall, the total primary energy supply increased by 13% during the 2000-2010 period, followed by a more rapid increase of 39% from 2010 to 2019 – which is consistent with consumption and economic growth patterns during these periods (Figure 2.3). Oil, hydropower and coal were the key sources in 2019 accounting for 37%, 30% and 26%, respectively (IEA, 2020b).

Figure 2.2 Total final energy consumption by source, various years

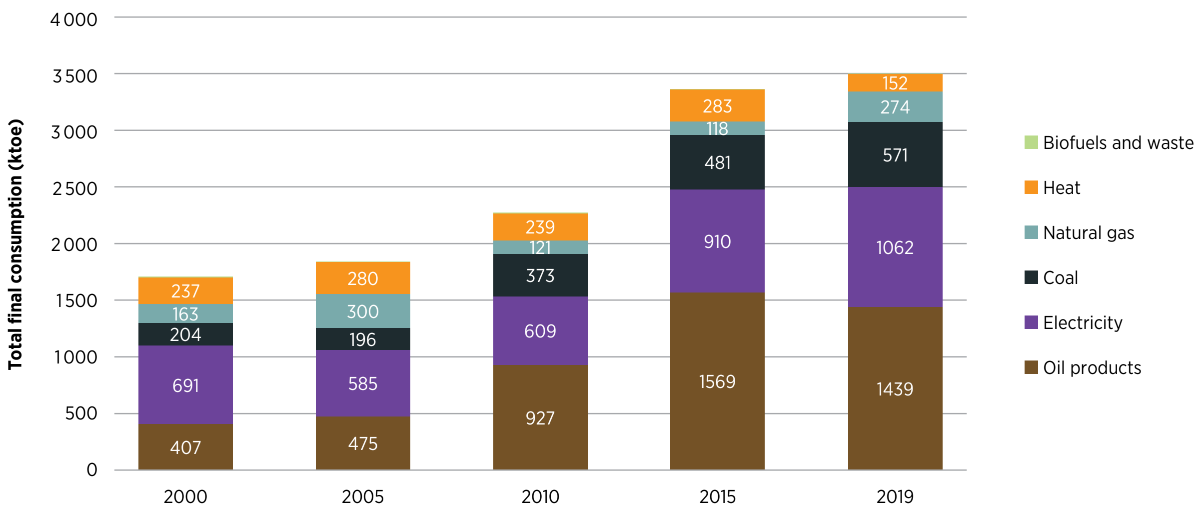
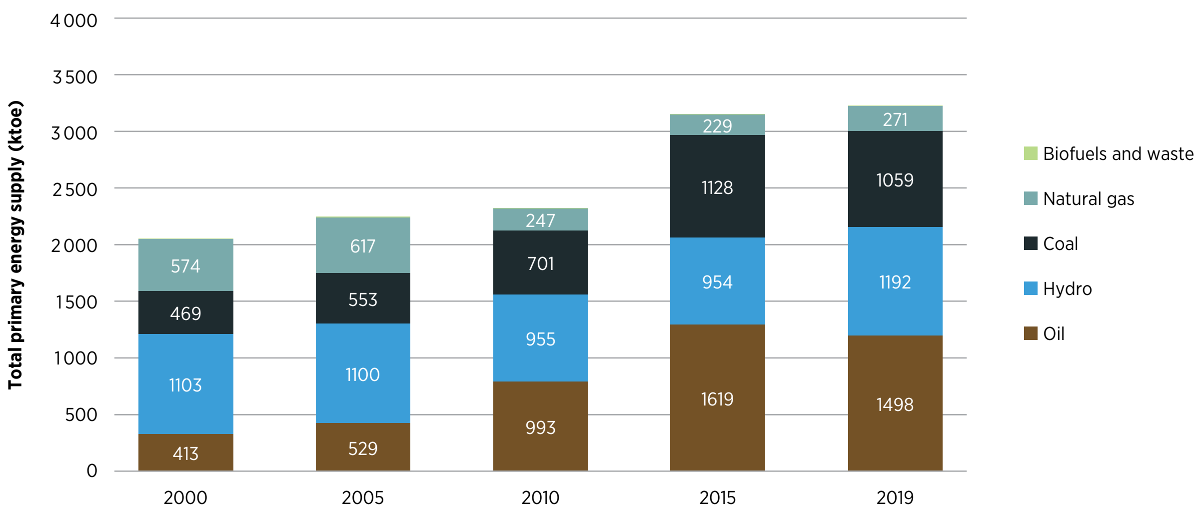


Figure 2.3 Total primary energy supply by fuel, various years



Source: IEA (2020b).

Note: ktoe = kilotonne of oil equivalent.

The Kyrgyz Republic is among the most energy-intensive countries in the world. According to the International Energy Agency, in 2019 the energy intensity of GDP was 0.19 toe per USD 1000, as compared with a world average of 0.12 toe, 0.11 toe for the Organisation for Economic Co-operation and Development (OECD) countries, 0.15 toe for China and 0.20 toe for Eastern Europe and Eurasia as well as neighbouring Kazakhstan. Energy intensity leads to persistent energy shortages and also reduces economic productivity and competitiveness (IEA, 2020b; World Bank, 2017b)

2.2 Electricity sector

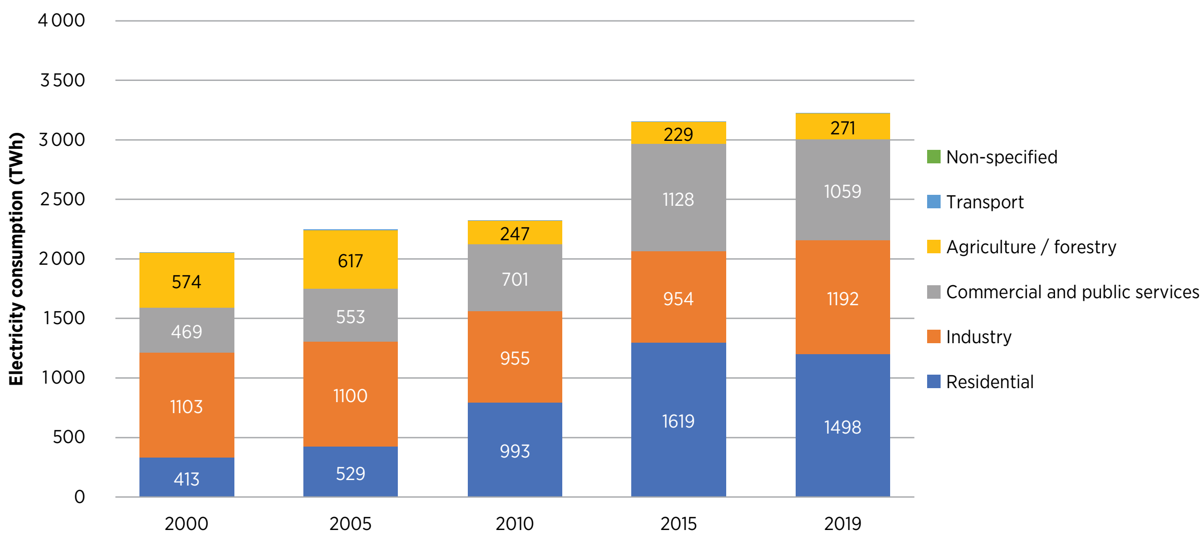
The power sector faces the challenging task of meeting rising electricity demand. The sector also contributes to the socio-economic growth of the region through the electricity trade. The dominant role of hydropower leads to strong interlinkages between water and power, posing challenges to decision makers in the power sector. Ageing infrastructure, power sector entities' lack of financial viability, energy losses and limited new generation are other key challenges, which tend to reduce the quality and reliability of electricity.

Electricity consumption

Power consumption per capita, despite limitations imposed by power shortages, grew by close to 45% from 2010, reaching 2 megawatt hours (MWh)/capita in 2019. In the broader context of Central Asia, the per capita electricity consumption of the country is slightly higher than neighbouring Tajikistan (1.7 MWh/capita) and Uzbekistan (1.8 MWh/capita) but lower than Kazakhstan (5.2 MWh/capita) and Turkmenistan (2.8 MWh/capita) (IEA, 2020a, 2020b). The increasing per capita electricity consumption can be attributed to several factors including increased living standards and electrification of heating demand.

Electricity consumption increased by around 75% between 2010 and 2019, reaching 12.4 terawatt hours (TWh) (Figure 2.4). Demand from the residential sector increased by 152% between 2010 and 2019, reaching two-thirds of total electricity consumption in 2019. The increasing demand for electric heating in the residential sector was a key driver of this trend; other factors include improved living standards and subsidised tariff structures. The industrial sector with close to 18% of total demand was the second-largest power consumer in 2019. Demand in the sector increased by 24% from 2010 due to ongoing economic recovery, but remained well below the levels seen in 2000. Demand from the agricultural sector steadily declined, with the electricity intensity of agricultural GDP falling by almost 93% from 2000, and 45% from 2010 (IEA, 2020b).

Figure 2.4 Electricity consumption by sector, various years



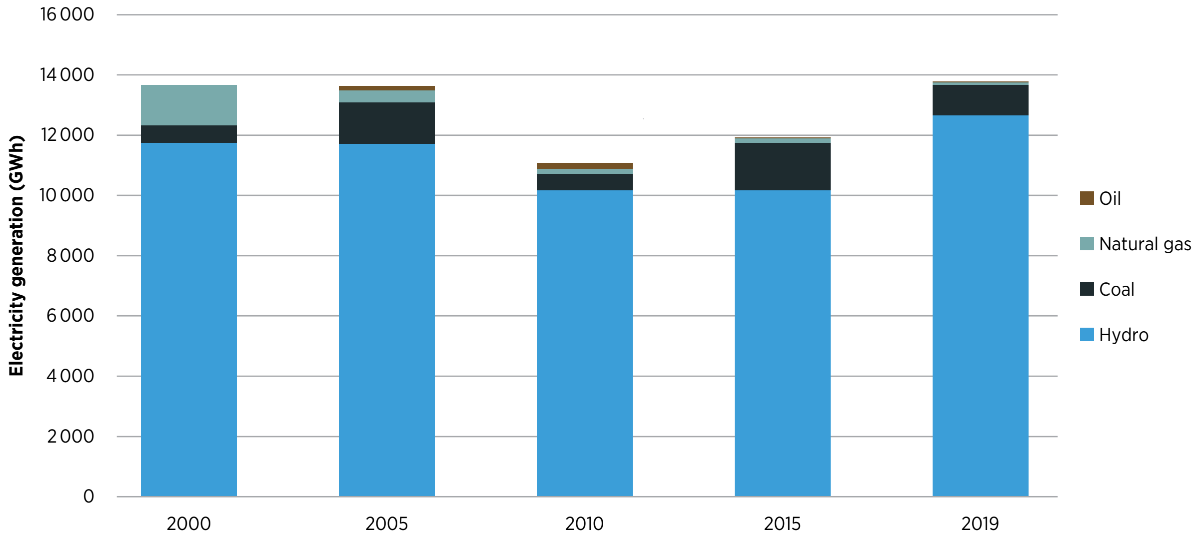
Source: IEA (2020b).

Note: TWh = terawatt hour.

Generation and trade

Total electricity generation has been increasing to address the rise in domestic demand and export requirements. In 2019, total generation was estimated at around 15 TWh, which is a 24% increase over 2010 but only slightly higher than in 2000 (Figure 2.5). The bulk of this generation (92%) was supplied by hydroelectric power plants followed by small contributions from coal- and fuel-oil-fired power plants (7% and 1%, respectively). While hydropower has always been the dominant technology for electricity generation, fossil-fuel-based generation has gradually shifted from gas to coal since 2000. This shift is due to shortages in gas supply from Uzbekistan, starting in 2003 due to large debts owed by the Kyrgyzgas company to Uzbek counterparts (Yusupkhanova, 2003). In 2014, Kyrgyzsgas was sold to Gazprom, after which some gas imports from Uzbekistan were restored. Kazakhstan, the Russian Federation and Uzbekistan are the key sources of gas for the Kyrgyz Republic (Pirani, 2019; Vedomosti, 2014).

Figure 2.5 Electricity generation by source, various years



Source: IEA (2020b).

Note: GWh = gigawatt hour.

The installed capacity of the country stood at 3 982 megawatts (MW) in 2020 and primarily comprised:

- seven large hydropower plants ranging from 40 MW to 1 200 MW, at a combined capacity of 3 067 MW, located on the Naryn and Bashy rivers;
- nineteen small hydropower plants ranging from 0.26 to 8.7 MW, with a total capacity of 54 MW, located on the Alamedin, Chu and other small rivers; and
- two combined heat and power plants with a total capacity of 862 MW (Bishkek, 812 MW; Osh, 50 MW).

The country's hydropower production fluctuates seasonally, which significantly affects power reliability. Power supply is typically most reliable in spring and summer, when it satisfies national energy demand and even provides electricity for export. During the autumn-winter period, the country stores water in dams (instead of maximising power generation) to meet downstream irrigation requirements in the spring season (Imanaliyeva, 2021; Zeng *et al.*, 2017).[6] Moreover, rainfall and glacial meltwater tend to decline in the winter months. The resulting shortfall in power generation in autumn and winter is addressed through imports of electricity (mainly from Kazakhstan). This seasonality coupled with trends in domestic demand have a significant impact on the electricity trade. In 2013, for instance, all generation was used to fulfil domestic demand and in 2014 the country moved from being a net electricity exporter to a net electricity importer. In 2017 and 2018, however, high water levels meant that the country was a net exporter of power. In 2021, severe drought resulted in significant challenges to the food and energy security of the country and the broader region. Prospective plans include the construction of 8 cascades of 34 hydroelectric power plants with a total installed capacity of 6 450 MW.

[6] *During the Soviet era, electricity was supplied to the Kyrgyz Soviet Republic by the Kazakh and Uzbek Soviet Republics in autumn and winter. In spring and summer, with reservoir gates wide open, the Kyrgyz Soviet Republic supplied water and electricity to its neighbours.*

As domestic electricity demand continues to increase and investments in new generation capacity are lacking, exports of electricity are likely to decline in future.

The Kyrgyz Republic is part of the Central Asian Power System, which connects it with Kazakhstan, Tajikistan and Uzbekistan. Future projects such as the Central Asia–South Asia power project (CASA-1000), aim to take regional power sector integration further by connecting the electricity-exporting Central Asian countries including the Kyrgyz Republic and Tajikistan with Afghanistan and Pakistan to export surplus summer electricity. Project implementation started with the construction of generation and transmission infrastructure in the Kyrgyz Republic, Tajikistan, Afghanistan and Pakistan (CASA-1000, 2021; USAID, 2021). Further investments in the Kyrgyz power sector to increase generation capacity, while simultaneously decreasing the intensity of domestic demand, could help ensure that the country benefits from the power trade opportunities offered by the project.

Infrastructure and tariffs

The bulk of investment in the Kyrgyz power sector was carried out in the Soviet era, which means that about 45% of available generation capacity is beyond its useful service life, and transmission and distribution assets are also deteriorating. The largest power distributor in the country, Severelectro, for instance, reported in 2016 that close to 40% of the underground cables in Bishkek required urgent replacement. Old assets and infrastructure, especially when undermaintained, could put supply reliability and quality at risk (World Bank, 2017b). In 2018-2019, around 43% of firms reported experiencing power outages, and around 34% reported that they own or share a generator (World Bank, 2022).

