Subregional Office for North and Central Asia

Sustainable and Clean Energy in North and Central Asia



ESCAP WORKING PAPER SERIES

SEPTEMBER 2021

UNITED NATIONS ESCAP
Economic and Social Commission for Asia and the Pacific

Available at: http://www.unescap.org/kp

Tracking number: ESCAP/8.3-WP/24

Acknowledgements:

The paper was prepared under the overall guidance of Nikolay Pomoshchnikov, Head, Subregional Office for North and Central Asia.

Preparation of the paper was led by Patricia Wong Bi Yi, with inputs from Jiayue Cheng, Aizhan Omirzak, Arukhan Rakhmanova, Athina Anastasiadou and Fabian Hafner of the Subregional Office for North and Central Asia.

Contents

1. Introduction

NORTH AND CENTRAL ASIAN COUNTRIES[1] ARE RICH WITH ENERGY SOURCES.

Energy was a key driver of economic growth in the subregion for several years after the dissolution of the Soviet Union. In the years after independence, the expansion of conventional energy sources – oil in Azerbaijan and Kazakhstan, natural gas in Turkmenistan and Uzbekistan, hydropower in Kyrgyzstan and Tajikistan – and the initiation of market reforms allowed countries in the subregion to establish a stable energy supply and benefit from energy trade. These efforts created favourable conditions and a conducive environment for restructuring the socioeconomic order. However, challenges remain in terms of energy efficiency, energy security and diversification. The uncertainty of resource price fluctuations exposes countries to external shocks, which impacts countries' fiscal space, currency value and trade balance. Additionally, the expansion of extractive industries in the subregion created limited job opportunities and brought about negative environmental externalities. As resource-driven growth begins to wane and the threat of climate change looms, countries in the subregion are increasingly recognizing the need to explore other sources of revenue and energy production.

In the past decade, energy transition plans have been set in the national strategies of North and Central Asian countries. Sustainable energy development is imperative in these plans. It must be just and suited to the differing contexts of countries in the subregion. Energy transition can be a catalyst for economic transformation in the subregion, and it is increasingly driven by the need to decrease dependence on fossil fuels and decrease fossil fuel subsidies. Technological innovation and advancements in energy that drive down renewable energy costs also make sustainable energy development a logical national priority. With the global shift towards greener policies and decarbonization, especially in the lucrative export markets of Europe and China that aim to be carbon-neutral by 2050 and 2060, respectively, hydrocarbon producing countries in North and Central Asia must adapt to changes in energy demand patterns. Countries in the subregion have made efforts to realign their economies to sustainable development principles, and they need to accelerate the current trajectory towards carbon neutrality. As of 2018, renewable energy adoption in the subregion is very low, amounting to approximately 3 per cent of the total energy supply.[2] Accelerated efforts to promote energy transition and the adoption of renewable energy are needed to realize the potential gains of energy sustainability and to build readiness in the subregion's socioeconomic structure in responding to a new energy paradigm.

[1] The countries in the North and Central Asia subregion are Armenia, Azerbaijan, Georgia, the Russian Federation, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.

[2] Author calculation based on data from International Energy Agency. Renewable energy sources include hydropower, biofuels and waste, and wind, solar, etc.

International and regional frameworks, such as the 2030 Agenda for Sustainable Development, provide good general concepts, goals and targets that can be adapted to local contexts of the subregion. Specifically, Goal 7 of the Sustainable Development Goals (SDGs) on access to affordable, reliable, sustainable and modern energy for all elaborates on international targets to increase the share of renewable energy in the global energy mix and enhance cooperation to facilitate access to clean energy research and technology. Spillover effects from the implementation of Goal 7 are expected to contribute to the achievement of other SDGs as well.

This paper examines the current energy landscape in North and Central Asia and proposes clean energy as a driver to achieve the 2030 Agenda. The interlinkages between clean energy and other SDGs are mapped out, and an analysis aims to ascertain the determinants of clean energy and its relationship to selected SDG indicators. Based on the findings, recommendations tailored to the subregion are provided to facilitate the implementation of clean and renewable energy initiatives which can enhance progress toward the 2030 Agenda. It is noted that the recommendations were formulated based on the analysis of the subregion as a whole, and tailored policies for each country will require further country-specific analyses, which are beyond the scope of this working paper.

The rest of this paper is organized as follows: section 2 elaborates on the energy landscape in North and Central Asia; section 3 proposes a conceptual framework and provides an analysis of the relationship between clean energy and the 2030 Agenda; section 4 outlines priority actions and policies to achieve clean energy in North and Central Asia; and section 5 concludes the paper.

2. Energy landscape in North and Central Asia

The development of energy systems in North and Central Asian countries built upon the remnants from the Soviet Union when electrical power supply was based on the Unified Electric Power System that covered all habitable areas of Soviet states. Electricity for the unified system was mainly generated by fossil fuel power plants, nuclear reactors and large-scale hydroelectric power plants. Due to this common heritage, countries in the subregion experience similar challenges in developing their energy systems and providing a sustainable power supply. The disintegration of the unified system created additional challenges for regional cooperation on energy and electricity production. Energy, along with transport, trade and information and communications technology, is a key transboundary component in regional dialogues.

Efforts have been made to overcome the legacy of disintegration in the subregion through subregional initiatives, such as the formation of the Eurasian Economic Union, and support from development partners, such as the United Nations Special Programme for the Economies of Central Asia and the Central Asia Regional Economic Cooperation Programme. Relevant international and regional documents that set out energy transition strategies for North and Central Asian countries include the Energy Charter Treaty, Energy Transition Pathways for Asia and the Pacific and Energy Strategy 2030. Notable initiatives include ongoing discussions on reviving features of the former unified system for energy and electricity to form an integrated energy supply system among the former Soviet countries.

It was observed that the restoration of parallel operations of all power systems in North and Central Asian countries is economically feasible and environmentally sound, though practical implementation may be impeded by political differences and national interests (ESCAP, 2016). Countries in the subregion need to realize that regional cooperation need not come at the expense of the national objective of energy security. Regional cooperation on energy development can be a driver for the subregion to realize the vision of becoming land-linked countries. Existing regional cooperation initiatives for energy development not only cover conventional energy sources, such as the development of transboundary oil and gas pipelines, but also include exploration of sustainable and clean energy sources, such as biogas, wind and solar power technologies. These efforts in regional cooperation complement the development of the energy sector in North and Central Asian countries and will be elaborated in the following sections.

Developing the energy sector is a priority in economic development strategies of North and Central Asian countries, and it is supported by specific laws, regulations and development programmes on energy efficiency and energy savings. In recent years, national energy policies of countries in the subregion have been concerned with energy transition and the development of energy-saving and renewable energy technologies. Countries are implementing energy policies that include the feed-in-tariff system, tax exemptions and provision of grants.

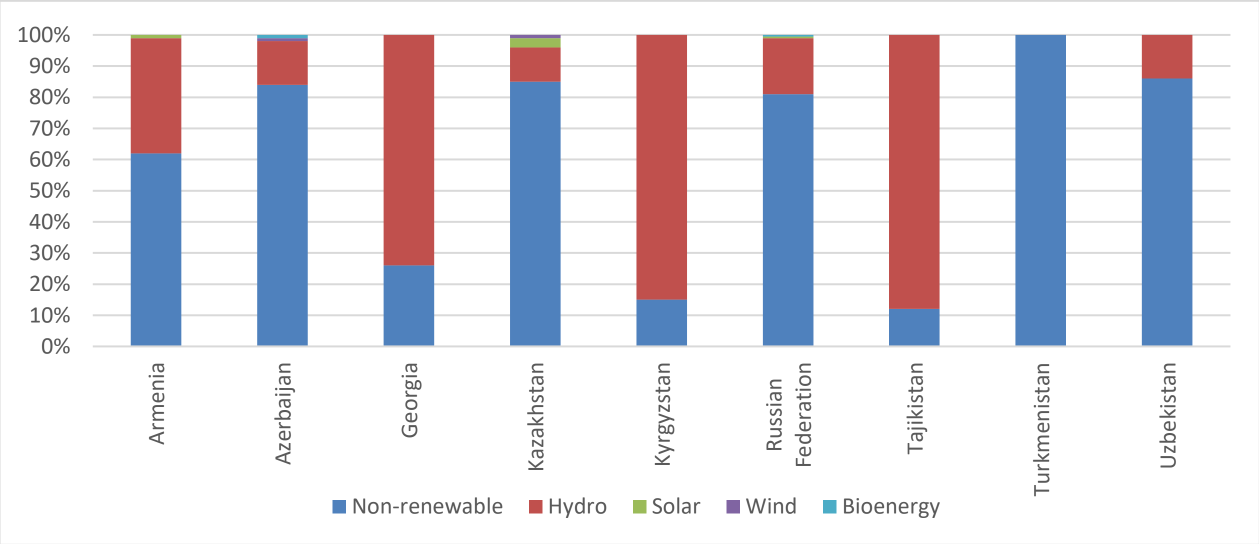
Aside from these policies, it is also critical to have supporting infrastructure which ensures that power generated from renewable sources is connected to power transmission grids. In Armenia, the Government ensures guaranteed access to power transmission grids and provides priority dispatch for power generated from renewable sources. Renewable energy producers also enjoy free connection to the transmission grids in countries such as Georgia, Kazakhstan and Tajikistan. As countries in the subregion tap into their unrealized potential in renewable energy, these initiatives need to be supported by good governance and transparency in processes that will attract investments needed to develop the sector.

2.1 Energy capacity, natural resources and geography

2.1.1 Energy capacity in North and Central Asia

Energy generation capacities highly depend on natural resources of each North and Central Asian economy. While landscapes and geography differ, a common feature shared by most countries in the subregion – except for the Russian Federation – is the lack of access to oceans. Most of the countries in the subregion are landlocked, and Uzbekistan is even doubly landlocked. From deserts in Turkmenistan and Uzbekistan, to the mountainous regions of Kyrgyzstan and Tajikistan, to the subtropical climate in Azerbaijan and Georgia, natural resources and weather conditions vary greatly in the subregion. On the one hand, countries such as Georgia, Kyrgyzstan and Tajikistan are poor in fossil fuel reserves, while they bear considerable capacity to generate hydropower. On the other hand, Azerbaijan, Kazakhstan, the Russian Federation and Turkmenistan have significant oil and gas reserves.

Figure 1: Installed energy capacity mix in North and Central Asian countries, 2019



Source: IRENA.

The installed capacity in North and Central Asian countries is mainly powered by non-renewable energy sources, as shown in figure 1. Although there has been an increase in the renewable energy capacity among countries in the subregion in 2014–2019, the increase in non-renewable energy capacity still outstrips it at double the pace.[3] Among the top increases in renewable energy capacity are solar, wind and bioenergy. Azerbaijan, Kazakhstan and the Russian Federation are among the countries which have considerably increased their solar energy capacities in the past few years. These countries also recorded positive trends in wind energy capacity. Despite efforts to diversify the mix of renewable capacities, hydropower remains the main source of renewable energy in the subregion. Hydropower constitutes 74 per cent of Georgia's total energy capacity, 85 per cent of Kyrgyzstan's total energy capacity and 88 per cent of Tajikistan's total energy capacity. The construction of large-scale hydropower plants is a contentious matter due to social and environmental concerns, and it has caused disputes between the upstream and downstream countries as water flows are disrupted. The social and environmental aspects of energy transition is further discussed in section 2.2.2.

The potential of renewable energy capacity in North and Central Asia remains underexplored as the subregion can tap into existing hydrocarbon reserves. Azerbaijan and Kazakhstan both discovered more oil reserves in 2019 than in 1999. In Azerbaijan, the proven oil reserves amounted to 7 billion barrels whereas natural gas deposits amounted to 1.3 trillion cubic metres at the end of 2017.[4] Kazakhstan has the highest oil reserves to production ratio in the subregion at 42.6, with proven oil reserves that amounted to 30 billion barrels at the end of 2018. The Russian Federation and Uzbekistan also have oil reserves to production ratios which are higher than that of other countries of the Commonwealth of Independent States.[5] These hydrocarbon-rich countries also have abundant renewable energy potential. Excluding hydropower, countries in the subregion have varying degrees of potential for the different types of renewable energy. The potential for solar power is especially high in the subregion. More than 50 per cent of land area in Armenia, Tajikistan, Turkmenistan and Uzbekistan has technical potential to produce 1400–1600 kilowatts per unit of solar capacity installed, which is significantly higher than the global average of approximately 20 per cent of land area with the same capacity.

[3] Data aggregated based on the country statistical profiles published by IRENA.

[4] Based on IEA country profile for Azerbaijan, www.iea.org/reports/azerbaijan-energy-profile/energy-security#abstract.

[5] Based on BP statistical review of world energy, www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/statistical-review/bp-stats-review-2020-oil.pdf.

Other countries in the subregion also record higher than global proportions of land area for different levels of solar potential. Onshore wind power potential varies according to geography in the subregion, with certain areas within Central Asian countries recording good potential wind power density greater than 420 watts per square metre. Azerbaijan stands out with a significant proportion of its land area having good potential onshore wind capacities of 420–820 watts per square metre. Additionally, countries in the South Caucasus have higher than global average biomass energy potential with annual net primary production of 4–6 tonnes of carbon per hectare.[6]

2.1.2 Energy infrastructure and cooperation

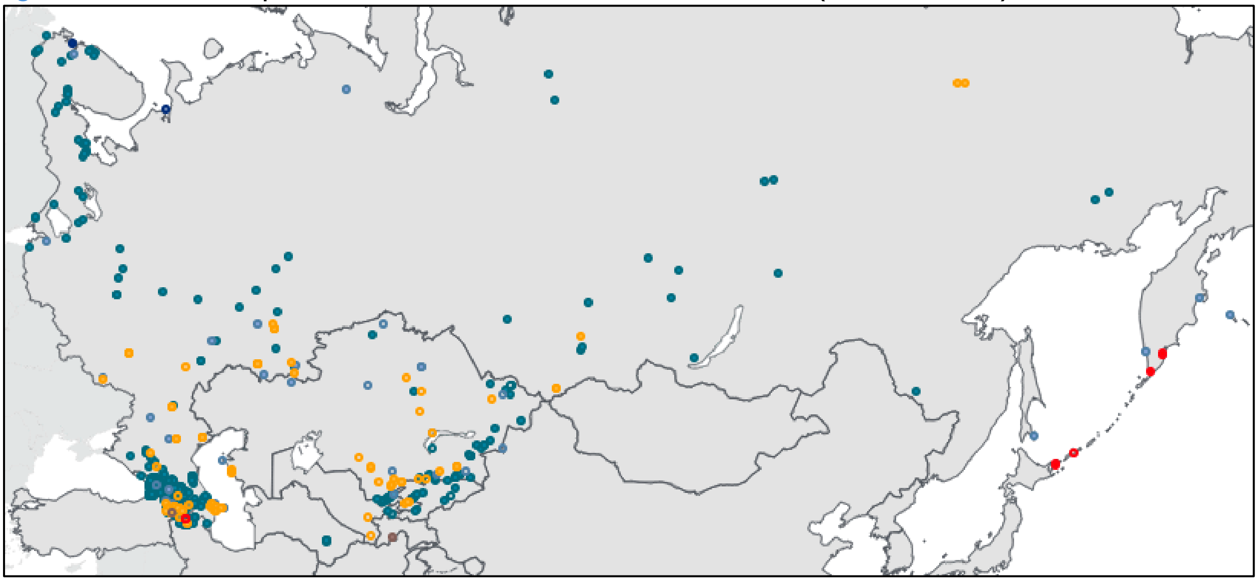
Progress in developing domestic energy infrastructure differs in the subregion. In the South Caucasus, Azerbaijan and Georgia have invested in the modernization and expansion of their natural gas networks, which have contributed to a decrease in network losses and electricity outages. Considerable efforts have also been made to develop renewable energy infrastructure, though the share of renewable energy infrastructure is still small. Countries in Central Asia still face challenges in energy access because energy and electricity infrastructure are not evenly distributed within and across the countries. In resource-rich Kazakhstan, certain parts of the country are reliant on gas imports from the Russian Federation and Uzbekistan to meet domestic demands because domestic pipelines are underdeveloped.

Countries in the subregion face similar challenges in developing energy infrastructure. These challenges mainly stem from three aspects – technical, economic and governance. Technical challenges include the level of knowledge, skill and expertise needed to upgrade ageing infrastructure and the technical compatibility of newer renewable energy power plants and existing grid operations. Lack of infrastructure financing and investments, the abundance of hydrocarbon resources and administrative burdens also hinder the development of energy infrastructure. Given the multitude of challenges, domestic energy infrastructure development in North and Central Asian countries needs to build upon stronger foundations by prioritizing access to clean energy and electricity sources, improving energy efficiency and developing clean fuels and technology.

[6] Based on country statistical profiles published by IRENA.

Figure 2a: Power plants in North and Central Asia (non-renewable), 2020

Figure 2b: Power plants in North and Central Asia (renewable), 2020



Source: Asia Pacific Energy Portal.

Transboundary energy infrastructure development plays a key role in economic development for the subregion. The history of linked energy and electricity infrastructure in North and Central Asia highlights the need for regional cooperation to achieve energy security. However, the complementary nature of energy resources in the subregion has not fully benefitted countries and instead led to disputes. Several multilateral projects have been initiated to foster regional dialogue on energy connectivity once again.

The geographic peculiarity of being landlocked gives some countries in the subregion a strategic advantage. For instance, the South Caucasus countries are situated at crossroads for power grid connections between both ends of the Eurasian continent, and they have an advantage in related transboundary infrastructure projects. For energy importers, such as Armenia and Georgia, their location enhances their bargaining position on the terms and tariffs for their own energy supply. Transboundary energy and electricity infrastructure includes the South Caucasus Gas Pipeline, oil pipelines running from Azerbaijan to Georgia and Turkey and electricity transmission grids that connect countries in the South Caucasus countries to Iran and the Russian Federation.

In Central Asia, one of the early initiatives is the Central Asia South Asia Regional Energy Markets to develop transboundary infrastructure for electricity trade. The concept relied on connecting the electricity transmission infrastructure of thermal- and hydropower-rich countries in Central Asia with power grids in Afghanistan, which surplus can be exported to Pakistan. This is complemented by the Central Asia South Asia power project (CASA-1000), which has similar objectives. Countries in Central Asia can benefit from further integration of their electricity transmission infrastructure, with a reduction of US$6.4 billion in operating expenses in the next 10 years, according to the World Bank.[7] Countries in Central Asia and the Russian Federation are cooperating with China to lay gas pipelines to facilitate energy trade.

Besides transregional initiatives and projects, intraregional projects include the North Caucasus gas pipeline between Armenia, Georgia and the Russian Federation, the Trans-Caspian Gas Pipeline between Azerbaijan and Turkmenistan, the Shymkent Gas Pipeline connecting Kazakhstan and Uzbekistan, and the transcontinental Central Asia–Center gas pipeline system connecting Kazakhstan, the Russian Federation, Turkmenistan and Uzbekistan. Further development of energy infrastructure in the subregion needs to mainstream climate-friendly decisions and policies, integrate renewable energy sources and contribute to harmonizing the energy systems for mutual benefits.