The power system needs significant investment to maintain ageing equipment or develop the capacity required to meet growing demand. This is unlikely under current conditions since the system is not viable from a financial standpoint and is kept functioning through inputs from the government budget. Subsidies on retail prices are at the heart of the financial issues faced by the power and energy sector (World Bank, 2017b).

The retail tariffs for power in the Kyrgyz Republic are among the lowest in the world. This incentivises an inefficient energy consumption pattern. The resulting lack of revenue leads to underinvestment in infrastructure and severe underspending on maintenance. Consequently, the reliability and quality of the power system suffers (Holzhacker and Skakova, 2019). The decline in reliability is most evident in the winter season, when the gap between the available generation capacity and rising demand emerges (World Bank, 2017b).

Large residential consumers (above 700 kilowatt- hour [kWh] consumption) and non-residential consumers pay tariffs (2.16 and 2.52 KGS/kWh [2.5 and 3 US cents (USDc)/kWh],[7] respectively) that are above cost-recovery levels (1.97 and 1.55 KGS/kWh [2.3 and 1.8 USDc/kWh], respectively) and cross-subsidise small residential consumers, who pay tariffs (0.77 KGS/kWh [0.9 USDc/kWh]) that are below cost-recovery levels. Small residential consumers account for more than half of total consumption, which means that the average tariff remains below cost recovery and the sector's revenue continues to be offset by the cost of power production and delivery (Rosenthal, Gassner and Hankinson, 2017).

Several tariff reforms have been designed in recent years. Concerns about poverty and affordability have repeatedly held back implementation (Holzhacker and Skakova, 2019). The latest of such reforms has increased tariffs for non-residential customers by 0.4 USDc/kWh to 3 USDc/kWh, but has decreased the tariff for low-income families receiving a monthly allowance for needy citizens (families) with children under 16, down to 0.5 KGS/kWh (0.59 USDc/kWh) in October 2021 (SARFEC, 2021).

Governance of the power sector

Until 2001, the Kyrgyz electricity system was operated by a vertically integrated state-owned company, Kyrgyzenergo, which was responsible for all power generation, transportation, distribution and supply. From 2001, the Kyrgyz electricity sector was legally unbundled to create two generating companies (called Electric Power Stations and the Chakan Hydropower Plant); one transmission company responsible for dispatch and market operations (the National Electric Grid of Kyrgyzstan); and four distribution and supply companies (Severelectro, Vostokelectro, Oshelectro and Jalal-Abadelectro) (Energy Charter, 2018). All were formed as joint-stock companies (JSCs).

In 2016, the sector underwent a new reform aiming to increase the operational efficiency of the power system. The government established a new company, the Energy Holding Company (EHC), an open JSC, which became responsible for the efficient operation of all electricity producers and transmission and distribution companies. At the time of writing, all the above-mentioned eight companies, created as part of the unbundling reforms during the period 1997-2001, still exist and operate. Their stocks, however, belong to the EHC, which is now a part of the Ministry of Energy.

[7] *USD 1 = KGS 84.8 (as of 30 January 2021).*

Electricity tariffs are set by the regulator, the State Agency for Regulation of the Fuel and Energy Complex (SARFEC), now also a part of the Ministry of Energy.

The Kyrgyz Energy Settlement Center, an open JSC, provides paid services to participants in the electrical energy market. The centre uses an analytical system to collect, process, verify and analyse data on power flows, electricity losses and reliability. It develops electricity balances, and monitors settlements for all participants in the electricity market (UNECE, 2018).

2.3 Heating sector

Given the cold climate, access to reliable heat supply is important for the well-being of the Kyrgyz population. Heating demand is fulfilled by various fuels and technologies ranging from large, centralised district heating systems to large and small heat-only boilers (HOBs, or boiler houses) to individual heating systems.

The nature of heating demand varies a lot across large cities (Bishkek and Osh) and smaller cities and rural areas. Stoves, often fuelled by dried dung, wood and coal, are the main sources of heating for rural households and urban households outside large cities. Low-income households often use coal with wood or dung (in rural settings). Higher-income households typically use coal with electricity or wood (World Bank, 2020). These stoves often tend to be inefficient (with efficiency rates of 25% to 40% as opposed to 60% to 80% for high-efficiency models) and lead to significant indoor air pollution. As a result, the Kyrgyz Republic is among the European and Central Asian nations most affected by diseases resulting from indoor air pollution. In urban households outside Bishkek, stoves (50%) are followed by electric heating (37%) and district heating (9%) in popularity. In Bishkek, close to 43% of households rely on district heating as a main source of heating, followed by electricity (21%) and stoves (22%) (Balabanyan *et al.*, 2015).

Small HOBs provide heat for buildings that are not linked to the district heating systems. Nearly 300 HOBs are operated by district heating companies, half of which are fuelled by coal, and around a further 2 500 small HOBs are owned and operated by public institutions and used to heat public buildings. These are largely fuelled by coal and electricity in fairly equal shares (Balabanyan *et al.*, 2015).

About 95% of the heat energy provided by the country's district heating systems is consumed for household and municipal needs. The remaining heat is supplied to the industrial sector. The total consumption of heat energy supplied by district heating systems decreased by about 10% in the past decade, which is primarily due to the decreasing demand of industrial consumers, driven by the unreliability of the deteriorating district heating network (Energy Charter, 2018).

Fuel consumption in the heating sector

Heat production from combined heat and power plants and boiler houses remained unchanged from 2010 to 2018. Combined heat and power plants in Bishkek and Osh (Bishkekteplosetj and the Osh municipal company Teplosnabjenie) account for three-quarters of heat production.

Most of the district heating systems and HOBs in the Kyrgyz Republic were originally designed for natural gas. The collapse of the Soviet Union led to gas becoming scarcer and more expensive. Therefore, district heating systems and HOBs were converted to run on coal, mazut or electricity. The district heating companies are initiating several projects to switch fuels from coal, mazut and electricity to natural gas. Overall, four types of fuels are used by the district heating systems: coal, mazut (heavy, low-quality fuel oil), electricity and natural gas (Energy Charter, 2018). Renewables such as solar thermal and biomass are also viable candidates for fuelling heat generation. The Gagarin, Orto-Say and Rotor boiler houses' solar pilot projects in Bishkek have shown that solar thermal can be successfully incorporated into existing heating infrastructure to reduce fossil fuel consumption and emissions (see Box 2.1 for details) (SAEPF, 2020).

The combined heat and power plant in Bishkek is primarily fuelled by coal, whereas the one based in Osh has been performing as an HOB since 2014.

The boiler houses (HOBs) are primarily fuelled by coal and electricity, but some also use gas and fuel oil/mazut (SAEPF, 2020).

Households not connected to the district heating system started to increase their reliance on electricity for heating as gas became increasingly expensive and scarce after the collapse of the Soviet Union. Households connected to district heating also use electricity as a supplementary source of heat. The resulting increase in power demand strains the grid and decreases the reliability of supply during the winter months (Balabanyan *et al.*, 2015).

Box 2.1 Solar-assisted district heating: The Gagarin, Orto-Say and Rotor boiler houses

Bishkekteploenergo began operating a combined solar and natural gas pilot project as part of the refurbishment of the Gagarin, Orto-Say and Rotor boiler houses. The Gagarin pilot project involved the substitution of two old coal-fired boilers with modern oil- and gas-fired units combined with an installation of 800 square metres (364 panels at 0.5 megawatt thermal [MW_{th}]) of solar thermal panels on the roof of a boiler house and hot water storage capacity of 40 cubic metres (m^3). The Orto-Say and Rotor boiler houses received 120 and 396 panels (0.168 MW_{th} and 0.6 MW_{th}, respectively).

The renovation of the boiler houses significantly decreased gas consumption resulting in savings of 42.7 trillion m^3 and 10 trillion m^3 in Gagarin and Orto-Say, respectively.

Source: SAEPF (2020).

Infrastructure and tariffs

Access to reliable and affordable heat is critical to the good health and well-being of the people of the Kyrgyz Republic. The heating sector suffers from a host of interlinked issues including a significant supply-demand gap, insufficient and unreliable supply, ageing infrastructure, lack of financial viability and inefficiencies in both generation and end use.

The centralised infrastructure used for heating in urban areas is deteriorating. Most of the district heating assets (combined heat and power plants, boilers and distribution networks) were built more than 20 years ago. As in the power sector, inadequate investments in replacement and maintenance mean that this infrastructure is deteriorating. Consequently, assets often end up operating at 20% to 50% of their name-plate capacity, with losses exceeding a quarter of generation. Service quality has also declined. In 2013, district heating customers in Bishkek suffered more than 300 outages (Rosenthal, Gassner and Hankinson, 2017).

The demand side also suffers from significant efficiency issues. The building stock is old and has low energy performance. Around half of the residential building stock in the country was built before 1980, and around three-quarters was built before 2004. The inefficiency of the building stock is compounded by subsidised tariffs leading to excessive energy consumption in the sector (Energy Charter, 2018).

The lack of cost-reflective tariffs is one of the root causes of the above-mentioned challenges, *i.e.* ageing infrastructure and inefficiencies on the demand side. Heat tariffs are below cost-recovery levels, which means that most suppliers lack the necessary funds for proper maintenance – leading to decaying infrastructure.

Residential heating tariffs are estimated at around 13% to 50% (based on the source of heat) of the supply cost. Only 25% of heat consumption is metered, and the billing for consumers without meters is based on parameters that are not linked to energy consumption. Thus, the system fails to provide price signals for efficient energy use (Balabanyan *et al.*, 2015; Energy Charter, 2018). In metered systems, the heating price is set at 1134.76 KGS/gigacalorie (143 USD/toe), which is a fraction of the cost of delivery. The cost of heat generation in Bishkek in 2017, for instance, was 3 741.2 KGS/gigacalorie (472 USD/toe). The cost differential is borne by the city and government budget (SAEPF, 2020).

In 2021, the tariffs for non-residential customers of the Bishkek heating system were increased to 1 802 KGS/gigacalorie to account for inflation.

Governance of the heating sector

The State Agency for Regulation of the Fuel and Energy Complex (SARFEC) under the GoK's Ministry of Energy and Industry is the energy regulator of the country and is also responsible for setting tariffs for the electricity, natural gas and district heating sectors.

The Kyrgyz Republic's district heating sector is mainly owned and governed by state and municipally owned enterprises operating in the capital and other big cities (see Table 2.1). Municipal governments own the district heating infrastructure in Osh, Tokmok and the western part of Bishkek. Combined heat and power plants that provide district heating in eastern Bishkek and Osh are owned by the EHC. Kyrgyzteploenergo, which are state enterprises under the State Committee, are responsible for district heat in Tokmok, Kyzyl-Kiya, Karakol and other small cities (Energy Charter, 2018).

Overall, heat supply enterprises (such as Kyrgyzteploenergo, Bishkekteploenergo and Osh MP) operate around 277 HOBs, local self-government bodies own 398 HOBs and public institutions and departments own around 2013 HOBs, which are primarily used for public buildings (Energy Charter, 2018; SAEPF, 2020).

Table 2.1 Stakeholders responsible for district heating in urban areas

Cities	Generation and distribution infrastructure and ownership
Bishkek (east)	Generation is provided by the Bishkek combined heat and power plant (owned by the Energy Holding Company) and the NUR heat-only boiler house (privately owned), while distribution is by Bishkekteploset (a joint stock company with mixed public and private ownership)
Bishkek (west)	Municipal enterprise Bishkekteploenergo (owned by the Bishkek City Council)
Osh	Generation is provided by the Osh combined heat and power plant (owned by the Energy Holding Company) and distribution by the Osh communal heat supply (owned by the Osh City Council)
Tokmok	Tokmok communal heat supply (which belongs to the Tokmok City Council) and Kyrgyzteplo-energo (a state enterprise under the State Committee)
Kyzyl-Kiya	Kyrgyzteploenergo (a state enterprise under the State Committee)
Karakol	
Other small cities	

Source: Based on Energy Charter (2018).

2.4 Transport sector

While the transport sector involves various modes (rail, road, air and water), roads dominate.

The transport sector is one of the main sources of energy consumption and greenhouse gas (GHG) emissions in the country. The sector accounted for around a quarter of final energy consumption in 2015. The sector accounted for around 31% of energy sector emissions in the country (SAEPF, 2016).

Nearly all the fuel consumed by the sector is either gasoline or diesel, with the share of gasoline being slightly larger than that of diesel. Gasoline is primarily used in private cars, whereas diesel is the fuel of choice for vehicles engaged in agriculture, construction, freight and public transport. More recently, the demand for liquefied petroleum gas (LPG) in the transport sector is also rising (Kabar, 2022a).

The growth in vehicle ownership and population means that the consumption of transport fuels continues to rise. Between 2015 and 2018, the consumption of gasoline and diesel increased by 20% and 40% reaching 792 000 and 750 000 tonnes, respectively (SAEPF, 2020).

Given the lack of significant domestic reserves of hydrocarbons, fuel consumption in the transport sector leads to almost complete dependence on energy imports. The transition towards more sustainable means of transportation is a key focus of the Kyrgyz government. In this context, greater adoption of public transport and electric vehicles offer a way to reduce wasteful fuel consumption and local pollution. The Kyrgyz Republic already has a zero customs duty on the import of electric vehicles and is also introducing tax and customs incentives on vehicles with hybrid engines (SAEPF, 2020). As of now, there are no initiatives by the government to develop charging stations.

2.5 Energy sector policy framework

The State Committee on Industry, Energy and Subsoil Use (GKPEN) was charged to design and implement a holistic state policy for the energy sector, covering the sector's linkages with the water-food nexus, fuel resources, renewable energy sources and the potential for industrial value creation. In 2016, the committee was replaced by the Ministry of Energy and Industry in 2020, renamed the Ministry of Energy in 2021 (IEA, 2020a).

Strategic framework

The main policy documents of the Kyrgyz Republic that regulate the energy sector include the Law of the Kyrgyz Republic on "Energy", "Electric Power Industry" and "Energy Conservation". The following documents collectively create the strategic framework of the Kyrgyz energy sector:

- National Energy Programme of the Kyrgyz Republic for 2008-2010 and the Fuel and Energy Complex Development Strategy until 2025.
- Law on Renewable Energy, 2008.
- Law on Energy Efficiency of Buildings, 2011.
- Mid-Term Power Sector Development Strategy for 2012-2017.
- National Sustainable Development Strategy for 2013-2017.
- National Development Strategy for 2018-2040.
- Concept of the Green Economy of the Kyrgyz Republic.
- Green Economy Development Program in the Kyrgyz Republic for 2019-2023.
- National Development Program of the Kyrgyz Republic until 2026.

The National Development Strategy in particular sets out the strategic vision for a sustainable energy sector (GoK, 2018):

- The Kyrgyz Republic aims to comprise a major regional power producer that sustainably develops its energy sector, promotes energy efficiency and ensures reliable delivery of energy to all consumers.
- Activities related to the CASA-1000 project will be prioritised.
- Environmentally friendly energy sources (small hydropower, solar PV and wind energy, solar collectors, biogas, heat pumps, etc.) were targeted at more than 10% of the total national energy mix.
- Indicators for energy generation and consumption will be improved to approach those of the OECD countries.
- Investment in the construction and reconstruction of large hydropower plants will be prioritised.
- Mandatory requirements will be used to increase efficiency of power facilities.
- Subsidies will be targeted to reduce consumption while improving quality of life.