2.2 Energy usage and wastage

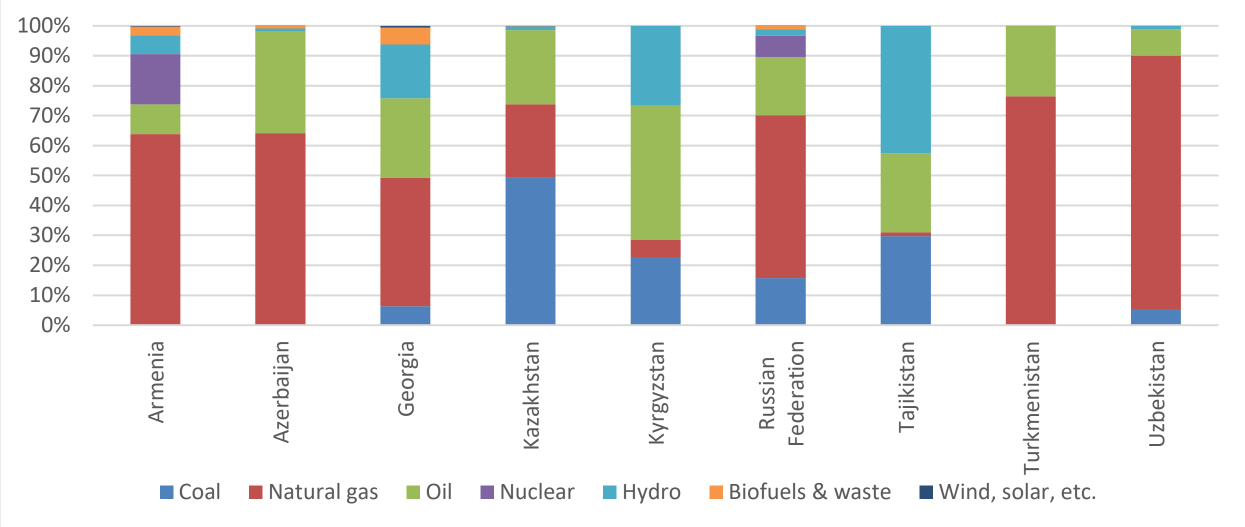
2.2.1 Energy production and consumption

Fossil fuels constitute the largest source of energy production in most North and Central Asian countries. As of 2019, fossil fuels accounted for more than 70 per cent of total electricity output in the subregion, except for Georgia, Kyrgyzstan and Tajikistan.[8] Most countries in the subregion are rich in hydrocarbons and have limited diversification in their energy mix, as shown in figure 3. For the South Caucasus countries, Azerbaijan is a major producer of crude oil and gas, while Georgia and Armenia have insufficient fossil fuel resources and mainly rely on imports to meet domestic energy demands. In the subregion, the Russian Federation has the most diversified sources of energy supply, including oil, gas, nuclear, hydropower and biofuels, yet the share of renewable energy is very small in the energy mix.

[7] Based on the World Bank feature story, Central Asia Electricity Trade Brings Economic Growth and Fosters Regional Cooperation. Available at www.worldbank.org/en/news/feature/2020/10/20/central-asia-electricity-trade-brings-economic-growth-and-fosters-regional-cooperation.

[8] Based on data from BP statistical review of world energy.

Figure 3: Total energy supply by source, 2018



Source: International Energy Agency.
Notes: Total energy supply is made up of production + imports – exports +/- stock changes. It excludes electricity and heat trade.

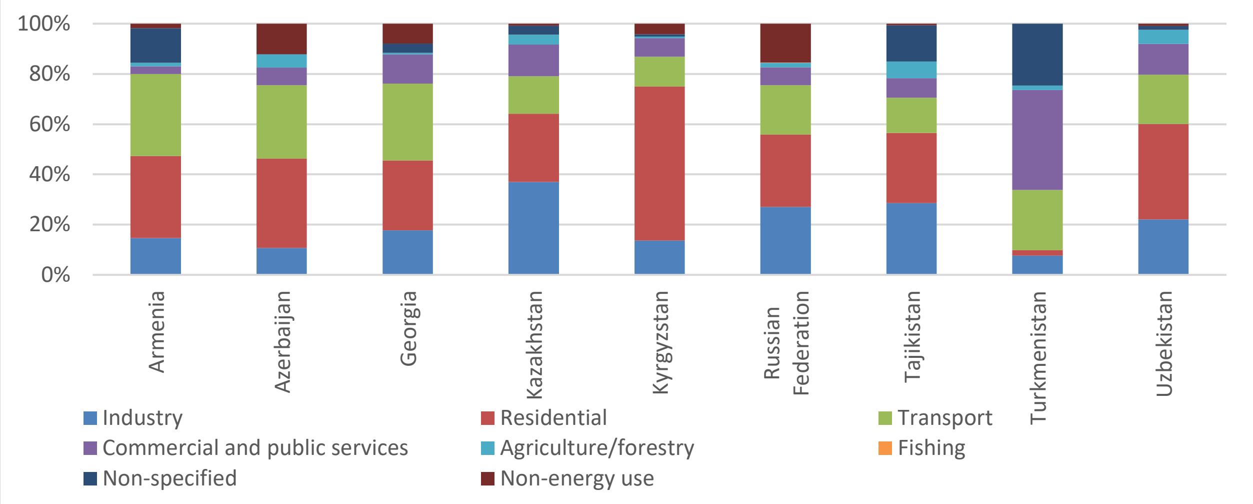
The general trend over the past decades shows that the output of oil and natural gas production has been declining due to the subregion's commitment to diversify energy sources, reduce the overreliance on hydrocarbon resources and embark on a more sustainable path of development. However, oil and gas production has rebounded over the past few years. Both Kazakhstan and Uzbekistan are planning to increase oil and gas production to stimulate the domestic petrochemical and refining industry,[9] since processing oil and gas is more profitable and efficient than direct exports of oil and gas products, especially considering the constraints of logistics, limited availability of pipelines and fluctuations in market prices. Developing a more sophisticated domestic petrochemical and refining industry will also help countries to realize energy security objectives.

North and Central Asian countries have been developing their renewable energy capacity and are introducing renewable energy sources into the energy mix. The development of renewable energy has several factors. First, hydropower accounts for the largest proportion of renewable energy in the subregion. Hydropower is a conventional source of energy for many of the countries. In comparison, the development of other sources of renewable energy remains insignificant. Second, technical constraints limit the integration of renewable power into existing distribution networks. Supporting the development of infrastructure and technological expertise requires significant investments and improvements to fully realize the benefits of renewable energy production. Third, a large share of renewable energy potential remains untapped in the region, as elaborated in section 2.1.1. As countries transition towards a low-carbon development pathway, it is necessary to develop diverse sources of renewable energy that complement the current energy mix and satisfy energy needs during any season.

Energy consumption in the subregion declined sharply between 1990 and 1995. It significantly increased in the years that followed as the regional economy started to pick up after the period of recession. As of 2018, growth in industry, residential needs and transport use have driven the increase in energy consumption, as shown in figure 4.

[9] See www.ispionline.it/en/pubblicazione/future-energy-central-asia-24063.

Figure 4: Total final consumption by sector, 2018



Source: International Energy Agency
Notes: Non-energy use includes energy products used as raw materials in the different sectors that are not consumed as a fuel or transformed into another fuel.

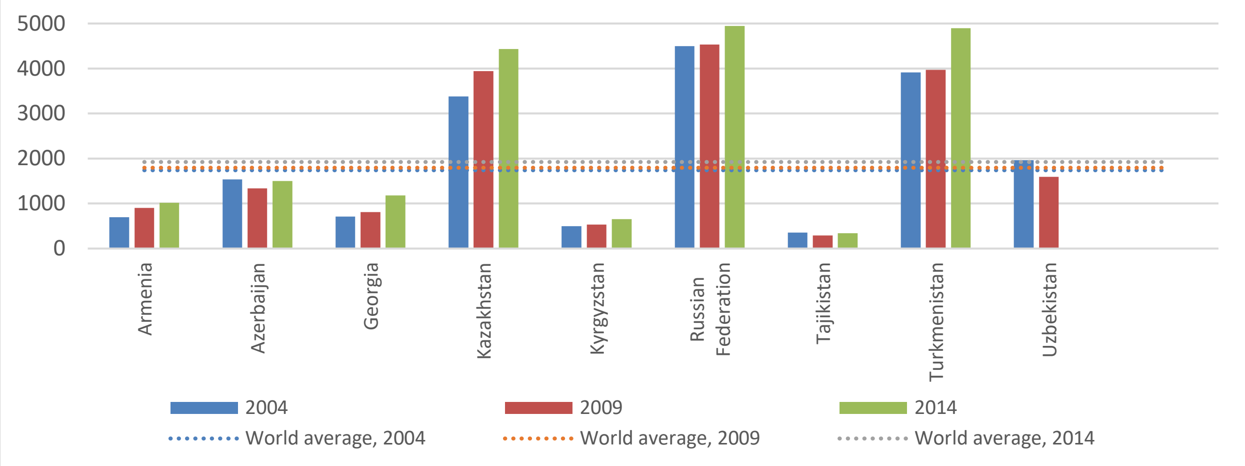
The growth in industry in the subregion, mainly extractive industries, is energy-intensive and explains the high energy consumption. The residential sector, which heavily relies on centralized heating systems, consumes a lot of energy. The large proportion of residential energy consumption in Kyrgyzstan is mainly due to the poor energy performance of existing residential buildings, the majority of which are multi-apartment buildings built between the 1960s and 1980s.[10] Transport use has accounted for a large share of energy consumption in the subregion over the decades. As landlocked countries, they have heavy reliance on freight transport.

COVID-19 has impacted economies in the subregion and changed energy consumption patterns. In the early phases of the pandemic, there was a decrease in energy consumption in the transport and industrial sectors due to the implementation of lockdown measures. At the same time, residential energy consumption witnessed an increase. The decrease in global energy demand prompted by lockdown measures affected the prices of coal and oil, which are key energy exports for some North and Central Asian countries. Energy consumption rates recovered as economies and societies gradually adjusted to changing conditions during the pandemic. It is unclear whether the impact of COVID-19 on energy consumption patterns and prices also caused a change in the share of different energy sources, given that there is no official data on changes in energy mix in North and Central Asia in 2020.

The energy consumption pattern in the region is not sustainable. Most countries exhibit high energy use per capita and a high rate of energy consumption growth compared to the world average, as shown in figure 5. The economic structure led by the mining and quarrying industry, losses in energy transmission and distribution, and energy overconsumption are the key factors underlying this phenomenon.

[10] Based on summary report "Keeping warm: urban heating options in the Kyrgyz Republic". Available at http://documents1.worldbank.org/curated/en/555021468011161504/pdf/97409-WP-P133058-Box391503B-PUBLIC-Heating-Assessment-for-Kyrgyz-P133058-Final.pdf.