The strategy sets out a goal for clean energy sources to be 10% of the total energy mix without specifying a target date. It is important to note that this does not include large hydropower. As noted in section 2.1, hydropower already accounts for 30% of the primary energy supply, but this is overwhelmingly large hydropower. Small hydropower contributed only about 1.5% of the total. Therefore, the target of 10% will require significant investments in small hydro as well as solar and wind energy technologies.

The Law on Renewable Energy establishes the legal, organisational, economic and financial foundations and mechanisms for promoting the development and use of renewable energy sources in the country.

The Law on Energy Efficiency of Buildings No. 137 sets out the legal framework for reducing energy consumption in the building sector, and regulates the legal and organisational relations between building owners, certified professionals and government executive authorities.

A concept note on the green economy in the Kyrgyz Republic establishes the overarching guidelines for the clean energy sector's development and energy conservation (Ministry of Justice, 2018b). A green economy aims to decrease losses in the energy sector, reduce subsidies, cut reliance on coal and promote the development of technologies such as hydropower, solar, wind and bioenergy. Given the national obligations under the Sustainable Development Goals, the concept note establishes a vision for the energy sector until 2040, with a target of increasing the renewable energy share (small hydropower, solar, wind and biogas) to 10% of total power generation.

As part of the implementation of the concept note, the Green Economy Development Program in the Kyrgyz Republic for 2019-2023 was developed and accepted in 2019, together with an action plan and indicators for 2020-2023. The goal by 2023 is to reduce the energy intensity of GDP while increasing the access of citizens and economic entities to reliable and modern energy supply. Achieving this will be contingent on: (1) improving the system for assessing and monitoring the state of the energy sector; (2) strengthening energy policy; (3) increasing the transparency of fuel and energy prices and ensuring that energy companies break even; (4) improving the efficiency of energy consumption; (5) improving energy efficiency in buildings; (6) increasing the share of renewable energy sources in the total volume of final energy consumption; and (7) raising people's awareness of energy savings and renewable energy sources.

The National Development Program of the Kyrgyz Republic until 2026 briefly outlines short-term priorities in the implementation of the following projects:

- Construction of large hydropower facilities Kambarata HPP-1, Upper Naryn HPP cascade, Suusamyr-Kokomeren HPP cascade, Kazarman HPP cascade, etc.
- Construction of small hydropower plants.
- Implementation of the CASA-1000 project.
- Phased transition of the state motor transport fleet to electric vehicles.
- Implementation of a project on the energy efficiency of buildings.
- Development of alternative energy sources (solar and wind energy).

Climate change

The Kyrgyz Republic is among the most vulnerable countries to climate change. Increasing temperatures are already resulting in the greater duration and frequency of heatwaves. Changing temperatures and rainfall patterns could have severe impacts on the sensitive water and agricultural systems, with significant implications for the water-energy-food nexus. Decision makers of the country understand the importance of addressing these challenges and are making every effort to ensure that relevant initiatives are successful. The country remains committed to addressing the global challenge of climate change.

The Kyrgyz Republic's total GHG emissions (including land-use change and forestry [LUCF]) stood at 15.5 metric tonnes of carbon dioxide equivalent ($MtCO_2eq$) in 2017 compared to 7.3 $MtCO_2eq$ in 2000 and 30 $MtCO_2eq$ in 1990. While emissions have been increasing gradually since 2000, they remain well below the levels in 1990, which reflects the trends in the macroeconomic indicators as well as changes in the economy. The Kyrgyz Republic's GHG emissions are relatively low as the country contributed just 0.035% of total global GHG emissions (excluding LUCF) in 2017, while its population was 0.083% of the world's total population. The per capita GHG emissions were less than one-third of the world average in 2017. GHG emissions in 2017, excluding LUCF, were mainly from the energy sector (59%), followed by agriculture (32%), industrial processes (5%) and waste (4%). The transport and the electricity/heating sectors are included in the energy sector and account for 11% and 9% of total GHG emissions, respectively (OECD, 2019; WRI, 2020).

The Kyrgyz Republic has signed and ratified 13 international environmental conventions. It ratified the United Nations Framework Convention on Climate Change in January 2000 and the Kyoto Protocol in January 2003. The country partnered with Tajikistan and Turkmenistan in 2006 to further the regional climate effort by signing the Framework Convention on Environmental Protection for Sustainable Development in Central Asia (OECD, 2019). It signed the Paris Agreement on Climate Change in September 2016, followed by formal ratification in February 2020.

In 2015, the Kyrgyz Republic submitted its Intended Nationally Determined Contribution (INDC), outlining both adaptation and mitigation targets and actions. As part of mitigation targets, the country plans to reduce GHG gas emissions by up to 13.8% by 2030 compared to the business-as-usual scenario. If international support is forthcoming, a more ambitious goal aims to cut emissions by up to 31% by 2030 (Table 2.2). Agriculture, energy, water, emergencies (*e.g.* disaster risk management), health care, and forest and biodiversity have been identified as the key sectors for adaptation (OECD, 2019).

Table 2.2 Emission reduction targets under the Intended Nationally Determined Contribution

Cities		Unconditional	Conditional
All emission reduction scenarios are with respect to business as usual			
Intended Nationally Determined Contribution	**2030**	11.5-13.8%*↓ GHG emissions	29-30.9% ↓ GHG emissions
	2050	12.7-15.7% ↓ GHG emissions	35.1-36.8% ↓ GHG emissions
Updated Nationally Determined Contribution	**2025**	16.6% ↓ GHG emissions	36.6% ↓ GHG emissions
	2030	15.97% ↓ GHG emissions	43.6% ↓ GHG emissions

Source: UNFCCC (2015, 2021).

Note: *Ranges for emission reductions refer to scenarios with low, medium and high population growth scenarios. GHG = greenhouse gas.

In 2021, the Kyrgyz Republic adopted an updated NDC, outlining plans to reduce GHG emissions across different economic sectors. The second NDC provides more ambitious targets for emissions reductions (Table 2.2) and identifies energy and agriculture as the key sectors for mitigation and adaptation measures. Interventions in the energy sector could focus on greater energy conservation, improved efficiency, and investments in renewables and natural gas (UNFCCC, 2021).

Energy efficiency

The Law on Energy Conservation, enacted in 1998, sets out to increase the efficiency of the energy sector. It includes several important guidelines for establishing effective institutional and regulatory frameworks for energy efficiency. Most of those guidelines, however, have not been enforced or adopted in the form of secondary legislative acts (Dikambaev, 2019).

The Law on Energy Efficiency in Buildings is a relatively new and progressive legislative act that was developed with the technical assistance of the UNDP and Global Environment Facility and came into force in February 2012. The law is aligned with the European Union's best practices and based on the key requirements of the Union's Energy Performance in Building Directive. It contains many important provisions for establishing effective institutional and regulatory frameworks. Despite the adoption of the secondary legislation required by this law, its requirements have not been implemented or enforced effectively.

There are currently no laws or minimum energy performance standards and energy labelling schemes for household appliances in the Kyrgyz Republic. That said, there are some Eurasian Economic Union (EEU) standards on energy efficiency and minimum energy performance standards for industrial energy-consuming appliances, such as motors and pumps. These standards were adopted by the Centre for Standardisation and Metrology under the Ministry of Economy (Kyrgyzstandard) before the Kyrgyz Republic acceded to the EEU in August 2015. Following the country's official accession to the EEU, all EEU standards became applicable in the territory of the Kyrgyz Republic.

The State Programme on Energy Savings and Energy Efficiency Policy for 2015-2017 introduced energy efficiency criteria for public procurement. However, provisions of the programme were not implemented.

3. RENEWABLE ENERGY

Large hydropower is the backbone of the renewable energy landscape in the country and is responsible for meeting the bulk of domestic demand and electricity exports (see Section 2.2). Other renewables such as solar, wind and bioenergy are at the preliminary stages of deployment – often limited to relatively small applications (see Section 2.3 and Box 2.1). Going forward, these renewable energy technologies could play a more prominent role in addressing energy demand and increasing the resilience of the sector.

3.1 Renewable energy resources

The Kyrgyz Republic has considerable and diverse renewable energy resources. While some of its hydropower resources have been utilised, those for other renewables such as solar PV, wind and bioenergy remain largely untapped. It is estimated that small hydropower can generate 5-8 TWh/year; wind, 44.6 gigawatt hours (GWh)/year; solar, 490 million GWh/year and biomass power, 1.3 TWh/year (UNECE, 2018).

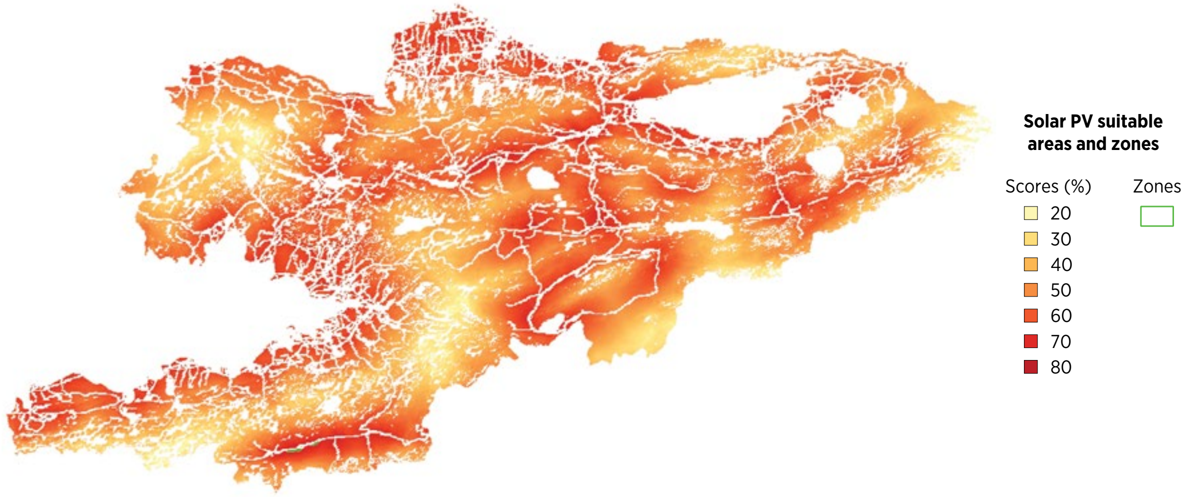
Hydropower

According to a GoK concept note on developing small hydropower, the hydropower resources of the Kyrgyz Republic consist of 268 rivers, 97 large canals and 18 reservoirs, with a total electricity generation potential of 143 TWh per year. Today, about 10% of the potential is used. The hydropower potential of small rivers and waterways is about 5-8 TWh/year, of which the republic uses less than 1% (Ministry of Justice, 2018a). There is significant room for development in the Kyrgyz hydropower sector; some countries have been seen to tap over 30% of their hydropower potential (IMF, 2019).

Solar

IRENA's preliminary assessment of solar PV resources in the country shows that more than 3 645 km^2 of the area in the country has good suitability for solar PV (meaning that it has a suitability score of greater than 50%). The analysis further identifies three ideal zones (with a suitability score of greater than 75%) spanning a total of 26 km^2, which can be used to deploy around 650 MW of utility-scale solar PV projects (see Annex Table A2 for details). The assessment reveals that the most suitable solar PV zones are clustered in the southern region of Osh along the river Kyzyl-Suu (Figure 3.1). These zones are close to the city of Osh, which would allow them to help address urban demand (IRENA, 2021b).

Figure 3.1 Zoning assessment for solar PV



Source: Global Atlas (2022); IRENA (2021b). Map data: United Nations administrative boundaries 2021.

Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply the expression of any opinion on the part of IRENA concerning the status of any region, country, territory, city or area or of its authorities, or concerning the delimitation of frontiers or boundaries.

[8] The assessment combines renewable resource data with technical (electrical grid network, slope), and socio-environmental (protected areas, land features and population growth) criteria to determine suitable zones.

Wind

IRENA's preliminary assessment indicates promising wind resources. Around 94 000 km^2 have a suitability score higher than 50% for onshore wind. The analysis further identifies 77 ideal wind zones (more than 83% suitability score) spanning a total of 2 304 km^2, which can be used to deploy around 5.8 GW of wind energy projects (see Annex Table A3 for details). Wind zones are clustered in the southern region of Osh along the border with Tajikistan, the northern and southern regions in Naryn and the southern region of Issyk-Kul. Other, sparse clusters are found in western Batken and southern Chuy (Figure 3.2) (IRENA, 2021b).

Figure 3.2 Zoning assessment for wind power

Source: Global Atlas (2022); IRENA (2021b). Map data: United Nations administrative boundaries 2021.

Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply the expression of any opinion on the part of IRENA concerning the status of any region, country, territory, city or area or of its authorities, or concerning the delimitation of frontiers or boundaries.

Geothermal

The Issyk-Kul region is home to the country's main geothermal sources, with other resources in the Chui province. In areas with touristic resorts, these resources are occasionally used for heating and hot water supply. In other spots, they are primarily used as spas or for medicinal purposes. The geothermal resources have relatively low temperatures (of not more than 55-60°C) and are characterised by high mineral content, which leads to scaling and corrosion of materials – thus limiting their use (Baybagyshov and Degembaeva, 2019).

3.2 Current status of renewable energy deployment

Renewable energy, in the form of large hydropower, dominates the power sector of the country. Other renewables such as solar PV, wind and bioenergy are virtually non-existent in the electricity mix. The transport and heating sectors are dominated by fossil fuels.

Electricity generation is driven by large hydropower, which accounts for 92% of the total production. The large hydropower fleet, which consists of seven large dam hydropower plants ranging from 40 MW to 1 200 MW, account for most of this generation. Almost all of these dams are located on the Naryn river. Small hydropower constitutes below 1.5% of total electricity generation, produced by 19 small hydroelectric power plants with a total capacity of 54 MW (total generation of 54 GWh). These small power plants are located on the Alamedin, Chu and other small rivers (Vedeneva, 2020).

Developing small hydropower plants is one of the Kyrgyz government's top priorities due to the potential to cut down emissions as well as fuel imports. Greater adoption of small hydropower also represents a move back to the past, when small hydropower was a more significant generation technology. According to statistics, in 1960 more than 100 small hydroelectric power plants were operating in the Kyrgyz Republic with annual electricity generation of about

285 GWh (as opposed to just 54 GWh). This was around a third of the total electricity generation in the country. It is estimated that the energy potential of small rivers in all regions allows for the construction of about 87 new small hydroelectric power plants with a total capacity of about 180 MW and average annual electricity generation of up to 1 TWh (Ministry of Justice, 2018a; UNIDO, 2018).

A decree on a tendering process for the right to build small hydropower plants in the Kyrgyz Republic was announced in 2017. Shortly after, a tender for the right to construct 14 small hydropower plants was announced. While some tender results for these plants were announced, they have since been cancelled.

As of now, there are no large solar power plants in the Kyrgyz Republic. Solar panels are used mainly in small enterprises and households. Some pilot solar projects have been carried out by development partners and donors. Under the United Nations' Industrial Development Organization project "Reliable Energy Supply of Rural Health Post," together with UNDP and the World Health Organization, solar installations ranging from 3 kW to 1.5 kW were set up at 19 rural health facilities in the country to support the provision of reliable medical services (UNECE, 2018). Plans are set to construct a 1000 MW solar power plant in the Issyk-Kul region, with investment agreements signed between the government and Chinese investors (Kudryavtseva, 2022).

Solar energy technologies are also being used in pilot district heating projects. The Republican Fund for Environmental Protection and the State Agency for Environmental Protection and Forestry provided co-financing at the request of KP Bishkekteploenergo for the installation of solar collectors in 2017-2019. In 2017, 364 solar thermal panels with a total capacity of 0.5 megawatt thermal (MW_{th}) were installed on the administrative territory of KP Bishkekteploenergo. In 2017, 120 panels with a total capacity of 0.168 MW_{th} were installed in the Orto-Say boiler house, and in 2019 396 solar thermal panels with a total capacity of 0.6 MW_{th} were put into operation in the Rotor boiler house (SAEPF, 2020; UN ESCAP, forthcoming).

The UNDP's Small and Medium Business Development Project on Energy Access, implemented by the Center for Renewable Energy and Energy Efficiency Development, has also helped start 11 renewable energy and energy efficiency projects. This includes the installation of PV systems for a kindergarten in Isfana, heat pumps in health facilities in Sulukta and Zhin-Zhigen (UNDP, 2021a, 2021b) and solar water heaters in several schools across the country (UNDP, 2020).

Commercial installation of renewable energy systems includes off-grid PV, solar water heating systems and biogas plants, but is limited to 10-20 installations of small capacity per year.

3.3 Renewable energy policies and regulation

Legislation governing the management of the system for provision of electricity services using renewable energy sources in the Kyrgyz Republic includes the Law of the Kyrgyz Republic on Energy (1996), the Law of the Kyrgyz Republic on Electricity, the Law of the Kyrgyz Republic on Renewable Energy Sources and several other legal acts including the Civil, Land, Water Codes of the Kyrgyz Republic. These last acts regulate aspects of system management for the provision of electricity services using renewable energy sources.

The Law of the Kyrgyz Republic on Energy defined the general principles of organising and regulating the activities of entities in the fuel and energy complex. The law defines renewable energy resources as "resources that arise naturally, are constantly renewed by nature and can be converted into energy, including geothermal, solar, water and wind energy".

In 1997, the Law of the Kyrgyz Republic on Electrical Energy was adopted, aimed at ensuring a reliable, safe and uninterrupted supply of electricity and heat; improving the quality of service; creating a competitive environment; forming an energy market; encouraging private sector development and attracting investment. This law is aimed at regulating the activities of generating, supplying and distributing companies (with any form of ownership) to the end consumer. Article 5 of the law states that the production of renewables-based electricity as well as the production of electricity (from any energy source) for own use with a capacity of up to 1 MW is not licensed.

At the same time, the sale of electricity, including import and export, is carried out based on a license issued by the authorised body for regulating the fuel and energy complex, for any person, regardless of the organisational legal form and type of ownership (Article 18 of the law).

Special regulation in the field of renewables is carried out through the Law of the Kyrgyz Republic on Renewable Energy Sources (2008). According to the preamble, the law defines the legal, organisational, economic and financial framework; the mechanisms governing the relations between the state, generators, suppliers and consumers of renewable energy; as well as the production equipment for the use of renewables. It also contains the definition of renewable energy sources (UNECE, 2018).

By the order of the State Agency for Regulation of the Fuel and Energy Complex under the Government of the Kyrgyz Republic dated 6 August 2015, No. 1, a methodology for calculating tariffs for electricity supplied by stations generating it from renewable energy sources was adopted.

It is also worth noting that the development of renewables was included in the National Energy Program of the Kyrgyz Republic for 2008-2010 and the Strategy for the Development of the Fuel and Energy Complex until 2025 as one of the most important measures for ensuring energy security. These documents proposed to complete the rehabilitation and reconstruction of existing small hydropower stations and to build new, small hydropower plants totalling 178 MW of installed capacity by 2010. The annual average production from renewables was to reach 1 billion kWh/year, which could be achieved through increasing yearly production by local manufacturers of solar collectors (up to 100 000-150 000 m^2), the addition of micro hydropower plants up to 2-2.5 MW/year, PV modules up to 2-3 MW/year and cumulative installation of wind power stations up to 250 MW. The overall costs of these projects were estimated at around KGS 520-950 billion (USD 13-25 billion). Planned growth of the electricity tariff was supposed to ensure the competitiveness of planned small hydropower plants and renewable energy.

According to another policy document, the Program of Development of Small and Medium Power Plants up to 2012, accepted in October 2008, a wind farm with a capacity of 22 MW was to be built near Balykchy city in Issyk-Kul oblast, and small hydropower plants totalling 255.25 MW were to be reconstructed and built. Unfortunately, none of the policy documents accepted in 2008 were implemented, as there was no development of secondary legislation, needed to provide implementation mechanisms.

Measures for the implementation of the Medium-Term Strategy for the Development of the Power Sector (2012-2017) were accepted in May 2012. These included plans for the construction of four small hydropower plants by 2017 within the framework of a European Bank for Reconstruction and Development project.

Also in 2012, much-needed amendments to the Law on Renewable Energy were introduced. Producers of renewable energy were to gain several important advantages, creating favourable conditions for attracting investments. These amendments included:

- Guaranteed connection to the grid for installations producing renewable energy.
- Guaranteed purchase of all renewable electricity produced by distribution companies throughout the project.
- Tariffs for energy equivalent to the maximum amount fixed by the retail tariffs, with increasing coefficients, differentiated by the type of renewable energy (introduced by amending the law in 2012).
- A preferential fixed rate for up to 8 years from the date of plant commissioning.
- The removal of licensing requirements for renewable energy projects.
- Import duties set at 0% for renewable-energy-related equipment (introduced by amending the law in 2012).

In 2015, the Concept of Small Hydropower Development of the Kyrgyz Republic until 2017 was accepted. The development of the Concept was planned within the framework of the Program for the Transition of the Republic to Sustainable Development for 2013-2017. However, secondary legislation to support implementation was not forthcoming.

In 2018, the next developmental phase of renewable energy legislation started. The National Development Strategy 2018-2040 indicates a target of 10% for renewables (excluding large hydropower) in the energy mix. The target is not time bound and does not seem to be legally binding. Given that renewables' share of the energy mix (excluding large hydropower) is negligible (<1.5% of electric generation), the target would remain elusive in the absence of concrete policies and regulations.

The following main changes addressing several issues were introduced to the Renewable Energy Law in July 2019:

- Compensation for additional costs of distributing companies for the purchase of electricity generated using renewable energy sources will be considered when calculating and approving the national electricity tariff for consumers, which reduces the financial load on distribution companies.
- The feed-in tariffs (FITs) for renewable electricity were defined. Renewable electricity will be compensated at 1.3 times the highest consumer tariff.
- Quotas for renewable energy capacities were introduced for each region. The preferential tariffs (*i.e.* using the coefficient of 1.3 times the highest consumer tariff) could be availed by those who were registered under these quotas.

In 2020, the regulation "On conditions and procedure of generation and supply of energy with the use of renewable energy sources" was introduced. The new document determines the rules of the renewable energy market (Kudaiberdieva, 2020):

- The responsibilities of the stakeholders are identified. GKPEN determines the policy in the renewable energy sector, the State Agency for Fuel and Energy Complex regulates tariffs, while local governments address issues related to the allocation of land.
- The regulation described the procedures and requirements to be fulfilled by a "green" energy producer or supplier in order to become a market player, eligible for all preferences provided by the state.
- It introduces the concept of a register of renewable energy entities, which will be used to develop an official list of market players and their annual renewable energy generation.
- Green energy production will be controlled through quotas. Electricity production through the allotted quotas will be eligible for a preferential tariff (*i.e.* using the coefficient of 1.3 times the highest consumer tariff).
- A standard contract for the supply of green energy demanded by the banks for the loan issue procedure was developed.
- The regulation instructs distribution companies to procure green energy from producers at 0.034 USD/kWh (or 1.3 x 2.24 KGS/kWh [1.3 x 2.6 USDc/kWh]). With the acceptance of the new medium-term tariff policy for electricity and heat for 2021-2025, the FIT would be increased with the tariff to 0.0386 USD/kWh (or 1.3 x 2.52 KGS/kWh [1.3 x 2.97 USDc/kWh]).

While the policy and regulatory structures seem to be in place, practical implementation of the regulation is still lagging due to the following:

- 3.86 USDc/kWh is not enough for most renewable energy technologies. Solar projects have just started touching 3 USDc/kWh in locations with perfect conditions (in terms of resources, financing and regulation); it would be difficult to replicate those results in a new market with significant financial constraints.
- The institutional responsibilities are still not clear. The quotas have not been defined yet, therefore relevant authorities, having registered the first two batches of total of 63 developers, have proposed some changes to the newly accepted regulation to overcome dependence on quota definition by National Energy Holding.

Acceptance of the regulation "On conditions and procedure of generation and supply of energy with the use of renewable energy sources" led to an increase of interest in renewable energy generation from the private sector, and the Ministry of Energy has already issued certificates for being a green energy producer to:

- 20 companies on 15 November 2021, which received 48 certificates for renewable energy entities, for a total planned capacity of 639.5 MW (of which solar stations comprise 300 MW; floating PV power plants, 0.1 MW; wind stations, 10 MW; and small hydroelectric power plants, 329.45 MW) (Kabar, 2022b).
- 43 companies on 28 February 2022, which received 61 certificates for renewable energy entities, for a total planned capacity of 1 059.3 MW (of which solar stations compose 298 MW; wind stations, 50 MW; geothermal stations, 300 MW; and small hydropower plants, 411.3 MW). These companies will be included in the state register of renewable energy entities.

Renewable energy auctions/tenders were identified by the World Bank (2017c) as an alternative to the FIT-based approach for the deployment of small hydropower in the Kyrgyz Republic. It was suggested that the incentive mechanism can be based on the size of projects, for example, (1) tenders/auctions for larger projects; (2) registration/approval based on screening criteria for medium-sized projects and (3) a simplified regime for micro-hydropower plants.

In June 2017, the GKPEN officially conducted a tender for the construction of 14 small hydropower plants from 3 to 20 MW. The tender was open to both national and foreign companies interested in investing in small hydropower, whereas the GKPEN assumed responsibility for facilitating the obtaining of the necessary permits and licences, including land permits. The land for the project was to be allocated by the state, and the land was to remain under state ownership.

As a result of the tender, GKPEN selected winners for 11 small hydropower projects. However, the official announcement of the winners was followed by a request from members of parliament that the government annul the results of the tender (Asanov, 2017; Energy Charter, 2018). The projects have not been implemented.

While distributed renewables that produce electricity are supported by the Law on Renewable Energy, the current tariff regime of the Kyrgyz Republic means that distributed renewables will struggle to compete financially with cheap electricity from the national grid (or cheap diesel-based power generators) at the retail level. The introduction of net metering with the current tariff regime is unlikely to generate significant interest. The introduction of wheeling regulations, coupled with easy licensing for self-consumption, can allow large users to use renewables to complement power from the national grid (which could be less reliable).

Moreover, the current energy legislation does not allow for the sale of electricity at unregulated rates to household consumers. In regions with unreliable power, this prohibition stops private institutions from setting up mini-grids to supply power to consumers.

The Cabinet of Ministers is reviewing all legislation, including for the energy sector. Therefore, the above-mentioned laws and regulations could undergo major changes. As a part of this effort, the Ministry of Energy has formulated a draft Renewable Energy Law, which is expected to abolish the quotas, allow the sale of renewable electricity to customers at unregulated prices, increase the term of FITs up to 15 years and include statutes governing thermal energy and gas fuel, along with renewable electricity production. As of July 2022, the Law was approved by the President of the Kyrgyz Republic.

3.4 A strong rationale for renewables

This section analyses numerous factors that promise to boost the adoption of renewable energy technologies such as solar PV, wind, bioenergy and small hydropower.

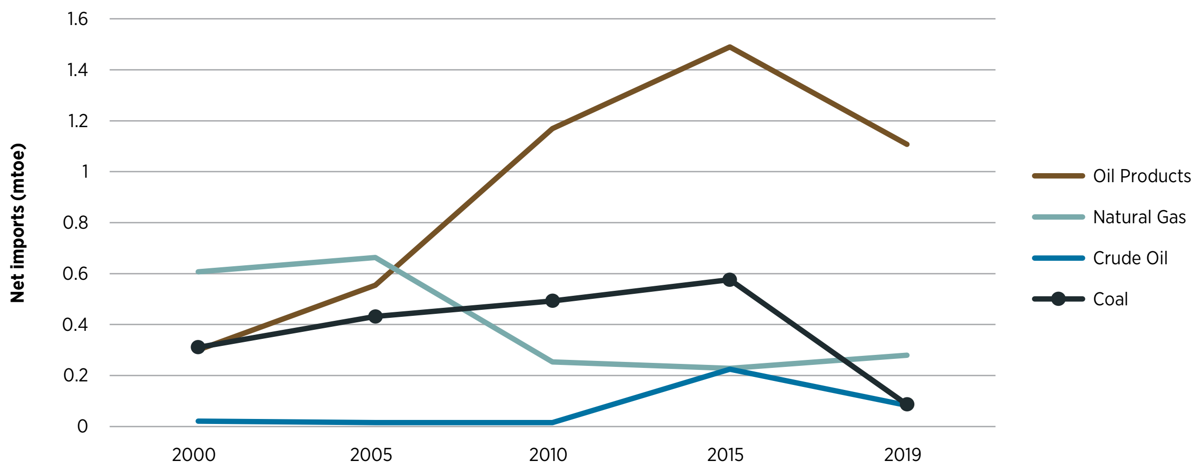
Rising domestic demand and fuel imports

Energy consumption in the country has been growing rapidly. About half of this demand is met with imported fossil fuels, which poses a substantial and growing economic burden, with implications for energy security. Final energy consumption increased by 54% between 2010 and 2019, to reach 3.5 mtoe (Figure 2.1). Electricity consumption, meanwhile, increased by about 75%, reaching 12.4 TWh (Figure 2.4). Residential electricity demand, the main driver behind consumption growth, increased by 152% after 2010 to account for two-thirds of electricity consumption in 2019. As living standards continue to improve and other sectors of the economy also pick up, growth in energy consumption is expected to continue. If the country does not invest in more sustainable energy sources the dependence on coal and oil is likely to increase, leading to more pollution from the burning of coal and transport fuels, and more imports of oil products.

The Kyrgyz Republic's energy consumption outstrips local production, leading to expensive energy imports. This makes the transition towards clean fuels a key imperative for the country. The Kyrgyz Republic exploits local reserves of coal and some oil and gas, but most fossil fuels are imported. In fact, more than half of its energy demand is met through oil and gas imports. More than 90% of oil products (primarily diesel and motor gasoline) and natural gas are also imported (IEA, 2020a).

Net energy imports increased from 0.94 mtoe in 2000 to around 1.56 mtoe in 2019 (Figure 3.3). This increase was driven by rising net imports of oil products (mainly diesel and gasoline), which increased four-fold from just 0.3 mtoe to 1.1 mtoe in 2019. Net imports of crude oil also increased, as did domestic refining capacity. Net imports of coal have declined in recent years as the utilisation of local reserves increased. While local coal may reduce import dependence, it results in harmful impacts on air quality, health and the climate.