Figure 5: Energy use per capita, 2004–2014



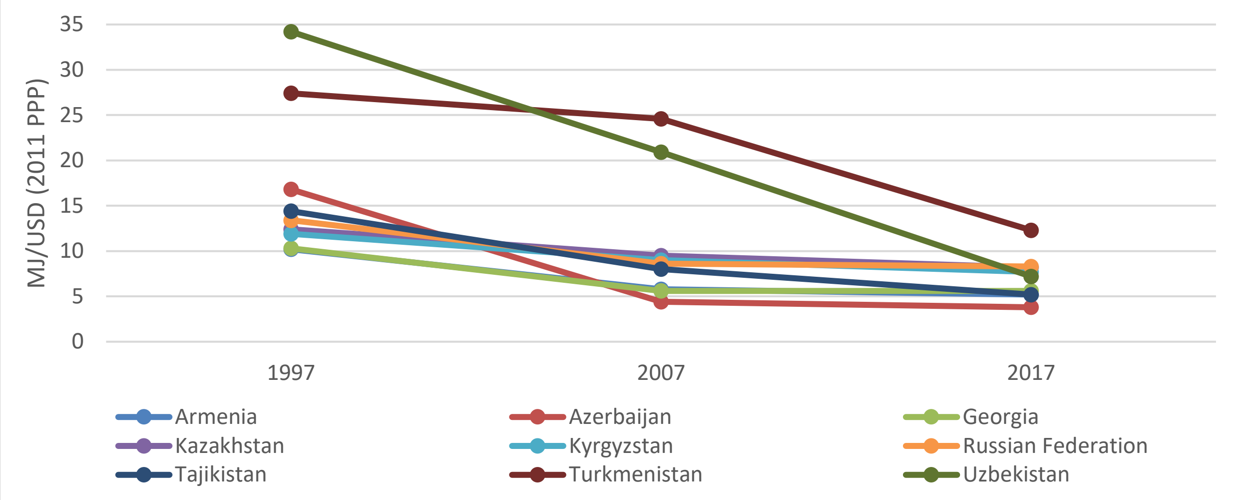
Source: World Development Indicators.

Despite high energy use per capita, huge gaps exist in access to energy services in urban and rural areas, with most rural residents having no access to central heating or the natural gas network. For residents covered by energy services, energy stability is still a major concern given limitations in infrastructure and seasonal energy supply patterns. Energy efficiency needs to be improved, especially in the main energy-consuming sectors mentioned above.

2.2.2 Energy transition

Energy transition is a priority for many North and Central Asian countries. The current energy landscape is reliant on outdated infrastructure, conventional energy sources and limited subregional cooperation, and different areas require changes to achieve successful energy transition. As of 2017, the average subregional energy intensity stood at 7.06 megajoules per one unit of economic output produced, significantly higher than the world average of 5 megajoules per one unit of economic output produced. As seen in figure 6, although there is a decreasing trend in energy intensity in North and Central Asia, energy intensity levels between 2007 and 2017 have remained stagnant for most of the countries. Annual improvements in energy intensity in the subregion are inadequate to achieve SDG target 7.3, which requires an average improvement in annual energy intensity of 2.6 per cent (IEA, 2020a). Energy transition strategies need to be in place for countries to achieve the targeted improvements in energy use, taking into consideration the supply and demand of energy, as well as the social and environmental aspects of energy access and the disruption of social and ecological balances.

Figure 6: Energy intensity in North and Central Asia, 1997–2017



Source: International Energy Agency.

Economic aspects

To assess the economic dimension of energy transition, countries need to consider how the current price and subsidy structure of energy and electricity impacts supply and demand. Cheap and readily available hydrocarbon sources are a disincentive for energy transition. In North and Central Asia, many resource-rich countries grant favourable tax benefits for oil and gas producers, especially for export-oriented production. In comparison, subsidies and incentives for renewable energy production have been exercised to a limited extent and have largely focused on the conventional source of hydropower.

In the subregion, subsidies for electricity consumption and heating mainly aim to address the social concerns of affordability and access. Many of the North and Central Asian countries offer high fossil fuel subsidies and set electricity tariffs at below cost-reflective levels, especially Central Asian countries, creating an uneven playing field for renewable energy on the electricity market. This measure creates obstacles to generating necessary revenues for the maintenance and upgrading of infrastructure and services, leading to network breakdowns and limited availability of heating and electricity, especially in winter. This vicious cycle prevents countries from achieving the objective of ensuring access to affordable electricity and heating. Energy subsidies have also led to domestic overconsumption. Aside from residential consumption, energy-intensive industries also greatly benefit from the reduced tariffs. The heavy metal industries of chemical, steel, aluminium and power – which consumes just under 10 billion cubic metres of natural gas per month in Azerbaijan – all enjoy subsidized prices for natural gas. It is estimated that annual energy subsides for natural gas in Azerbaijan amounted to US$634 million in 2017, an increase from US$487 million in 2015 (IRENA, 2019). Energy overconsumption is also a problem in Turkmenistan where consumers have free access to electricity and heating up to a certain level of consumption. As the country seeks to transition towards more sustainable energy pathways, the Government is taking steps to phase out these subsidies.

Social aspects

All countries in the subregion have achieved universal access to electricity, except for Tajikistan (about 0.8 per cent of population still do not have access to electricity).[11] However, obtaining a permanent electricity connection can still be a lengthy process. The subregional average for time required to get electricity is 74 days.[12] This is mainly attributed to bureaucratic procedures which require much back-and-forth between customers and utility providers. With the trend of digitalization and e-governance in the subregion, governments and utility providers can leverage digital technologies to enhance efficiency and reduce the cost of utility service provision. In certain areas, delays occur when utility providers do not have readily available materials to provide electricity connection. Azerbaijan and the Russian Federation have the shortest duration in the subregion – approximately 41 days – to obtain electricity connection.

One of the recurring problems in energy and electricity supply for the subregion is electrical outage. Uzbekistan recorded one of the highest losses of value due to electrical outages in the subregion at 3 per cent of sales value in 2019, though the country already made significant improvements from 6.7 per cent of sales value lost in 2013. The problem of energy outages and accessibility is a burden especially for rural residents. The development of off-grid renewable energy sources, especially in rural areas, can help overcome the problem of electrical outages due to infrastructure limitations and improve access to electricity and heating. A just transition to renewable energies can also lead to the creation of jobs across the value chain. Expanding renewable energy capacities beyond hydropower will stimulate employment opportunities, and this highlights the need for countries in the subregion to further build the skill base available to facilitate the transition to renewable energies. Moreover, the global percentage of women working in the renewable energy sector (32 per cent) is already higher than the fossil fuel sector (22 per cent) and is expected to keep rising and improve gender equality in the job sector (IRENA, 2020b).

Environmental aspects

Currently, electricity production in North and Central Asia mainly relies on conventional sources, such as coal, natural gas, oil, hydropower and nuclear power. Electricity production from conventional energy sources comes with environmental challenges. The pollution and waste emitted throughout the production cycle of hydrocarbon resources motivate countries to explore cleaner sources of energy. In 2017, the subregion is estimated to have emitted 1.5 billion tons of carbon dioxide from hydrocarbon fuel sources.[13] Air pollution continues to plague the subregion, especially in urban areas in the winter months. The extractive industry also consumes a lot of water and leaves behind chemical waste that causes water pollution and habitat destruction. Although not a key energy source for most of the North and Central Asian countries, nuclear power development needs to be approached with caution given the disastrous impact of nuclear power plant meltdowns, notably in Chernobyl and Fukushima. The radioactive waste produced must be treated properly to prevent environmental contamination.

[11] Based on 2018 data from the World Development Indicators Database, World Bank.

[12] Based on 2019 data from the Asia Pacific Energy Portal, UN ESCAP.

[13] Based on 2017 data from the Asia Pacific Energy Portal, UN ESCAP.

Although hydropower is considered a clean and renewable source of energy and is widely used in North and Central Asia, there are environmental side effects throughout the lifecycle of a hydropower plant. The legacy of large-scale hydropower plants in the subregion has raised environmental and geopolitical concerns. The three main environmental concerns when constructing large-scale hydropower plants are the destruction of biodiversity, alteration of landscape and greenhouse gas emissions from reservoirs. A study on the characteristics of hydropower plants and dam development in South Caucasus showed that business as usual practices for hydropower plants and dam construction fell short in ecosystem management and environmental impact assessments were weak.[14] Additionally, given the transboundary nature of water and its importance in the landlocked countries of North and Central Asia, construction of dams for power generation creates trade-offs and tensions between upstream and downstream countries. The Rogun Dam in Central Asia is an example of this.

Climate change is a wake-up call for countries to do more to accelerate the transition to sustainable and clean energy. The energy sector is the biggest emitter of carbon dioxide in the subregion. As countries commit to decarbonize their economy, the energy transition strategies need to be in line with international and regional frameworks and agreements. Goal 7 of the 2030 Agenda outlines targets for ensuring access to affordable, reliable, sustainable and modern energy which can be adapted to contexts of North and Central Asian countries.

Countries in the subregion need to diversify away from conventional energy sources to achieve energy security and ensure energy accessibility. The development of new energy projects – whether they are renewable or non-renewable – must take an integrated assessment approach to ensure sustainability.

2.3 Energy trade, financing and investment

2.3.1 Energy trade and key trading partners

Energy trade is a key aspect shaping the subregional energy landscape in North and Central Asia. The Central Asia Leaders Consultative Summit in recent years recognized the importance of subregional cooperation for energy matters, calling for expanding opportunities of energy trade and developing modern energy infrastructure.[15] With complementary energy capacities in the subregion, expanding energy trade can bring cost efficiencies which can free up capital for needed investments in renewable energy development. This can potentially bring about energy efficiency gains in both renewable and non-renewable energy while supporting energy transition strategies in the subregion. Subregional energy trade infrastructure will lay a good foundation for further integration with other energy markets in neighbouring countries.

Significant intraregional energy trade is already happening, although it is largely limited to non-renewable energy sources. The Russian Federation is a key market for oil and gas in the subregion, serving the rest of the countries in the subregion. Turkmenistan is also a key supplier of oil products for Azerbaijan, Georgia and Uzbekistan, while Uzbekistan is a key supplier of natural gas to Kazakhstan and oil products to Kyrgyzstan.