Figure 3.3 Net energy imports

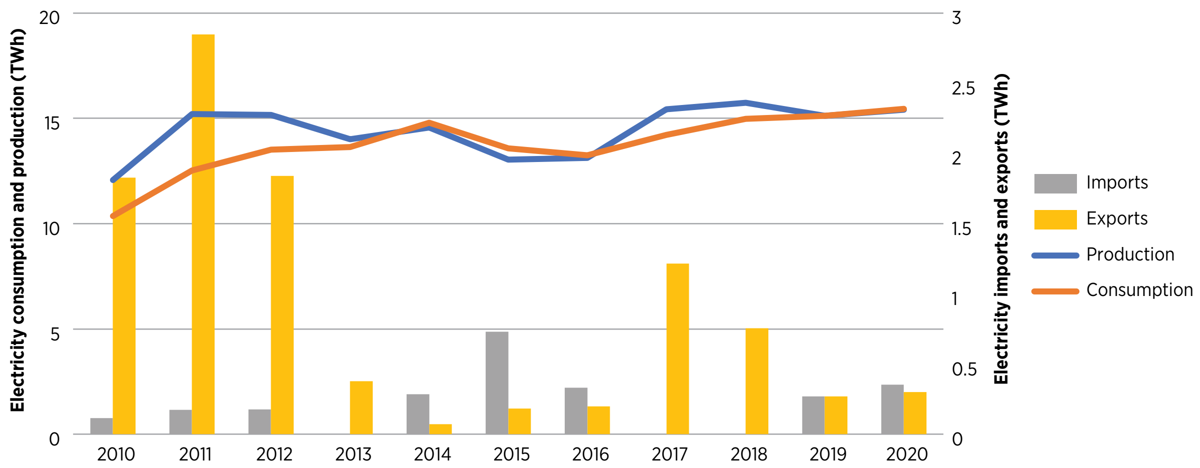


Source: IEA (2020b).

Note: mtoe = million tonnes of oil equivalent.

The imports and exports of electricity fluctuate in response to seasonal weather conditions and domestic demand. From 2014 to 2016, the country was a net electricity importer due to rising electricity demand and declining flow in rivers (Figure 3.4). In 2017 and 2018, the Kyrgyz Republic was again a net electricity exporter due to high water levels in reservoirs. As electricity demand continues to increase, and production remains unchanged, exports are expected to decline (SAEPF, 2020).

Figure 3.4 Electricity production, consumption, imports and exports, 2010-2020



Source: NSC (2021).

Note: TWh = terawatt hour.

As energy consumption continues to rise, reliance on imported fossil fuels will increase. Dependence on imports of fossil fuels can be an energy security issue and is a significant burden on government budgets. Furthermore, dependence on imported fossil fuels could also make the Kyrgyz Republic more vulnerable to volatility in the international and regional fuel markets. Renewable energy solutions can help cater to the domestic demand for electricity and heating, thus helping cut down the import bill.

Deteriorating infrastructure

The assets and infrastructure of the Kyrgyz Republic's energy and power sector are old and not well maintained (see Sections 2.2 and 2.3 for details). The deterioration of the infrastructure coupled with the financial crisis of the energy system, at some point, will eventually lead either to a significant decrease in the quality of produced energy or an increase in energy prices, both of which will increase demand for independent energy production and support the development of renewable energy.

Old and undermaintained assets and infrastructure undermine reliability and supply quality. The issue of reliability becomes more pressing in the winter season, as the demand for heating grows and the winter generation capacity cannot keep up (World Bank, 2017b).

The power system (and the Kyrgyz Republic's energy system in general) needs significant investments to maintain ageing equipment or develop the capacity required to meet growing demand. Such investments are unlikely under current conditions since the system is losing money and is kept afloat through significant support from the government budget. Tariffs that do not reflect generation costs have significant financial ramifications and are at the heart of the financial issues faced by the power and energy sector (World Bank, 2017b).

Reducing local air pollution

The Kyrgyz Republic is among the European and Central Asian countries most affected by diseases linked to indoor air pollution (Balabanyan *et al.*, 2015; World Bank, 2020). Thermal power plants, coal-fired heating units, emissions from road vehicles and the construction and mining industries are some of the key sources of air pollution.

The burning of coal for heating and power generation is one of the main reasons for local air pollution, especially during the colder, winter months. Household heating with coal also leads to indoor and outdoor air pollution resulting in significant health problems. The transport sector is a key contributor to air pollution throughout the year. In the winter season, traffic often slows down or comes to a halt on the icy roads. Drivers often do not turn off engines because they need heat. Their idling engines add to the already polluted atmosphere. New high-rise buildings in cities like Bishkek act as barriers to the flow of wind, which would normally carry these pollutants out of the city.

Renewable energy technologies coupled with energy efficiency could help replace fossil fuels (especially coal) in heating and power generation, thus reducing air pollution. Vehicular emissions can be reduced through greater adoption of public transport and the uptake of electric vehicles, which are powered by an electric grid with high shares of renewables.

Climate change mitigation and adaptation

The Kyrgyz Republic has identified the water, energy, agriculture and infrastructure sectors as the most vulnerable to climate change. Projections indicate that the country could experience temperature rises significantly above the global average, reaching 5.3°C by 2090 under the highest emission pathways. Climate change could lead to impacts such as heat stress, increased arid land cover, erratic water flows and drying watersheds – all with significant implications for the country's population, especially the poorest and marginalised groups (World Bank Group and ADB, 2021).

Decision makers in the country understand the importance of addressing the challenge and are making every effort to ensure that these initiatives are successful. Despite low emission levels, the Kyrgyz Republic remains committed to addressing the global challenge of climate change.

The latest available national estimates (see Section 2.5 for details) show that GHG emissions in 2017 (excluding LUCF) were mainly from the energy sector (59%), followed by agriculture (32%), industrial processes (5%) and waste (4%). The transport and the electricity/heating sectors are included in the energy sector and account for 11% and 9% of total GHG emissions, respectively (OECD, 2019; WRI, 2020). A greater role of renewable energy and energy efficiency could help reduce the carbon footprint of the country's energy sector. Renewables can also contribute to adaptation by providing reliable, affordable and modern energy services. Well-designed hydropower projects could be coupled with watershed restoration efforts leading to more climate-resilient water systems.

As the decision makers of the Kyrgyz Republic move towards a clean energy transition signified by a more ambitious NDC, they can make a strong case for securing a sizable share of climate finance to support renewable energy deployments. In this context, the government could also approach multilateral financing institutions and other intermediary development financing institutions created to channel public funds from developed countries to climate-relevant projects in developing countries (IRENA, 2016; IRENA and CPI, 2020).

Declining renewable energy costs

The increasing competitiveness of renewable energy technology prices further strengthens the case for the uptake of non-hydro renewables. Falling prices are especially evident for solar PV and wind. The global weighted average levelised cost of energy (LCOE) for utility-scale solar PV fell by 85% between 2010 and 2020 to reach 0.057 USD/kWh. Meanwhile, the weighted average levelised cost of onshore wind energy decreased by around 56% over the same period to reach 0.039 USD/kWh (IRENA, 2021a). Recent supply chain constraints and commodity price increases are likely to result in increased costs for projects commissioned over the next two years, but to what extent these will be offset by technology improvements and cost savings elsewhere is not yet clear. What is clear is that despite the potential increase in renewable equipment costs, the competitiveness of renewable power has actually improved, given the roughly five-fold increase in gas and coal prices over the past year.[9]

Hydropower also remains a very competitive option, where undeveloped economic resources exist, although lead times are longer than for solar and wind projects. The global weighted average LCOE of newly commissioned hydropower projects in 2020 was around 0.044 USD/kWh (around 18% higher than a decade ago). The increase in average LCOE is due to a range of factors but is likely to have been predominantly driven by a shift towards the exploitation of sites with more challenging civil engineering conditions. Still, hydropower is competitive with fossil-fuel-based generation. It was estimated that nine-tenths of all hydropower capacity commissioned in 2020 was producing power for less than the cheapest new fossil-fuel-fired projects (IRENA, 2021a).

The decreasing renewable energy costs are facilitated through a conducive financing environment and innovative financing schemes. As the competitiveness of renewable power continues to improve, the case for greater integration of renewables in the Kyrgyz Republic's energy sector becomes stronger.

[9] *Data are based on API2 Rotterdam Coal Futures and Dutch TTF futures contracts for northwest Europe benchmark prices.*

Abundant renewable energy resources

The country has significant renewable energy potential for technologies such as solar PV, wind, bioenergy and hydropower. As shown in Section 3.1, the preliminary findings of IRENA's resource assessment study reveal that vast areas in the Kyrgyz Republic are suitable for utility-scale solar and wind power. Considering the overall technical potential, solar and wind resources can be successfully used to address part of the future energy demands of the country.

The assessment combines renewable resource data with technical (electrical grid network, elevation and slope), and socio-environmental (protected areas, land features and population growth) criteria to determine suitable zones. It reveals that solar PV zones are located in the southern part of the Osh region along the river Kyzyl-Suu (Figure 3.1).

Wind zones are clustered in the southern region of Osh along the border with Tajikistan, the northern and southern regions in Naryn and the southern region of Issyk-Kul. Other sparse clusters are found in western Batken and southern Chuy (Figure 3.2).

Short construction periods of solar and wind energy

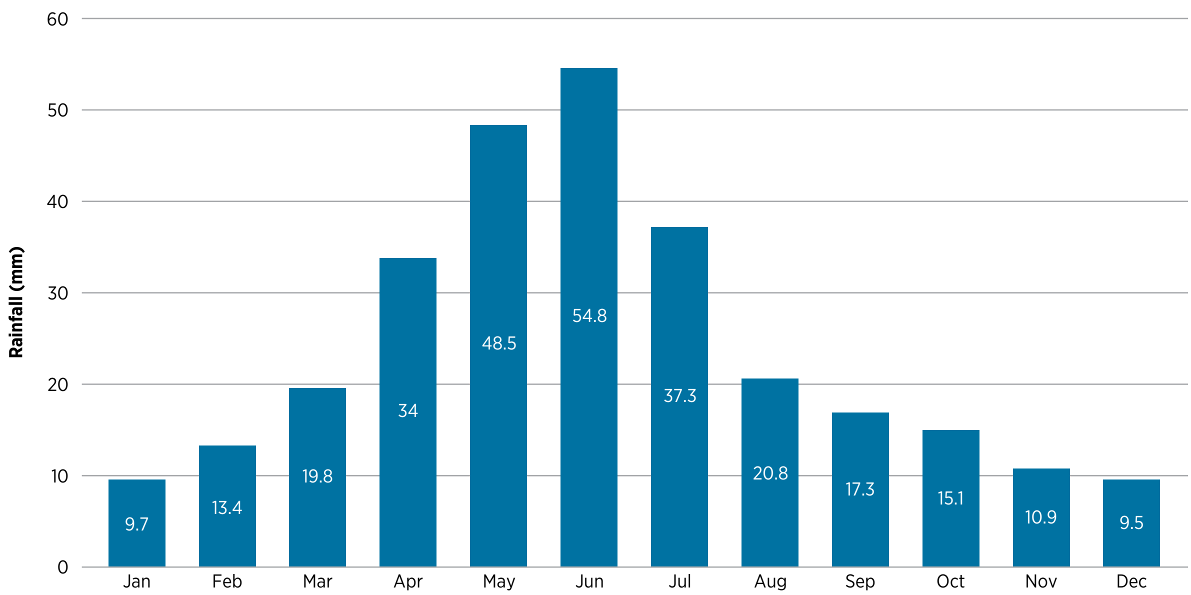
The challenge of the Kyrgyz Republic's rising energy demand needs to be met with investments in sustainable and clean technologies. Renewable energy technologies such as solar PV, wind and small hydropower tend to be modular and can be constructed in a very short time. Large solar PV projects (around 100 MW) can be completed in less than one year and construction times of six months have been reported for 50 MW wind parks.

In contrast, large hydropower projects tend to require longer construction times and can be susceptible to delays and cost overruns. According to Sovacool, Gilbert and Nugent (2014), more than two-thirds of hydropower projects suffer from cost and time overruns, whereas less than 10% of solar and wind energy projects suffer from a similar fate. Renewable energy technologies such as solar PV and wind can provide a quick way of fulfilling rising domestic demand sustainably.

Seasonal variation in hydroelectricity generation

Hydropower generation in the Kyrgyz Republic is influenced by several factors such as the state of river flows, the demand for electricity (especially in winter) and the demand for water for irrigation (especially in the irrigation season, *i.e.* summer). Seasonal weather patterns and weather extremes can adversely affect the supply of hydropower. Rainfall in the Kyrgyz Republic tends to decline in the winter months (Figure 3.5), which, coupled with reduced meltwater from glaciers, decreases river flows. Low river flows combine with high electricity demand for heating in winters leading to imports of electricity from neighbouring Kazakhstan (around 5 KGS/kWh or 5.9 USDc/kWh) and Tajikistan (around 1-1.8 KGS/kWh or 1.2-2.1 USDc/kWh).

Figure 3.5 Rainfall in the Kyrgyz Republic



Source: Weather Atlas (n.d.).

Note: mm = millimetre.

Several renewable energy technologies such as solar PV, wind, hydropower and bioenergy have diverse daily and seasonal generation profiles. This allows them to complement one another in a diversified system. In the winter season, wind, for instance, can potentially complement hydropower. An energy system that includes a balanced mix of renewables can therefore be more resilient to seasonal variations.

Environmental impacts of hydropower

Hydropower projects should be developed and operated sustainably according to international best practices. As with any other large infrastructure project, large hydropower plants can lead to several negative environmental and social impacts during their construction and operation. These may include habitat destruction, population displacement, loss of forest, disturbance to wildlife, damage to water bodies such as streams and ponds, stress on water resources, heavy dust pollution and equipment noise pollution.

Environmental impact assessments of several Kyrgyz hydropower projects report that environmental benefits outweigh impacts. The construction of Kambarata-1, for instance, has had a mainly beneficial impact in the Syr Darya river basin, improving the management of the Central Asian water-energy-food nexus. It can provide the Kyrgyz Republic with electricity during winters, and allow the Toktogul reservoir to store water during the winter, thereby reducing the risk of flooding in the lower reaches of the river and providing sufficient water for irrigation of the downstream countries in spring and summer (Tazabek, 2014). Some studies (*e.g.* World Bank, 1995) have cautioned that new hydropower projects may create environmental problems such as loss of farmland, resettlement, downstream loss of nutrients due to deposition of silt and impacts on fauna and flora. Natural disasters such as earthquakes and/or landslides could create hazards for downstream populations as the existing Toktogul dam and the planned Kambarata project are located near a major fault in an active seismic area.

A shift towards small hydropower projects can help avoid some of the impacts linked with large projects. Run-of-river hydropower installations can sidestep several impacts associated with reservoirs. However, deployment should still aim to minimise environmental implications for land use, water flow and ecosystems. Operation and maintenance (O&M) of small hydropower projects can help improve their long-term sustainability, while ensuring that they continue to meet the demand for clean and reliable electricity.