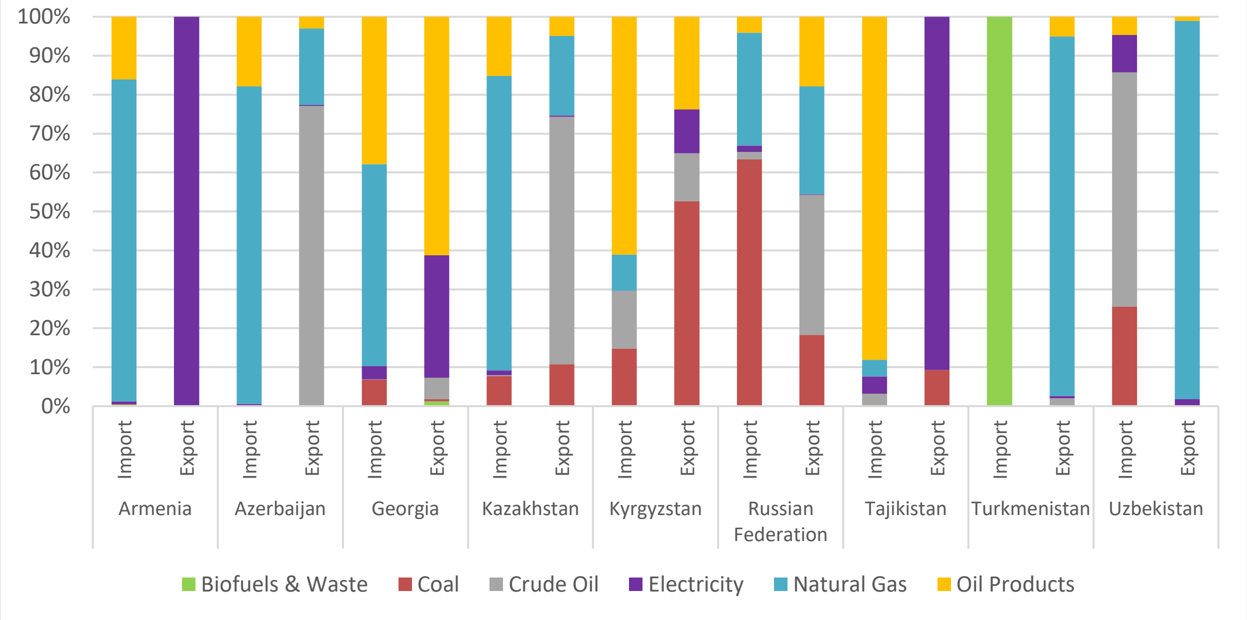
[14] Towards sustainable dam and hydropower in the South Caucasus, https://wwfint.awsassets.panda.org/downloads/towards_sustainable_dam_and_hydropower_1.pdf.

[15] The Central Asia Leaders Consultative Summit brings together leaders of Central Asian countries to have a regular platform for dialogue and to discuss focus areas for regional cooperation.

As of 2019, intraregional energy trade accounted for approximately US$7.6 billion.[16] However, infrastructure and mechanisms for intraregional energy trade can still be significantly improved, which can then generate spillover effects to other aspects of sustainable development such as increasing access to electricity and generating economic gains. The World Bank (2016) indicated that energy trade among Central Asian countries could be more efficient with unrealized benefits of up to US$5.2 billion during 2010–2014. North and Central Asian countries also have significant energy trade relationships with countries from other subregions. Armenia and Azerbaijan import significant amounts of natural gas from Iran, whereas China is a key export market of coal, crude oil and natural gas for the Russian Federation, Kazakhstan and Kyrgyzstan.

North and Central Asian countries trade a range of energy products (figure 7). Natural gas is the main energy import for the South Caucasus countries and Kazakhstan, whereas the less resource-endowed countries in Central Asia – Kyrgyzstan and Tajikistan – import a larger share of oil products. The subregion has a Herfindahl-Hershman Index value for crude oil and natural gas imports of 0.6–0.7 for the years 2018–2019, indicating a slight dependence on these imports and exposure to energy vulnerability. Disparities should also be noted, as some countries have greater wealth than others in certain energy products, hence they differ in energy import dependence. The Herfindahl-Hershman Index value for coal imports is above 0.9 for Azerbaijan, Georgia, Kazakhstan and Kyrgyzstan. Countries may diversify the energy product mix by developing the market for renewable energy.

Figure 7: Energy trade by product in North and Central Asian countries, 2018



Source: ESCAP based on data from the International Energy Agency, World Energy Statistics and Balances.

[16] Author calculations based on data available on the Asia Pacific Energy Portal.

The implications and sensitivities of energy prices, geopolitical influences, resource intensity and environmental commitments all impact energy trade in North and Central Asia. International price volatility in commodity markets is expected to continue, and this does not bode well for countries in the subregion which are dependent on the contribution of energy exports to the fiscal and trade balances of their economies. The decrease in oil prices in 2020, which coincided with the onslaught of COVID-19, severely tightened the fiscal space for oil-exporting countries in the subregion. An example of this is Azerbaijan, which was forced to revise its 2020 budget to reflect lower oil prices.[17] Despite the positive outlook for energy reserves in the subregion, international commitments towards more carbon-conscious choices of energy products signals a shift towards new energy production methods that may render countries in the subregion at a disadvantage in the longer term. Significant investments and collaboration will be required to develop technical and industrial capacities in the subregion to sail with the winds of change.

2.3.2 Financing and investment for energy development

The development of the energy sector in North and Central Asia has mainly relied on public sector financing and focused on the development of extractive industries. Extractive industries and mining are estimated to contribute a significant part of the gross domestic product (GDP) in countries such as Kazakhstan, the Russian Federation and Turkmenistan. In addition to public financing, extractive industries in resource-rich countries are primary beneficiaries of foreign direct investment.

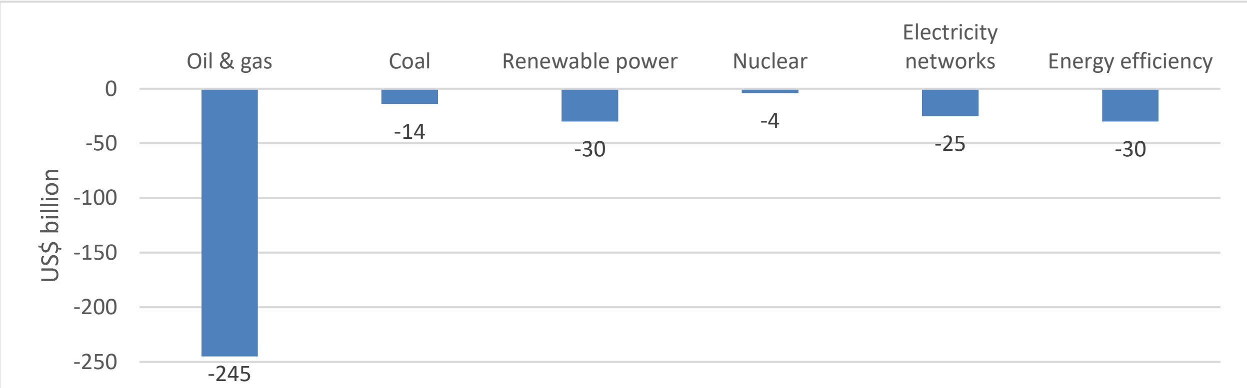
For example, between 2013 and 2017 investments in coal, oil and natural gas in Kazakhstan accounted for 49.5 per cent of total investments while only 2.2 per cent was directed to the renewable energy sector. Public-private partnerships are a key tool for energy development, especially in Kazakhstan and the Russian Federation where investments in the energy sector with private participation were valued at US$553.6 million and US$652.31 million, respectively, in 2019. However, disruptions in energy prices and investments, especially in the oil and gas industries, pose a risk to economies in the subregion. This was demonstrated recently by the impact of COVID-19. Global energy investments were estimated to decrease by 20 per cent in 2020, one of the largest declines in global energy investment on record (IEA, 2020). As seen in figure 8, the oil and gas sectors are expected to be the most affected, with an estimated decrease in investment value of US$245 billion.

These recent developments highlighted the urgent need for energy transition in North and Central Asia. For the years 2015–2050, a global cumulative investment to transform the energy sector is estimated at US$110.431 trillion, to improve energy efficiency, develop renewable energy and maximize the effectiveness of energy supply (IRENA, 2020a). In the subregion, countries have actively attracted investments to develop renewable energy. Amid increasing interest to attract foreign investment to develop the renewable energy sector, it is important that North and Central Asian countries can facilitate technology transfer and develop domestic technology capacity.

[17] Based on “Policy Responses to COVID-19”, www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19.

Energy transition needs to be complemented by financing and investment strategies that focus more on sustainable energy development. At the current rate, investments in the energy sector are inadequate to meet the projected needs and scenarios for sustainable development. In the subregion, countries have been exploring new modes of financing for energy development projects based on green energy transformation strategies. In the South Caucasus, the Sustainable Energy Finance Facility was initiated in 2013 to provide loans for energy efficiency projects and renewable energy investments through respective national partners. Projects funded by the Facility are estimated to have contributed to energy savings of approximately 227,630 kWh per year.[18] The Astana International Financial Center and its initiative to develop the Green Financial Center is redirecting investments towards sustainable energy development. These initiatives show the important role of regional and international developmental cooperation in contributing to successful energy transition by breaking down barriers in access to finance and overcoming limitations in technical expertise.

Figure 8: Estimated change in energy investment in North and Central Asia by sector, 2019–2020



Source: International Energy Agency.

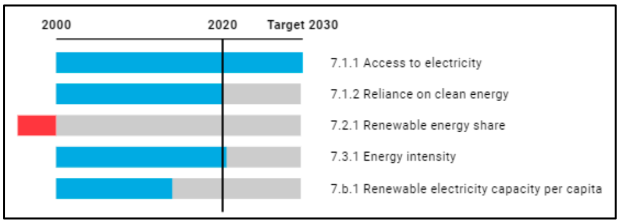
[18] Details of the Caucasus Sustainable Energy Financing Facility is available at https://ebrdgeff.com/seff_facilities/georgia-commercial/.

3. Analysing clean energy and sustainable development

AFFORDABLE AND CLEAN ENERGY (GOAL 7) IS EXPLICITLY INCLUDED IN THE 2030 AGENDA.

In North and Central Asia, accelerated actions are required for the subregion to achieve SDG 7 by the year 2030. Looking into the different indicators of Goal 7 as shown in figure 9, the subregion is on track to achieve target 7.1 to ensure universal access to energy services and target 7.3 to improve energy efficiency. However, overall progress in the subregion conceals challenges different countries are facing. Seasonal energy shortages and outages are still common occurrences. Obsolete power infrastructure and unsustainable energy production and consumption patterns give rise to high energy intensity. Urgent action is required to reverse the regressing trend in the share of renewable energy. There is clearly room for improvement.

Figure 9: Progress toward SDG 7 indicators in North and Central Asia



Source: Asia Pacific SDG Gateway.

3.1 Interlinkages of sustainable and clean energy

The 2030 Agenda consists of 17 goals which are highly interlinked with one another in ways that can be positive or negative, direct or indirect, significant or insignificant. To better understand the interlinkages between the indicators of affordable and clean energy with the other SDG indicators, a preliminary analysis was conducted to map out the synergies and trade-offs of Goal 7. The method used to identify the interlinkages of Goal 7 is based on the framework developed by Zhou and Moinuddin for the SDG interlinkages analysis and visualisation tool.[19] Methodological notes are included in the Appendix.

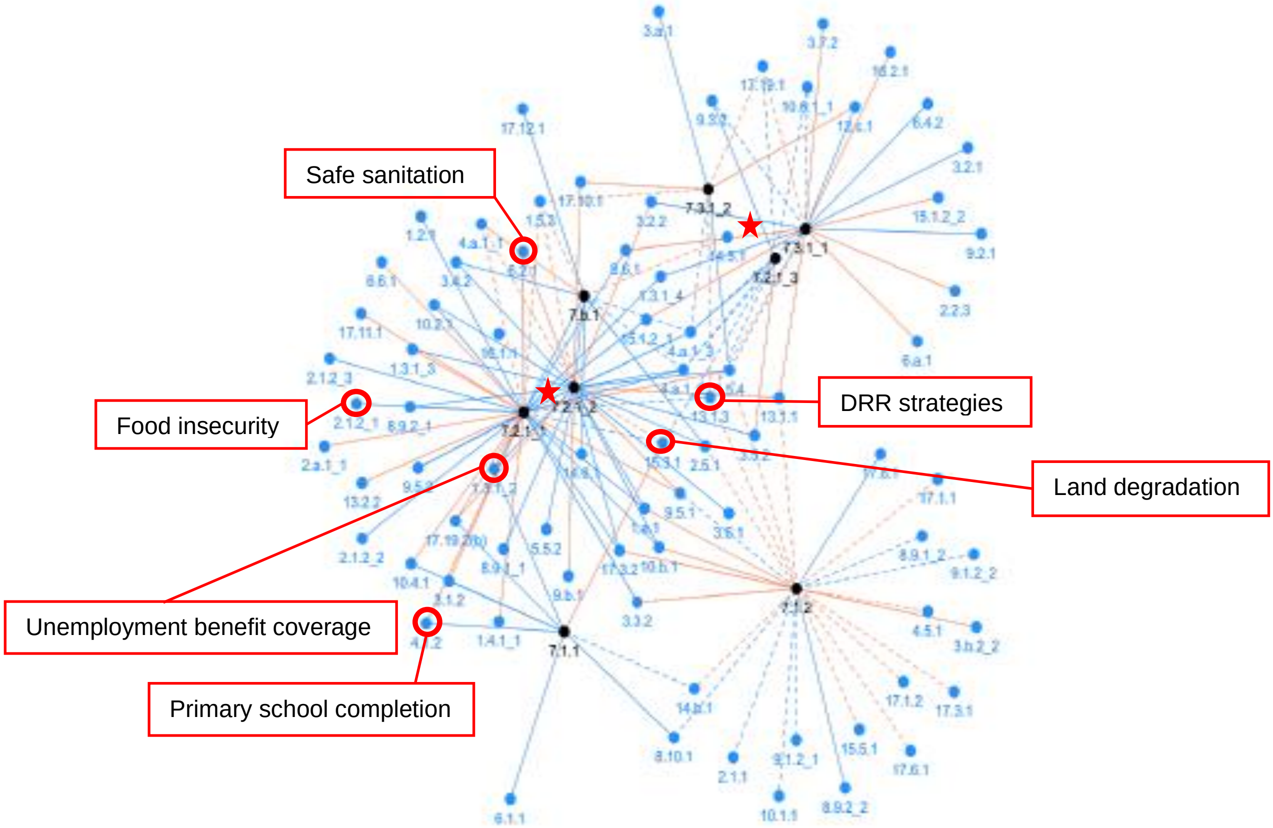
3.1.1 Synergies and trade-offs between clean energy and the 2030 Agenda

Figure 10 provides a vivid visualization of the network of correlations between Goal 7 indicators and other SDG indicators. Nodes coloured in black are Goal 7 indicators, including total electricity access (7.1.1), access to clean fuel (7.1.2), share of renewable energy consumption (7.2.1_1), renewable energy consumption in petajoule (7.2.1_2), growth of renewable energy consumption in petajoule (7.2.1_3), energy intensity (7.3.1_1), growth of energy intensity (7.3.1_2), and growth of renewable energy capacity in megawatt (7.b.1). Nodes coloured in blue are other SDG indicators apart from Goal 7.

[19] The tool and methodology are available at https://sdginterlinkages.iges.jp/methodology.html.

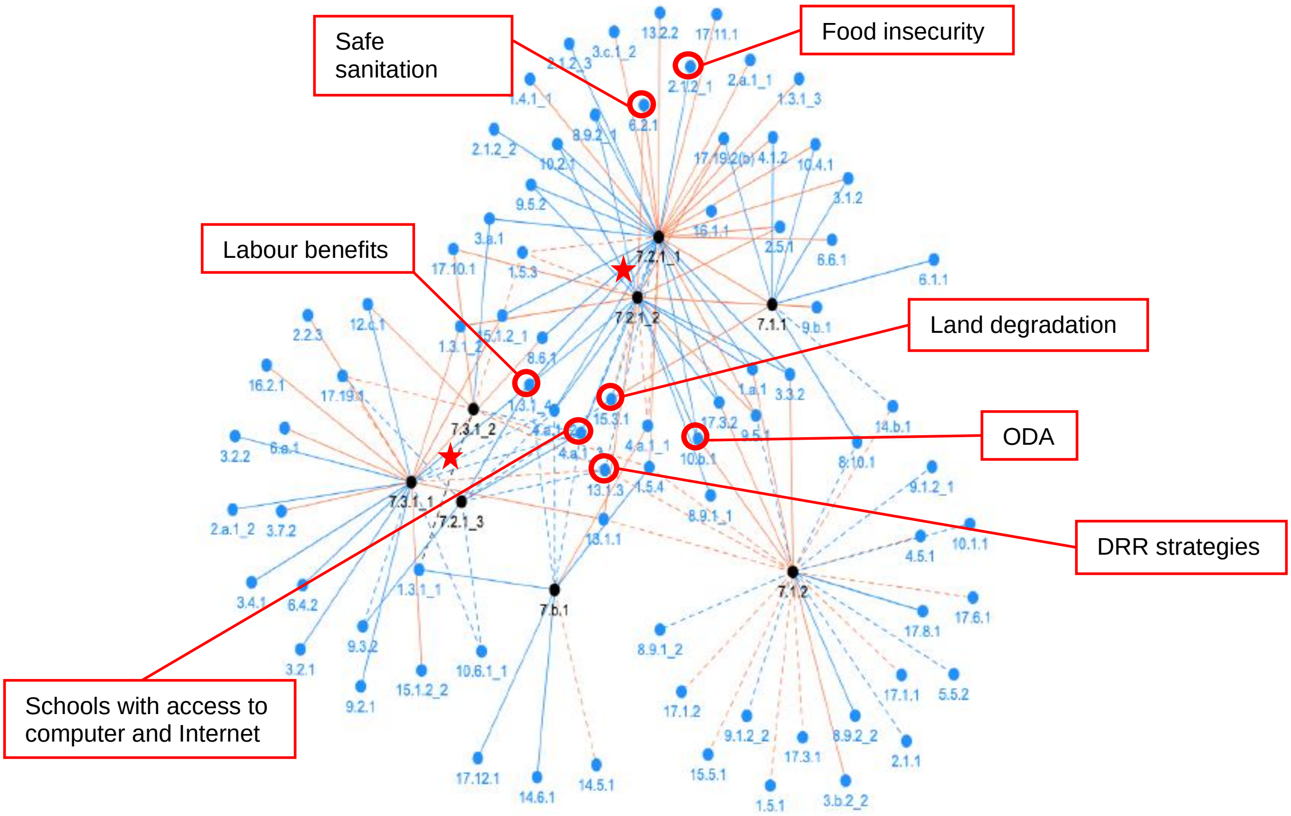
Edges (lines connecting the nodes) correspond with the correlation coefficients between Goal 7 indicators and other SDG indicators. Edges are distinguished by colour and line patterns. Edges coloured in blue indicate positive correlation, while edges coloured in red indicate negative correlation. Solid edges indicate the correlation coefficients are significant at 95 per cent confidence level, while dashed edges indicate insignificant correlation. As mentioned previously, only edges with correlation coefficients larger than 0.5 are mapped in this network. The network structure can visualize important interlinkages with Goal 7, identify priority SDG targets and ensure that the achievement of Goal 7 is aligned with sustainable development objectives in the subregion.

Figure 10: Interlinkages of Goal 7 in North and Central Asia



The analysis of all countries in North and Central Asia (figure 10), shows that Goal 7 indicators are highly correlated with no poverty (Goal 1), zero hunger (Goal 2), quality education (Goal 4), clean water and sanitation (Goal 6), climate action (Goal 13) and partnerships for the goals (Goal 17). The signs of the coefficients are also consistent with initial expectations. As seen from figure 11, most of the nodes and edges are clustered around indicators 7.2.1 and 7.3.1, indicating a larger number of correlations with other SDG indicators. The edges exhibit similar colours and line patterns for each of the subindicators since the subindicators are simply different forms of base data. Access to electricity is positively correlated with the unemployment benefit coverage rate, primary school completion rate, share of population using safely managed drinking water and access to financial services, and it is negatively correlated with the degree of land degradation. The share and volume of renewable energy consumption is positively correlated with unemployment benefits and the coverage rate of social assistance programmes, percentage of researchers, development assistance and investment and volume of remittances, and they are negatively correlated with the neonatal mortality rate, greenhouse gas emissions, deaths and injuries from natural disasters, and worldwide average weighted tariffs. Energy intensity is positively correlated with the proportion of manufacturing value added and amount of fossil fuel subsidies, and it is negatively correlated with the share of freshwater and land area protected. Among the Goal 7 indicators, renewable energy consumption and capacity are positively correlated.