3.5 Issues faced in the deployment of renewables

As technology costs continue to decline and the challenges of climate change, air pollution and rising demand intensify, the case for greater adoption of renewables is growing stronger. That said, wide-scale deployment of renewables in the Kyrgyz Republic has been held back by several issues discussed in Section 3.4:

- The lack of a level playing field hinders renewable energy deployment at the retail level. Average power and heat tariffs are well below the levels needed to recover costs (Sections 2.2 and 2.3).
- Renewable energy targets have not been effective as they are not enforced by law, nor backed by concrete policies. Responsible entities are not identified. Given the significant renewable energy resources, targets are not ambitious. Moreover, there are no clear targets for heating and transport (Section 3.3).
- So far, renewable energy policies remain limited to the electrical power sector. Policies such as mandates, fiscal and financial incentives and demonstration projects could encourage renewable heating (Section 3.3).
- Feed-in tariffs have not been successful in attracting investments. The current level of 3.27 KGS/kWh (USD 0.39/kWh)[10] (*i.e.* 1.3 x 2.52 KGS/kWh – the highest consumer tariff) is too low. The institutional responsibilities are still not clear, quotas remain undefined. While certificates of registration as renewable energy producer have been awarded to over 70 companies, they have not been offered FITs (Section 3.3).
- Auctions/tenders have not been successful in the past. While winners were selected, projects have not been implemented due to due to various disagreements (Section 3.3).
- Distributed generation policies such as net metering and wheeling are not in place. Even if they were enacted/implemented, the tariff regime is not conducive. The sale of electricity at a rate exceeding 2.52 KGS/kWh (USD 0.3/kWh) is hindered (Section 3.3).
- Permitting procedures require further clarification. Location of renewable energy plants is permitted on some categories and types of land, with some categories requiring transformation to other categories of land, which is difficult.
- Renewable energy capacity building is needed for both public and private stakeholders. Lack of adequate skills and know-how is hindering all stages of renewable energy deployment starting from policy making and going all the way to project construction and operation.

[10] *USD 1 = KGS 84.8 (as of 30 January 2021).*

4. RECOMMENDATIONS

A smooth transition towards a sustainable energy system that addresses the various energy sector challenges by utilising the extensive renewable energy resources in the Kyrgyz Republic requires a conducive policy and regulatory environment that is well designed and implemented. This section presents a set of short- to medium-term recommended actions to address key challenges and support the country in moving towards a diversified and climate-friendly energy system. These recommendations and actions focus on creating a more conducive environment for renewable energy investments and project development.

4.1 Legal and regulatory reform

Scaling up the deployment of non-hydropower renewables in the Kyrgyz Republic requires an extensive reform of the policy and regulatory framework. A shift towards overarching policy frameworks, complemented by strong institutions, laws and regulations is vital in catalysing change in the energy sector status quo. A substantive reform of energy pricing structures and streamlining of regulatory procedures for renewable energy deployment can help create a favourable regulatory environment for renewables.

The Kyrgyz Republic has one of the lowest electricity tariffs in the world. Tariffs for heat and electricity are well below cost-recovery levels (Energy Charter, 2018; Rosenthal, Gassner and Hankinson, 2017). As discussed in Section 3.4, this contributes to the inefficient use of energy and severe underspending on maintenance and new investments, while making renewables uncompetitive in comparison with easily and universally available cheaper grid energy. Concerns about poverty and affordability have meant that planned tariff reforms have not been implemented (Holzhacker and Skakova, 2019).

Renewable energy deployment in the Kyrgyz Republic has also been held back in the past by the lack of a streamlined process for bringing the projects online. Despite the presence of an approved FIT (see Action 3), projects were often held back for several reasons including a lack of clear institutional responsibilities governing the implementation and operation phases. The lack of comprehensive legislation governing land allocation had also been a key hindrance to the development of renewable energy sources.

Action 1: Create a level playing field with energy tariff reforms

Well-designed tariff reforms in the energy sector can help generate revenue for investments in clean and modern infrastructure. They can also help lower the barrier to market entry for distributed renewable energy technologies such as small-scale solar PV and solar water heating. Appropriate retail tariffs can stimulate the emergence of alternative suppliers of electricity and heat supported by regulations encouraging net metering and wheeling.

Political instability, an incomprehensive energy sector structure and lack of energy sector management transparency have resulted in a loss of trust and extremely low awareness of the population about the energy sector crisis. Over 65% of respondents to household surveys said that electricity tariffs are too high and should be reduced (World Bank, 2017a). To be sustainable, tariff reforms need to be designed in a way to minimise the economic impact on low-income and marginalised parts of society. Moreover, reforms should be coupled with awareness campaigns that provide more clarity about subsidies and the financial condition of the energy sector to help reduce the social and political opposition to increasing tariffs.

Countries such as India, Indonesia, Morocco, Pakistan and Zimbabwe are using tariff reforms to generate funds to make their energy sectors more sustainable while creating a level playing field for renewables. In Pakistan, retail tariffs have been increased gradually to improve the financial viability of the power sector. The higher tariffs have fuelled the growth of the domestic solar industry, which installed around 60 MW of net-metered residential and commercial rooftops in the 2019-2020 financial year (The News, 2020).

Current status: The government has recently (2021) indicated that an increase in tariffs is needed to help address the financial issues faced by the energy sector (Eurasianet, 2021). The tariffs for non-residential customers were increased by 12.5%; however, the tariffs for residential customers have been left unchanged, and were even lowered for low-income families due to the high political sensitivity of the issue (SARFEC, 2021). It is expected that the tariffs will be raised each year by a percentage to account for inflation in accordance with the medium-term tariff policy for electricity and heat for 2021-2025, accepted in October 2021 (GoK, 2021).

Action 2: Streamline the procedure for bringing renewable energy projects online

Permitting requirements and procedures should be streamlined under an overarching renewable energy law to provide a clear direction for deployment. The overarching law should be implemented through concrete secondary regulations that clearly articulate the process and identify responsible government entities to facilitate the renewable energy sector. The stability of the governance structure and well-defined responsibilities of each involved government body can increase investor confidence, reduce barriers to entry and lead to more efficient project deployment.

The overarching principles for the design of the procedures should focus on simplicity, transparency and the flexibility to adapt to evolving market and regulatory conditions. As a starting point, land for renewable energy project development could be allocated by the government in zones with adequate accessibility to infrastructure, such as the electricity grid, water and roads. The amendments and additions to the legislation on the "provision of land plots", accepted in July 2021 could help ease the process of land allocation for renewable energy projects. Further amendments to the Land Code, Water Code and the secondary legislation governing the provision of land plots are needed to enable the building of renewable energy plants on additional categories of land.

Furthermore, a one-stop-shop system for renewable energy projects could be set up to streamline the permitting process and enable better coordination of internal administrative processes. This system should be equipped with the necessary decision-making abilities to enable the different stages of project development. Publishing procedures online, with clear guidance on the necessary steps including the documentation, timelines and the relevant government institutions could give much-needed transparency to developers.

Current status: The procedures for renewable energy project development are outlined in Regulation No. 525 (October 2020). At the moment, the energy sector permitting processes are under revision as part of a wider reform of the sector's governance structure.

4.2 Policy support mechanisms

The current policy support framework for renewables has not been successful in encouraging private sector participation. Strengthening the confidence of the private sector to invest in renewables would require the implementation of well-designed support mechanisms that are attuned to specific national and local contexts. While long-term stability of policies is the key, policies must continuously adapt to changing market conditions to promote cost-competitiveness. There is a need to identify support mechanisms that would facilitate the transition towards a functioning renewable energy market. FITs are instrumental in the initial development of a national market for renewables. However, as the market matures, auctions, especially for large-scale installations, could help procure renewables at more competitive prices through price discovery. Furthermore, support mechanisms should also address the decarbonisation of the end uses, with a special focus on heating and transport.

The GoK has introduced several policy support mechanisms such as FITs, tenders and end-use sector-specific policies with limited success. FIT schemes have not yet been deployed due to factors such as unclear institutional responsibilities, low tariffs and concerns about the long-term certainty of FITs. So far, tenders have not led to project implementation. While winners were selected, projects have not been completed due to various disagreements. Finally, the transport and heating sectors are very important from the perspective of energy consumption and energy-sector-related emissions. Coal, natural gas and oil are heavily used for district heating and stand-alone heating systems leading to significant emissions[11] and local air pollution (IEA, 2020b). Simultaneously, the demand for diesel and gasoline has been increasing as more vehicles are added to the transport fleet. Cities such as Bishkek and Osh are suffering from local air pollution, which can be partly attributed to transport emissions. Policy support for the introduction of renewables and energy efficiency in the heating and transport sectors offers a promising opportunity to reduce air pollution and mitigate GHG emissions, with significant co-benefits.

[11] *While actual emissions are not known, energy production (power and heat) accounted for around 24% of total energy-related emissions in 2010 (SAEPF, 2016). Since most of the electricity comes from hydropower, heating likely accounts for the bulk of the energy production emissions.*

Action 3: Improve the feed-in tariffs

The FIT scheme should be revised and improved based on factors such as changing market conditions, competitive renewable energy costs and clearer resource assessments. The selection of an appropriate tariff is an extensive process that should be led by the government with active and diverse representation from all stakeholders (government institutions, private sector, academia and development partners). Any reform of FITs needs to be supported by a clear demarcation of institutional responsibilities. Moreover, FITs, just like any other policy mechanism, need to be supported by a conducive policy, regulatory and institutional landscape to ensure rapid uptake of renewables.

FITs (and feed-in premiums, FIPs) have been adopted by more than 80 countries around the world. Globally, some of the leading solar PV installation markets around the world such as China (49 GW), Viet Nam (11 GW) and Japan (5.4 GW) have achieved their levels of deployment in great part due to their FITs (IRENA, IEA and REN21, 2018). As their sectors matured, and with their growing need for a policy scheme that better reflects the falling technology costs, most of these countries are using auctions, at least for their large-size projects.

The main challenge of a FIT relates to setting the right tariff or premium level, and adjusting it as needed. FITs that are too high can lead to windfall profits, strain the government budget and possibly lead to high consumer tariffs and the development of surplus capacity, which may need to be curtailed. Countries have addressed these issues using several approaches. France, Germany and the United Kingdom, for instance, used degression mechanisms that lower the FITs as the level of deployment increases and costs decline (IRENA, 2014). China combines FITs with regional quotas to limit solar PV deployment to target levels (Ye, Rodrigues and Lin, 2017).

While many countries are moving towards auctions (Action 4) to curb deployment costs, some are choosing to implement both. For example, Germany, Italy and Malaysia have simultaneously used auctions for large-scale projects and FITs/FIPs for smaller projects (IRENA, IEA and REN21 2018).

Finally, it should be noted that tariff setting alone may not be the only determining factor and a more comprehensive reform of the policy, regulatory and institutional landscape might be in order. The current FIT regime provides a FIT of 3.27 KGS/kWh (*i.e.* using a coefficient of 1.3 times the highest consumer tariff) (3.86 USDc/kWh) for all electricity, produced by renewable plants. This FIT is deemed too low by sector stakeholders. However, it should be noted that the coefficient for solar plants used to be as high as 6 up until 2017.[12]

Current status: The FITs and their implementation mechanism are under review by the MOEI. In late 2021 and early 2022, 63 companies were registered as renewable energy producers, marking their intention to develop over 1 700 MW renewable capacity across solar, wind and small hydro. The new Renewable Energy Law, adopted in July 2022, offers a FIT with coefficient of 1.3 times the highest consumer tariff. It is not clear if the FIT will be offered to all stakeholders who have already registered as renewable energy producers.

Action 4: Implement auctions for large capacities

Renewable energy auctions need to be designed in a way that attracts investors and encourages competition, while also ensuring that the projects are delivered. Auctions can be used to attract investment for relatively large-scale projects in all technologies including hydropower, solar and wind. IRENA's report "Renewable Energy Auctions: A Guide to Design" offers an overview of auction design options and their resulting policy trade-offs (IRENA, 2015).

While it is important to have a developed renewable energy market that can ensure the required level of competition, it should be noted that several countries with nascent renewable energy markets are also using auctions to attract investments. Countries such as Madagascar, Senegal, Togo, Zambia and neighbouring Uzbekistan are using the World Bank's Scaling Solar Program, which is a package of technical support, document templates, pre-approved financing, insurance products and guarantees targeted towards large-scale solar project development facilitated through auctions and private financing (or from the International Finance Corporation). Uzbekistan awarded a 100 MW plant in the Navoi region to the United Arab Emirates' Masdar through auctions for 27 USD/MWh. The plant was commissioned in 2021 (Ellichipuram, 2021; IRENA, 2019). Elsewhere in the region, Kazakhstan has used auctions to award more than 1 GW of renewable energy projects including 600 MW of wind, 350 MW of solar PV and around 100 MW of small hydro. The success of renewable energy auctions in countries with relatively new renewable energy markets demonstrates that the design of the auctions and overarching regulatory landscape can be very important factors.

Current status: There are no officially confirmed plans in place to conduct any renewable energy auctions in the near future. Stakeholders have suggested that the EEU integration of the energy market in 2025 could be an opportune time for the introduction of auctions.

[12] *It should also be noted that wind and solar were much more expensive at that point in time.*

Action 5: Enact policies to decarbonise end-use sectors (heating and transport)

The decarbonisation of the heating sector requires a multifaceted approach, which includes renewables-based electrification, use of renewable heating (solar thermal, biomass, geothermal) and investments in efficiency and infrastructure including for district heating (IRENA, IEA and REN21, 2020). According to the 1.5°C Scenario in IRENA's World Energy Transitions Outlook, electrification will supply more than half of global energy demand, including for heating and cooling. As such, the electrification of heating and cooling will play an important role in the decarbonisation of the energy sector.

Heat pumps are becoming popular globally and incentives such as tax exemptions and rebates can be considered to promote them in the Kyrgyz Republic. China, for instance, offers a 10% rebate, approximately, on the purchase of air source heat pumps. Powered by the Kyrgyz hydroelectricity-based grid, heat pumps present a practical solution for increasing the share of renewable energy in heating end uses. Financial and fiscal incentives can be important near-term mechanisms to encourage the switch to solar water heaters in buildings. These incentives may include a range of grants, low-interest loans and tax incentives.

The electrification of heating requirements needs to be complemented by the strengthening of current generation and distribution capabilities. Due to shortages of water and related low flow to large hydropower dams, household use of electricity for heating has been restricted in the past several years.

Moreover, the authorities should continue to develop and pilot innovative solutions (*e.g.* solar-assisted district heating, heat meters) to increase efficiency and reduce fuel consumption. Lessons learnt from pilot projects should be used to implement extensive decarbonisation projects in the sector.

In the transport sector, more efficient public transport, electric vehicles and support for alternative modes (*e.g.* cycling and walking infrastructure) can help. In the long term, the introduction of electric vehicles can be significant in reducing local pollution and GHG emissions. This, and the electrification of end-use sectors in general, needs to be coupled with investments in the infrastructure needed for power generation, transmission and distribution.

Public procurement of electric vehicles, supported by investments in charging infrastructure, and related expertise, can help stimulate their roll-out in the Kyrgyz Republic by making them more visible in the public space. Buses, government-owned vehicles and taxis are attractive early targets on the road towards e-mobility. While the global electric bus market continues to be dominated by large economies like China, India and the United States, other governments in the developing world are also working to add them to their public transportation fleets – often in collaboration with international development partners. The city of Santiago, Chile, is home to the largest fleet of electric buses outside China (776 buses). Chile's federal government has set a goal of electrifying the country's entire bus fleet by 2040. Similarly, Bogotá (Colombia) and Mexico City (Mexico) increased their electric bus fleet with the acquisition of 406 buses and 193 trolleybuses, respectively, in 2020 (Bnamericas, 2021).

The penetration of electric vehicles in private transport demands a broader set of policies, including financial incentives to facilitate their acquisition and cut their usage costs. In the short term, greater adoption of public transport offers the most effective solution.

The decarbonisation of end-use sectors can be complemented through measures to encourage renewable generation by consumers. The government could use incentive schemes to encourage individual consumers and mini-grids to provide low-cost renewable generation to the grid (and to other consumers). The introduction of net metering, wheeling and other distributed generation policies can help unlock the small-scale market segment.

Current status: The Kyrgyz Republic had a zero customs duty on the import of electric vehicles for several years. The government is also planning to introduce tax and customs incentives on vehicles with hybrid engines (SAEPF, 2020). The new Tax Code was introduced on 18 January 2022 and the new incentives are not yet clear. As of now, there are no government initiatives to develop charging stations.

4.3 Long-term energy planning

The Kyrgyz energy sector needs long-term vision and planning that is cognisant of domestic and international trends and aims to ensure an affordable, sustainable, secure and reliable supply of energy to meet the country's development requirements.

A better assessment of certain renewable energy resources can help pave the way for renewable energy deployment in the Kyrgyz Republic. Given the country's extensive experience in large hydropower, the potential for hydro has been analysed in the past; however, more needs to be done to account for the planning challenges posed by erratic hydrological patterns due to climate change. For solar and wind resources, there is a lack of comprehensive economic potential analysis and zoning.

A comprehensive plan for the development of the energy sector to address the challenges of rising demand, ageing infrastructure and increasing climate impacts is yet to be developed. Electricity and energy consumption in the Kyrgyz Republic has been increasing rapidly. The ageing energy infrastructure requires significant investments to meet growing demand. The country's production from hydropower exhibits seasonal and annual variability, which significantly affects power reliability. Kyrgyz energy sector trends must be seen against the backdrop of the long-term impacts of climate change and an evolving global market in which renewable technology costs have been declining rapidly. Successful national energy sector planning demands a thorough analysis that incorporates all these dynamic factors.

Energy planning can contribute to the process of setting comprehensive and ambitious renewable energy targets. The existing targets are not specific and not ambitious enough to capitalise on the rich renewable energy resources of the country or to account for the rapidly increasing energy demand. As existing generation capacities cannot cope with growing demand, the choice would be to either import more electricity - which is limited by the technical capacities of the power lines connecting the Kyrgyz Republic with Kazakhstan and other neighbouring countries or support the development of local renewables, facilitating local energy sector and economic growth. Renewable energy technologies such as solar PV, wind and bioenergy tend to be modular and can be deployed rapidly, which makes them ideal candidates for meeting rising demand, while contributing to the diversification of energy sources, enhancing energy security and climate resilience.

Action 6: Improve renewable energy resource mapping

As the Kyrgyz Republic aims to achieve a more diversified power generation mix, zoning for solar PV and wind generation projects should be prioritised.

Renewable energy zones can be defined as areas with high-quality resource potential where deployment is viable from a technical, economic and environmental standpoint. These areas satisfy various criteria such as proximity to grid infrastructure, load centres, road networks and other generation projects. The zoning exercise can assist future planning, target setting and policy development.

The characteristics of each zone, such as annual generation and estimated LCOE, can help policy makers in planning. Moreover, an enhanced mapping exercise can also be a very useful basis for project developers, with the potential for reducing development and transactional costs.

IRENA's potential suitability analysis (Section 3.1), which identifies suitable zones for solar PV and wind, can serve as an important initial step towards a complete zoning assessment. The assessment identifies three suitable solar PV zones clustered in the southern region of Osh along the river Kyzyl-Suu (Annex Table A2). It also found 77 wind zones clustered in the southern region of Osh along the border with Tajikistan, the northern and southern regions in Naryn and the southern region of Issyk-Kul. Other sparse clusters were found in western Batken and southern Chuy (Annex Table A3). Follow-up studies could build on IRENA's zoning exercise by performing a detailed analysis of the technical and economic potential within the identified solar and wind zones. As a next step, these analyses can be strengthened by ground-based measurements.

Current status: There is an active initiative focusing on renewable energy resource assessment, mapping and zoning, supported by USAID.

Action 7: Develop long-term energy scenarios

A detailed long-term planning exercise should be undertaken for energy demand and supply in all sectors to identify the optimal energy mix and inform policy decisions accordingly. Given the strong share of the Kyrgyz Republic's non-electrified end-use sectors in energy consumption and emissions, a deeper focus on sectors such as heating and transport is needed, which should fully assess the potential for electrification, and energy efficiency and renewable energy penetration. Given the extensive linkages between the power and water sector of the country, the dynamics of seasonal and climatic patterns in water requirement for energy and food production should be a cornerstone of any national energy sector planning exercise. The long-term integrated energy plans can be essential for efficient investment in infrastructure which avoids duplications and stranded assets.

It should be noted that the demand for electricity (and energy in general) is relatively hard to predict. Scenario analyses that explore a host of different energy sector futures with their underlying assumptions can be used to develop a better understanding of the consequences of energy sector decisions. These scenarios can provide useful insights about the sector and can serve as essential inputs for setting targets and enacting policies for transitioning towards sustainability. Accurate and timely data and information are crucial for the formulation and revision of energy plans. Therefore, energy sector planning needs to be complemented by reforms in the collection and reporting of energy statistics.

IRENA's report, *Planning for the Renewable Future: Long-Term Modelling and Tools to Expand Variable Renewable Power in Emerging Economies*, provides insight for planning greater renewable energy integration in the power sector. The report emphasises the need to adequately address variability, uncertainty and the location-dependency of variable renewable energy in long-term generation expansion models, and to integrate stronger feedback loops between planning stages (IRENA, 2017).

The formulation of energy sector plans and scenarios can be an essential step in developing investment trajectories for the sector. Once the funding requirements for the energy scenario are determined, the government (and other stakeholders) could plan for accessing different funding sources. The funding could come from various revenue sources, including tariff reforms, taxes (*e.g.* on transport fuels), as well as contributions from donor organisations. Additionally, the government could also target international climate funds and climate finance institutions such as the Global Environment Facility, the Climate Investment Funds and the Green Climate Fund (IRENA, 2016; IRENA and CPI, 2020). The Climate Investment Platform, a joint initiative by IRENA, UNDP and SE4All, which is helping developers in preparing bankable projects and matchmaking with financing partners could provide another avenue for accessing renewable energy finance.

Current status: The Kyrgyz Republic has finalised the development of the National Expert Sustainable Development Goals Tool for Energy Planning (NEXSTEP) with the support of the United Nations Economic and Social Commission for Asia and the Pacific, which aims to help policy makers make informed policy decisions to achieve their Sustainable Development Goal (SDG) 7 and NDC targets by creating several energy sector development scenarios up to 2030. The scenarios will be used in the development of a national SDG 7 roadmap, which would be a good starting point to develop enabling policies to achieve SDG 7 and NDC targets.

Action 8: Establish comprehensive and ambitious renewable energy targets

The GoK can send strong signals to all sector stakeholders by establishing renewable energy targets that are representative of the country's strong renewable energy potential, declining technology costs, rising demand for energy and socio-economic development goals.

These targets should have a direct connection to national high-level priorities and be backed by strong political commitment and legislation. They must to be rooted in long-term energy plans and rigorous scenario analysis involving all generation technologies. They also need to be directly linked to the country's NDC, long-term strategies and broader climate objectives.

Furthermore, they should be defined at the level of the energy sector and disaggregated by sector (transport, heating, electricity, etc.). Within the electricity sector they could be divided by specific technologies (see examples in Table 4.1). Stakeholder engagement during the design of the process could strengthen credibility and feasibility. The targets should be clearly defined and the responsible entities identified. Finally, targets need to be backed by specific policies and measures that would expedite renewable deployment in the country. IRENA is already contributing to this effort to help build capacity in the local public and private sectors, with dissemination activities focusing on target setting and auction design.

Current status: The Green Billion Plan, which aims to stimulate the production of a billion kWh from renewable energy technologies, has been discussed on and off for over a year by the government but has not yet been offered for open discussion.

Table 4.1 Examples of technology-specific targets

Country	Technology	Target
Viet Nam	Hydropower	25.4 GW by 2030
	Wind	6 GW by 2030
	Solar	12 GW by 2030
Morocco	Wind	20% of capacity by 2030
	Solar	20% of capacity by 2030
	Hydropower	12% of capacity by 2030
India	Solar PV	300 GW by 2030
	Wind	140 GW by 2030

Note: GW = gigawatt; PV = photovoltaic.

4.4 Facilitate financing and de-risk investments

A large share of energy investments in the Kyrgyz Republic has been through foreign direct investment (FDI). The domestic banking sector does not have significant experience financing non-hydro renewables. Meanwhile, a lack of bankable renewable energy project proposals is a major deterrent to renewable energy financing in the sector. In this context, improved power purchase agreements (PPAs) and the greater adoption of public-private partnerships (PPPs) could de-risk investments and help leverage the financial and technical capabilities of the private sector.

PPAs have a high degree of relevance in facilitating renewable energy investments. PPAs are very important to renewables, given that before investing in independent power producer (IPP) plants, private entities and lenders want to be sure that there is a secure market for the output of their production facilities. In the Kyrgyz Republic, the duration of a PPA for renewables is set to a maximum of 10 years, and current draft changes to the Law on Renewable Energy sets the PPA duration at 15 years. The contract parties are responsible for monitoring the PPA implementation. In the past, there have been some issues of non-payment to small hydropower plants by distribution companies.

PPPs are projects in the field of infrastructure development that introduce private sector funds, expertise and motivation into areas that are normally the responsibility of the government. Globally, PPP arrangements have become widespread in the field of renewable energy. They have been used in developed and developing countries in conjunction with several policy mechanisms ranging from quotas in the United States to FITs and auctions in Europe and the rest of the world. In the region, the government of Uzbekistan recently entered a PPP arrangement with Masdar Clean Energy for the development of a competitively tendered 100 MW PV solar power plant.

Horses grazing near a lake in Song kul, Kyrgyzstan.

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Action 9: Adopt a standard power purchase agreement

The key design elements of current renewable energy PPAs should be reviewed in accordance with international best practices. Where possible, this effort should be complemented by a thorough review of contractual project document templates for renewables along with the development of standardised PPAs.

In this context, the Open Solar Contracts initiative, jointly launched by IRENA and the Terrawatt Initiative, can be a very useful resource for contractual templates to be included in solar power procurement. The initiative's contract templates are the result of a rigorous collaboration involving key stakeholders at the intersection of the solar energy and legal sectors. The contracts are primarily designed for small- and medium-sized, on-grid solar PV projects and include agreement templates for power purchase, implementation, O&M agreement, supply, installation and finance term sheets (IRENA and TWI, 2019).

Variable renewable energy technologies such as wind, solar and small hydropower have some distinct characteristics, which need to be accounted for in their PPAs. These characteristics include variability (how much generation and at what time), uncertainty (predictability of the generation) and location constraints (co-ordination between grid and generation). These characteristics should be adequately accommodated through PPA design features governing supply and purchase commitments, curtailment clauses and requirements for dispatch procedures.

Price uncertainty and the fear of non-payment can have a significant influence on investment decisions and financing costs. This makes the role of PPAs even more important. These agreements need to be backed by strong legal regulation that helps improve the credibility of the sector, lowers capital costs and attracts investors and project developers.

Current status: The government is in the process of approving a standard PPA for specific renewable energy technologies.

Action 10: Introduce public-private partnerships

To be successful, the introduction of PPPs in the Kyrgyz energy sector needs to be backed by strong political will, capable institutions and conducive legislation. Fair risk-sharing criteria must be established that support profitable returns for the private sector. If the services are not delivered at the required level the private sector must be penalised. On the public side, there must be acceptance of the principle of whole-life costing, and an absolute commitment to the government's long-term (15-30 year) payment for power generation. Overall, the responsibilities of all stakeholders should be clearly defined to ensure smooth operation and delivery of essential public services.

Well-designed PPPs allow for several advantages such as on-time/budget delivery; optimal risk management; efficiencies from the integration of design, construction, financing and O&M; competition and greater participation; and accountability for the provision of renewable energy. By bringing in a more experienced private developer backed by a credible off-taker, PPPs can help de-risk investments and lower deployment costs. PPPs transfer several risks such as cost overruns (construction, O&M) and forecast errors (*e.g.* overestimation of resources) from the public to the private sector, thereby creating value for the government (UNECE, 2013).

Investors are increasingly becoming risk averse and before lending to IPPs, they expect that formalities such as planning consents, grid connection offers, PPAs (Action 9) and construction contracts are in place. Therefore, governments should seek to facilitate the IPP in arranging these formalities. Moreover, the government should also ensure that the whole process is carried out transparently to develop credibility among developers and lenders.

Current status: While no PPPs have been announced in the renewable energy sector, a memorandum of understanding has been signed between the Ministry of Energy and private companies such as Masdar and EcoEner to develop solar and hydropower projects (AKIpress, 2022; Skopljak, 2022).

4.5 Capacity development in the public and private sectors

For the Kyrgyz Republic to achieve ambitious targets for renewables and energy efficiency, the country will need concerted capacity-building efforts on several fronts. The Kyrgyz Republic's renewable energy sector has historically focused on the deployment and maintenance of hydropower, which means that know-how and familiarity with other clean technologies (renewables and energy efficiency) are scarce in both the public and private sectors.

Lack of awareness of renewable energy is a key challenge in many government departments and ministries, which often end up blocking policy development and delaying approvals and funding for projects. Institutional stakeholders need to ensure adequate co-operation and co-ordination among themselves to respond promptly to the dynamics of the renewable energy sector.

The private sector could also benefit from extensive capacity building to help develop a capable renewable energy workforce and a thriving domestic renewable energy value chain. Several universities in the Kyrgyz Republic offer education with a specialisation in renewable energies, including the Kyrgyz State Technical University, Kyrgyz-Russian Slavic University and the Kyrgyz-Uzbek University. Some of these institutions are co-operating with international scientists on research projects focusing on different areas of the clean energy landscape. That said, the renewable energy market remains small, and it is not able to absorb the students graduating from universities.

Action 11: Enhance institutional capacities

The technical and co-ordination capabilities of public and private sector entities require improvement to facilitate renewable energy deployment. Capacity needs assessment studies aimed at different stakeholders, such as public institutions, private sector, academia, the general public, etc., could be an important preliminary step in this direction.

Support from international donors and development banks could be sought to set up periodic capacity-building efforts in relevant government entities. Capacity building in the public power sector institutions, for instance, could focus on areas such as cost competitiveness of renewables, technical issues in the integration of variable renewables in the grid, management of a system with substantial shares of renewables and introduction of flexibility mechanisms such as storage and demand-response.

Capacity building in the public institutions involved in policy making can focus on areas such as the design of renewable energy targets, renewable energy auctions, design and implementation of FITs, net metering, etc.