Figure 11: Interlinkages of Goal 7 in North and Central Asian countries, excluding the Russian Federation

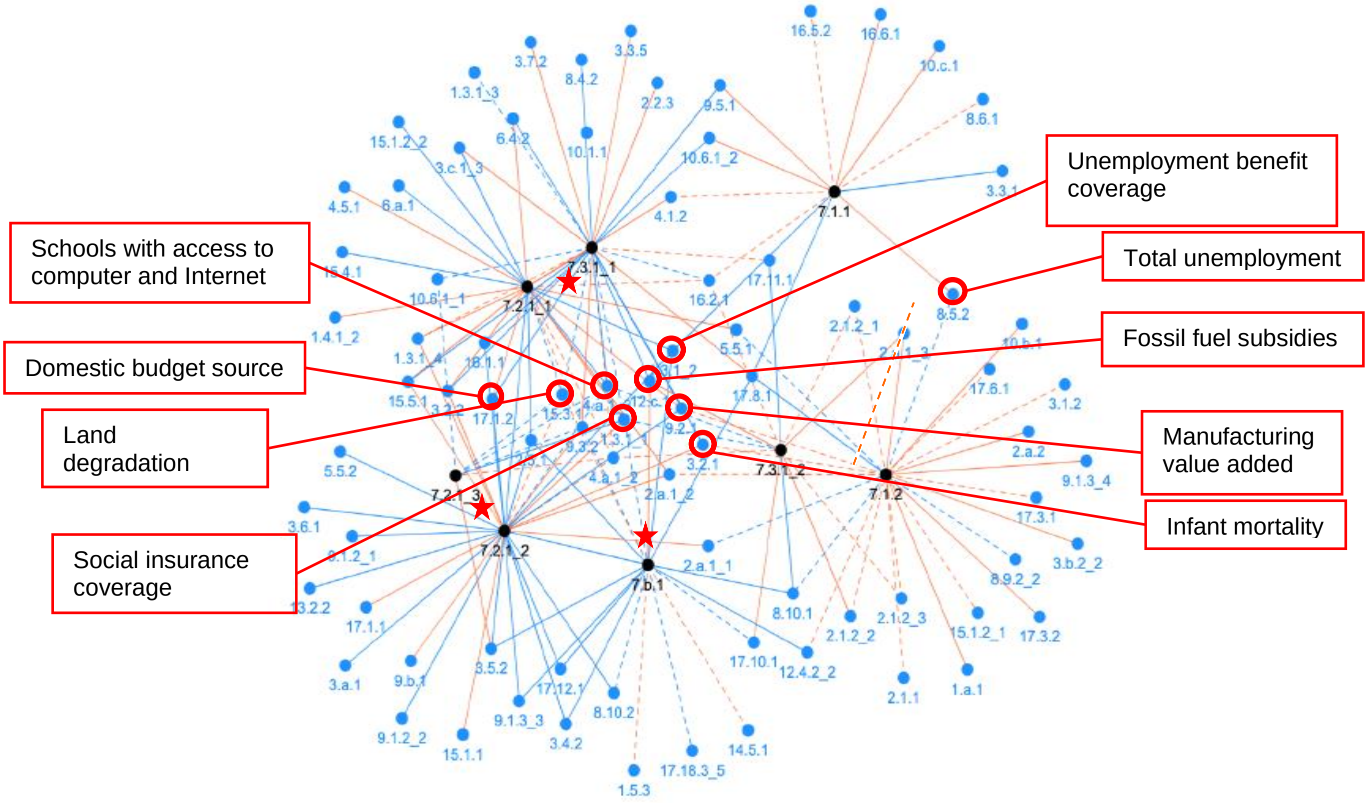


The analysis of the North and Central Asian subregion excluding the Russian Federation (figure 11) shows that Goal 7 indicators are highly correlated with no poverty (Goal 1), zero hunger (Goal 2), quality education (Goal 4), reduced inequalities (Goal 10) and climate action (Goal 13). This is largely aligned with the correlation results of the analysis on the whole subregion.

The specific interlinkages between indicators also reflect a similar pattern. Access to electricity is positively correlated with quality education, access to safely managed drinking water and access to financial services, and it is negatively correlated with land degradation. It also shows a positive correlation with birth attended by skilled health personnel and labour share of GDP (comprising wages and social protection transfers).

Renewable energy consumption shows a positive correlation with the labour programme coverage ratio, percentage of researchers and volume of remittances, and it shows a negative correlation with deaths and injuries from natural disasters. Besides, there are positive relationships between renewable energy consumption and food insecurity, schools with access to computers and the Internet, the contribution of tourism to GDP and sustainable tourism jobs. Energy intensity shows a positive correlation with the neonatal and infant mortality rate, levels of freshwater stress and manufacturing value added, and it shows a negative correlation with youth unemployment, share of land and freshwater protected and world average weighted tariffs. Growth of renewable energy capacity is positively correlated with social assistance and the coverage of labour programmes.

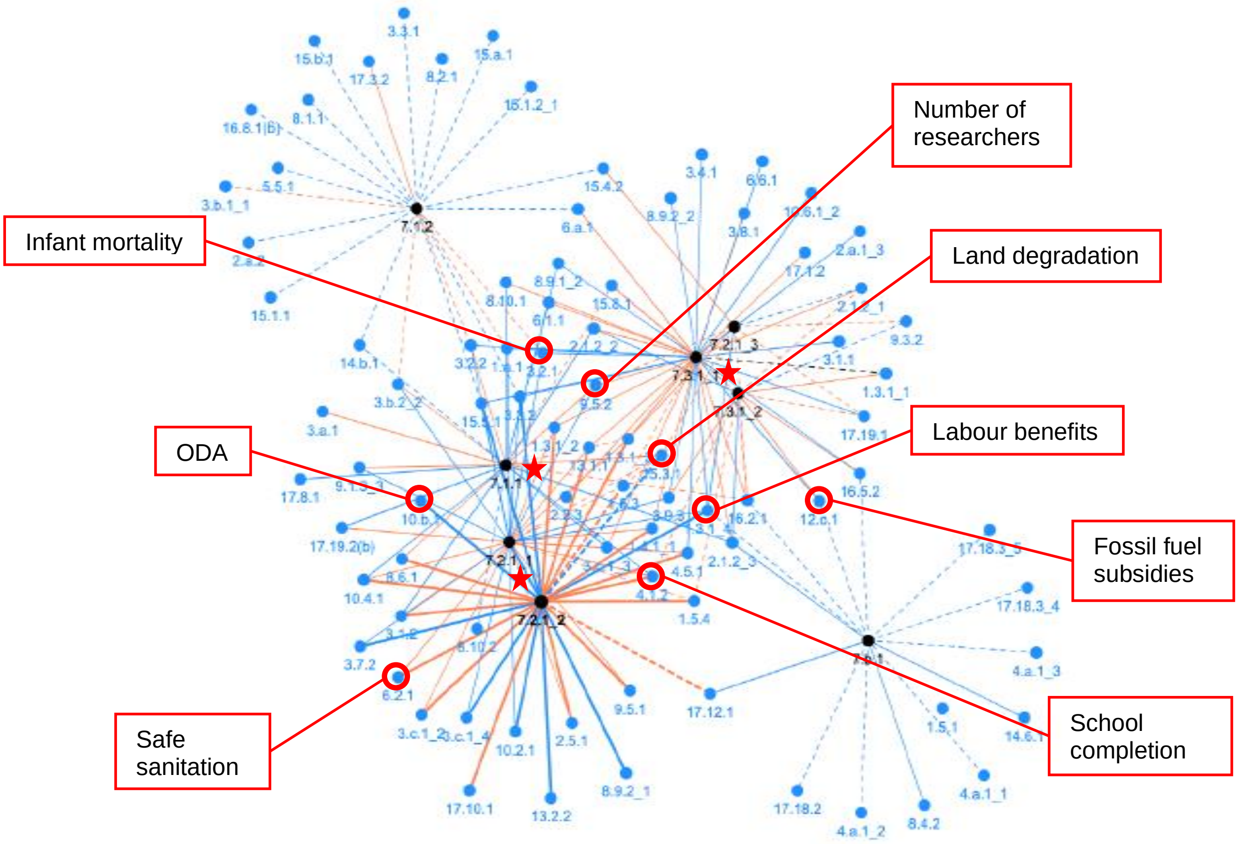
Figure 12: Interlinkages of Goal 7 in resource-rich countries of North and Central Asia (Azerbaijan, Kazakhstan, the Russian Federation, Turkmenistan and Uzbekistan)



Among resource-rich countries (figure 12), edges out of nodes 7.2.1, 7.3.1 and 7.b.1 are highly intertwined with each other, and most of them show significant correlation. Goal 7 indicators are highly correlated with no poverty (Goal 1), good health and well-being (Goal 3), quality education (Goal 4), industry, innovation and infrastructure (Goal 9), responsible consumption and production (Goal 12) and partnerships for the goals (Goal 17). The mapped interlinkages overlap with those for the whole subregion to a large extent, and the main differences will be elaborated upon.

Apart from the positive correlation with indicators of Goals 1 and Goal 4, there is also a positive relationship between access to electricity and the number of Internet users, and there are negative relationships with total unemployment and remittances costs. Positive relationships can be found between renewable energy consumption and the unemployment benefit coverage rate, passenger and freight volumes and land protection. Negative relationship can be found with the proportion of domestic budget funded by domestic taxes. Apart from indicators of Goal 9 and Goal 12, energy intensity is also positively correlated with domestic material consumption per GDP and access to financial services, and it is negatively correlated with health and well-being. Growth of renewable energy capacity is positively correlated with air freight volumes and hazardous waste generation, and it is negatively correlated with fossil fuel subsidies. Among the Goal 7 indicators, renewable energy consumption is negatively correlated with energy intensity, and it is positively correlated with renewable energy capacity.