IRENA is already contributing to this effort to help build capacity in the local public and private sectors with dissemination activities that could potentially focus on target setting, auction design and resource assessments. In this context, a lot can be learned from the experiences of countries at different stages of deployment. In solar deployment, the Kyrgyz Republic can learn from the experiences of a wide variety of countries including established markets (*e.g.* China, India, etc.), as well as markets that are only now starting to make strides in the sector (*e.g.* Kazakhstan, Türkiye, Ukraine, Uzbekistan, Zambia, etc.).

Furthermore, awareness of renewable energy's benefits and competitiveness can also encourage adoption among people in the private sector.

Current status: Several projects are already striving to create awareness in the tourism and agricultural sectors. The SWITCH-Asia project, for instance, aims to promote energy efficiency and renewable energy in the community-based tourism sector in Central Asia, while the PERETO project is aimed at promoting energy security and sustainable growth by promoting sustainable production and consumption and energy and resource efficiency practices among small- and medium-sized enterprises in the tourism sector of the Kyrgyz Republic.

Action 12: Educate and train a skilled workforce

Investment in the education and training of workers such as engineers, technicians and other skilled personnel is very important. Universities, vocational training institutes and schools all have a role to play. As such, the government authorities in charge of energy, training and education should collectively work towards the introduction of renewable energy training curricula.

The creation of renewable-energy-related skills is best seen in the context of an ongoing global transition that has transformational impacts on the energy sector workforce. Fossil-fuel-based jobs are already facing several challenges due to variations and fluctuations in demand. IRENA's analysis foresees that by 2050, 42 million people could be working globally in the renewable energy sector with an additional 21 million people employed in energy efficiency and almost 15 million in the power grid and energy flexibility. Undoubtedly, the skill requirements for jobs related to renewables and energy efficiency are set to increase. The Kyrgyz Republic can benefit from this trend by investing in a capable renewable energy workforce.

The development of a skilled workforce needs to go hand in hand with investments and policy support for the relevant industries. Industrial upgrade programmes can help strengthen the capabilities of local firms. These programmes should aim to enhance the technological capabilities of domestic industries by enabling them to derive value from renewable energy investments and to facilitate closer linkages with business partners. Joint ventures and tax breaks can also be used to strengthen local capabilities. Some countries, *e.g.* India, Morocco and South Africa, have also used domestic content requirements to strengthen local industry.

Current status: While universities in the Kyrgyz Republic are offering courses in topics related to renewable energy, the lack of opportunities in the sector is a major problem for youth with specialisation in renewables.

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ANNEX 1. Solar PV and wind potential in the Kyrgyz Republic

This report presents the results of an assessment conducted by the International Renewable Energy Agency (IRENA) to identify promising land areas in the Kyrgyz Republic for utility-scale solar and wind power development.

Zoning assessments are generally conducted to support transmission planning. Specifically, they allow:

- analysis of the quality of the solar and wind resources across the country (theoretical potential);
- identification of most suitable areas for solar photovoltaic (PV) and onshore wind development by considering renewable resources alongside technical, financial and socio-environmental criteria;
- identification of potential sites for solar PV and onshore wind farms;
- identification of suitable zones for grid integration; and
- examination of opportunities for cost-effective solar PV and onshore wind development.

Approach

The suggested approach to conducting the zoning assessment is outlined below.

Data setting

The required input data to conduct the zoning assessment for solar PV and onshore wind development relate to renewable resources, infrastructure, land and terrain features (Table A1). Such data are of great importance in mapping the suitability index and defining suitable zones for each technology. The annual solar and wind data – specifically the global horizontal irradiation or wind speed – is the most important dataset in evaluating the theoretical potential of an area for developing renewable energy projects (Figures A1 and A2). The required data also include infrastructure and socio-environmental datasets – on transmission lines, topography, protected areas, land use and population growth – which help in determining the technical potential.

Table A1 Data requirements

Date setting	
Solar resource	
Yearly global horizontal irradiation (GHI)	ESMAP
Hourly global horizontal irradiation (GHI)	MERRA2
Wind resources - meteorology	
Yearly 100 m wind speed (WS)	Technical University of Denmark (DTU)
Weather variables	ERA5
Technical, financial and socio-environmental data	
Electrical network	OpenStreetMap
Road network	Global roads inventory project (GRIP)
Topography	Shuttle radar topography mission (STRM)
Population density	Oak Ridge National Laboratory (ORNL)
Protected areas	World Database on Protected Areas ((WDPA)
Land cover	Global Land Cover map (GlobCover)

Note: ERA5 = European Centre for Medium-Range Weather Forecasts' fifth generation atmospheric reanalysis; ESMAP = Energy Sector Management Assistance Program; MERRA2 = Modern-Era Retrospective analysis for Research and Applications, Version 2.

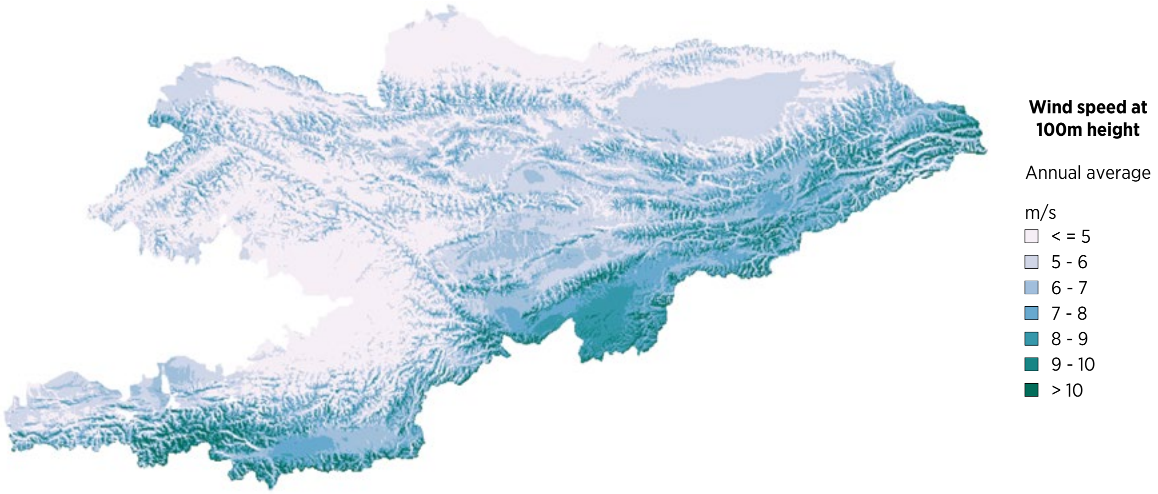
Figure A1 Global horizontal irradiation

Source: IRENA (2021b); Global Atlas (2022). Map data: World Bank; ESMAP 2021; United Nations administrative boundaries 2021.

Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply the expression of any opinion on the part of IRENA concerning the status of any region, country, territory, city or area, or of its authorities, or concerning the delimitation of frontiers or boundaries.

Note: kWh/m^2 = kilowatt hour per square metre.

Figure A2 Wind speed at 100 m height



Source: IRENA (2021b); Global Atlas (2022). Map data: Technical University of Denmark (DTU) 2021; United Nations administrative boundaries 2021.

Disclaimer: This map is provided for illustration purposes only. Boundaries and names shown on this map do not imply the expression of any opinion on the part of IRENA concerning the status of any region, country, territory, city or area, or of its authorities, or concerning the delimitation of frontiers or boundaries.

Note: m/s = metre per second.

Suitability assessment

The suitability assessment is a multicriteria decision analysis based on a geographic information system (GIS) that establishes the technical potential[13] of an area to host utility-scale renewable energy projects. These areas are assessed by combining renewable theoretical potential[14] with technical (electrical grid network, slope), and socio-environmental (protected areas, land features and population growth) criteria, using a weighted linear combination approach. The output of this assessment is a suitability map for every square kilometre (km^2) of land in the country (wherein highly suitable areas have high suitability index values) (Figures 3.1 and 3.2). The calculation of this map requires:

- specifying the lower bound (lowest score 0% for the least favourable area) and upper bound (highest score 100% for the most favourable area) values for each criterion;
- defining hypothetical weights for each criterion (0.38 resource, 0.33 grid distance, 0.13 distance to the road, 0.11 population density, 0.05 slope);
- scoring every kilometre of the considered criteria following the assumption and thresholds set;
- aggregating all criteria using a weighted linear combination to calculate the suitability index for every square kilometre; and
- excluding protected areas and land cover to refine suitable areas complying with national legislation.

Clustering assessment

A clustering technique has been used to create defined zones around the country to host utility-scale projects. The output of this clustering is a zone map showing prospective areas of sizes varying from 7 km^2 to 10 km^2 for solar and 6 km^2 to 215 km^2 for wind (Figures 3.1 and 3.2, respectively). The extraction of this map requires various assumptions to define the resulting zones (Table A2). The steps completed are as follows:

- specifying the cut-off suitability values for solar PV (72.5%) and wind (83%) as well as the maximum concentration capacity (5 000 megawatts) and land discount factor (1%);
- identifying adjacent areas with a suitability index higher than the cut-off value; and
- grouping adjacent suitable cells into definitive clusters or prospective development zones.

Provisional results

Based on public datasets and reasonable assumptions, the provisional results obtained suggest the following:

- **Solar PV** zones are clustered in the southern region of Osh along the river Kyzyl-Suu (Table A2).
- **Wind** zones are clustered in the southern region of Osh along the border with Tajikistan, northern and southern regions of Naryn and the southern region of Issyk-Kul. Other sparse clusters are found in western Batken and southern Chuy (Table A3).

Table A2 Utility-scale solar photovoltaic zones

Zone	Latitude (°)	Longitude (°)	Area (km^2)	Capacity (MW)	Distance to grid (km)	Distance to road (km)	Mean suitability
1	39.56	72.45	10	250	0.99	1.57	0.73
2	39.56	72.40	9	225	0.99	1.90	0.73
3	39.62	72.66	7	175	1.11	1.11	0.73

Note: km^2 = square kilometre; MW = megawatt.

[13] *Potential considering theoretical and supplementary information considering technical constraints to deploy projects.*

[14] *Resource availability sufficient to deploy projects.*

Table A3 Wind zones

Zone	Latitude (°)	Longitude (°)	Area (km^2)	Capacity (MW)	Distance to grid (km)	Distance to road (km)	Mean suitability
1	39.91	69.73	7	18	2.98	3.63	0.84
2	42.29	72.96	17	43	3.83	5.50	0.84
3	42.28	73.07	12	30	2.22	1.99	0.85
4	42.11	72.89	8	20	4.30	4.98	0.84
5	41.93	74.05	7	18	2.98	7.12	0.84
6	41.86	74.04	35	88	4.51	9.81	0.84
7	39.65	72.55	42	105	4.97	3.98	0.85
8	39.64	72.39	15	38	7.57	7.40	0.84
9	39.60	72.36	102	255	3.79	3.62	0.85
10	39.58	72.55	6	15	1.79	3.48	0.83
11	39.51	72.25	10	25	4.51	3.52	0.84
12	39.49	72.42	20	50	8.33	8.83	0.84
13	41.97	74.26	8	20	5.01	5.13	0.84
14	41.84	74.18	7	18	6.73	6.00	0.83
15	39.75	73.14	42	105	3.79	3.52	0.85
16	39.70	72.73	9	23	7.22	4.64	0.84
17	39.65	72.63	23	58	3.14	3.14	0.86
18	39.58	72.62	59	148	4.28	4.28	0.84
19	39.50	72.86	17	43	3.18	20.38	0.84
20	39.78	73.25	18	45	2.49	2.05	0.85
21	39.78	73.35	27	68	5.08	5.20	0.84
22	39.74	73.57	44	110	6.18	6.18	0.85
23	39.72	73.20	6	15	1.90	0.99	0.85
24	42.02	75.44	7	18	7.79	7.57	0.83
25	42.00	75.50	20	50	3.83	4.47	0.85
26	41.97	75.61	8	20	2.07	1.99	0.84
27	39.72	73.90	12	30	6.24	1.11	0.85
28	39.68	73.86	10	25	8.63	0.99	0.84
29	39.66	73.92	12	30	6.06	2.05	0.85
30	42.00	75.93	10	25	7.95	5.47	0.84
31	40.85	75.08	7	18	4.51	1.11	0.85
32	40.84	75.18	9	23	2.98	3.40	0.85
33	40.81	75.09	7	18	2.29	2.29	0.86
34	40.82	75.16	8	20	2.05	2.05	0.86
35	40.67	75.11	138	345	4.28	4.01	0.86
36	40.63	74.99	64	160	2.81	2.90	0.85
37	40.52	75.13	215	538	4.58	4.47	0.86

Note: km^2 = square kilometre; MW = megawatt.

38	41.83	76.65	23	58	6.93	6.21	0.84
39	41.85	76.55	18	45	6.27	3.83	0.85
40	41.73	76.69	7	18	4.47	4.47	0.84
41	41.71	76.49	12	30	6.06	6.92	0.84
42	40.68	75.46	29	73	10.11	2.90	0.85
43	40.63	75.48	39	98	7.53	1.99	0.86
44	40.61	75.39	20	50	3.79	1.11	0.88
45	40.53	75.33	14	35	2.98	2.98	0.86
46	41.20	76.37	40	100	4.45	4.45	0.84
47	41.15	76.50	100	250	4.97	4.69	0.85
48	41.11	76.39	89	223	5.82	4.25	0.85
49	42.05	77.66	11	28	4.67	3.40	0.84
50	41.99	77.56	44	110	4.08	4.08	0.85
51	42.00	77.67	24	60	2.68	3.31	0.85
52	41.92	77.74	62	155	4.10	4.45	0.85
53	41.93	77.59	6	15	3.40	3.40	0.84
54	41.87	77.61	60	150	5.08	4.58	0.85
55	41.80	77.81	36	90	2.49	3.33	0.86
56	41.76	77.71	76	190	4.25	4.58	0.86
57	41.61	77.68	6	15	9.51	4.17	0.83
58	41.80	77.91	108	270	4.58	8.55	0.85
59	41.84	78.15	7	18	2.55	24.57	0.83
60	41.66	78.13	14	35	2.98	13.42	0.84
61	41.65	78.00	17	43	5.12	10.90	0.84
62	41.64	77.82	8	20	1.57	2.22	0.84
63	41.60	77.82	59	148	4.28	3.88	0.86
64	41.62	77.95	30	75	2.68	5.71	0.86
65	41.57	78.10	71	178	5.62	7.73	0.84
66	41.62	77.71	7	18	8.81	2.55	0.84
67	41.51	77.95	20	50	7.89	2.98	0.84
68	41.51	77.82	16	40	6.98	2.49	0.84
69	42.08	79.11	12	30	5.21	2.22	0.84
70	42.02	79.01	8	20	5.61	2.72	0.83
71	41.96	78.96	45	113	3.48	8.75	0.85
72	41.90	78.93	19	48	2.72	14.30	0.84
73	41.89	78.84	11	28	1.99	17.24	0.84
74	41.88	78.72	8	20	1.99	24.32	0.84
75	41.61	78.26	24	60	2.81	16.80	0.84
76	41.56	78.26	16	40	4.90	16.86	0.83
77	42.02	79.14	20	50	4.12	6.38	0.84

Note: km^2 = square kilometre; MW = megawatt.

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