Figure 13: Interlinkages of Goal 7 in hydro-reliant countries of North and Central Asia (Armenia, Georgia, Kyrgyzstan and Tajikistan)



The network for hydro-reliant countries in North and Central Asia (figure 13) shows high image density around nodes 7.1.1, 7.2.1 and 7.3.1. Goal 7 indicators are highly correlated with no poverty (Goal 1), good health and well-being (Goal 3), industry, innovation and infrastructure (Goal 9) and life on land (Goal 15). Apart from Goal 1 and Goal 4, access to electricity is also positively correlated with births attended by skilled health personnel and dentistry personnel density, and it is negatively correlated with youth unemployment and land degradation. Renewable energy consumption is positively correlated with the number of researchers, air transport passengers carried, and development assistance and investment, and it is negatively correlated with deaths and injuries from natural disasters and the world average weighted tariff. Energy intensity is positively correlated with fossil fuel subsidies and negatively correlated with food insecurity.

The interlinkage patterns of network structure have overlapping patterns for the four different country groupings. Viewing Goal 7 indicators as the central nodes, the strongest significantly correlated indicators are those of Goal 1, Goal 4, Goal 9, Goal 13 and Goal 17, with each node connected to more than two indicators of Goal 7.

Among the indicators of Goal 7, access to electricity is highly correlated with poverty elimination, access to quality education and life above land. Renewable energy consumption is highly correlated with health and well-being, innovation and infrastructure, remittance costs and volume, and international partnerships and assistance. Energy intensity is highly correlated with manufacturing value added, responsible consumption and production, and land and animal protection. Edges connected to access to clean fuel and growth of renewable energy capacity are mostly insignificant and this result may be caused by the bias of using historical data only.

Figure 14: Interlinkages of Goal 7 for different country groups

Reviewing the different country groupings, results for the whole subregion with or without the Russian Federation are similar. Goal 7 has strong interlinkages with Goal 1, Goal 4, Goal 9 and Goal 13, although the whole subregion also has a correlation between Goal 7 and Goal 17. Results for resource-rich countries and hydro-reliant countries identified several distinct interlinkages. In addition to the strong significant correlation with the goals mentioned in the above paragraph, resource-rich countries also have strong interlinkages with Goal 3 and Goal 12, while hydro-reliant countries have strong interlinkages with Goal 9 and Goal 15.

The network mapping revealed that Goal 7 is highly correlated with the other SDGs in North and Central Asia. These interlinkages can guide countries in the subregion to prioritize sustainable and clean energy in development strategies and accelerate the achievement of other SDGs in the process.

3.2 Relationship between clean energy and sustainable development

The relationship between sustainable energy-related indicators (renewable energy consumption, electricity access, hydropower production) and other SDG indicators as inspired by the network analysis is selectively performed. For this, a panel data regression is employed controlling for country and time fixed effects.

$$SDG_{it}=c_0+c_1 E_{it}+cov_{it}+\mu_{it}+\tau_{it}+\epsilon_{it}$$

where SDG_{it} = SDG indicator, E_{it} = sustainable energy-related indicators, cov_{it} = covariates, μ_{it} = country fixed effects, τ_{it} = time fixed effects, ϵ_{it} = error term. Further descriptions of each variable and the detailed methodology are elaborated in the Appendix.

For the analysis, an unbalanced panel data set was used covering North and Central Asian countries for the period 1990–2019.[20] The Russian Federation is exempted from this panel to make the grouping economically, geographically and socially more homogenous.

Based on the conceptual framework and methodology, several combinations of data series have been used to identify possible determinants of sustainable and clean energy in North and Central Asia. The relative value of renewable energy consumption, hydropower generation, electricity access and energy intensity are used here to measure sustainable and clean energy. Table 1 shows the results of the panel regression analysis.

[20] Data availability varies for each variable.

Table 1: Results of analysing the determinants of sustainable and clean energy

	CO2 kg/GDP	Safe water access	Electricity access	National poverty	Undernourish-ment	GDP per capita
Renewable energy consumption (%)	**-0.01155*** (0.00194)**		0.01308 (0.01952)			**0.00954** (0.00389)**
Hydropower (% total generation)		**-0.32868* (0.15236)**			**-0.31450** (0.11502)**	
Electricity access (%)				**-1.07874* (0.52838)**		
Energy intensity	**0.04126*** (0.00224)**					
Intraregional energy trade			-0.00087 (0.00433)			
Fossil fuel rents (% GDP)			**0.00758* (0.00384)**			
ln GDP per capita		-1.77080 (4.09843)	**0.97488** (0.33662)**	6.21359 (3.30868)	-4.22782 (2.84430)	
Agriculture value added (% GDP)			-0.00095 (0.01328)			
Trade (% GDP)						**-0.00500** (0.00183)**
ODA (% of gross capital formation)						**0.00290** (0.00110)**
Governance Index	-0.03598 (0.07041)		0.14835 (0.25501)		1.78228 (3.59114)	**0.55593** (0.18101)**
Urban population (%)	-0.02341 (0.01740)	**-3.29191** (0.97238)**	**0.12245** (0.03427)**	**7.66810** (2.19942)**	0.42462 (0.98551)	-0.04834 (0.02556)
Unemployment rate						-0.00665 (0.01526)
Primary education attainment (%)				0.06435 (0.06535)		
Safe water access (%)				**1.11666** (0.34598)**		
Water stress		0.24760 (0.17255)				
R^2	0.99	0.94	0.59	0.98	0.86	0.98
Adj. R^2	0.99	0.93	0.35	0.97	0.81	0.98
Number of observations	120	127	81	77	87	137

*Notes: p < 0.1, ** p < 0.05, *** p < 0.01. All models include country and year fixed effects and are weighed by population size. Standard errors are robust and clustered by country.*

It is important to recognize the heterogeneity of clean energy technologies in North and Central Asia. Each country's energy system has different technological capabilities and therefore taking the average of all renewable technologies might have limitations for measuring the relationship.

Considering the indicator representativeness and data availability, share of population living in poverty by national poverty lines, undernourishment, share of the population with access to electricity, GDP per capita, carbon dioxide emissions per GDP, carbon dioxide emissions in metric tons per capita and safe water access are used as dependent variables in this stage covering social, economic and environmental dimensions. Different covariates are used to perform model tuning and have been decided for each dependent variable according to thorough deliberation.

Environmental variables

Carbon dioxide emissions per GDP and carbon dioxide emissions in metric tons per capita are used to analyse the environmental footprint of production and consumption patterns in the subregion. Results show that higher urbanization is negatively correlated with carbon dioxide emissions per capita. Exact results are not included as there was no significant relationship with sustainable energy-related indicators. For carbon dioxide emissions per GDP, renewable energy consumption has a negative significant coefficient suggesting that renewable energies can provide a more environment-friendly landscape. The results confirm that renewable energy could help alleviate the environmental burden due to significantly lower lifecycle emissions. However, it should also be noted that, unlike fossil fuel, which produces higher emissions in the process of energy extraction, fuel transport and electricity generation, clean energy sources have a hidden, indirect carbon footprint from the manufacturing and construction of power plants, especially for hydropower and biomass.

Energy intensity shows a significant positive relationship with carbon dioxide emissions. This result is as expected given that the energy sector is a key driver of the subregion's economy and is the largest emitter.

Social variables

Safe water access shows a significant negative relationship with hydropower share and urban population. Hydropower production competes with water used for human consumption and activities, thus showing a negative coefficient, whereas high urbanization strains water supply and requires high investment into water and sanitation infrastructure. The proportion of people with access to electricity is significantly and positively linked with GDP per capita, urbanization and fossil fuel rent, though it shows no significant relationship with sustainable energy variables. While the coefficient for renewable energy consumption is positive, suggesting a positive correlation, it is not significant. This is attributed to the fact that electricity production has been more dependent on non-renewable sources in North and Central Asia. For the poverty rate, access to electricity is significantly negatively linked, while surprisingly the coefficients for access to safe water and GDP per capita are positive. This suggests that for the subregion overall when controlling for other covariates and fixed effects, improvements in safe water access and growth in GDP per capita do not automatically translate into decreased poverty rates. At first, this might seem counter-intuitive, but previous research highlighted how high initial levels of inequality limit the effectiveness of economic growth in reducing poverty (Adams, 2004). Undernourishment has a significant negative relationship with hydropower share, suggesting that there is a potential conflict of interest between using water resources for food and agricultural activities and power generation.

Economic variables

Results show that higher renewable energy consumption coupled with higher governance index and higher official development assistance contributes to higher GDP per capita. The significantly positive coefficient of renewable energy consumption indicates that higher renewable energy consumption is conducive to economic growth in the region. Development of renewable energy helps diversify the energy mix and lower countries' sensitivity to oil price volatility, encourage investment in energy saving and energy efficiency, and promote the development of new economic drivers apart from fossil fuel rent.

Summary

The results suggest that sustainable and clean energy can facilitate social development, economic growth and environmental quality improvement. It should be noted that the regression analysis is conducted for the whole subregion without consideration of different country groupings due to limited sample size, hence the results may be distorted by data from larger economies in the subregion. While there are somewhat homogenous aspects across the subregion, there are still huge differences in governmental structure, economic features and natural resources.

Built upon the important nodes identified through the network analysis, the panel regression displays similar findings on the interlinkages between Goal 7 and other SDGs and gives a more nuanced picture. The regression analysis makes up for the shortcoming of only using the correlation coefficients by including multiple significant covariates in the model to incorporate interlinkages among SDGs. Besides, the results are significant and meaningful from economic, social and environmental dimensions, which may also be used for reference when detecting proximate clusters of nodes such that countries can better capitalize on the synergies and trade-offs among indicators to accelerate the achievement of the SDGs.

4. Policy considerations for sustainable and clean energy

PROGRESS TOWARDS THE ACHIEVEMENT OF SUSTAINABLE AND CLEAN ENERGY IN NORTH AND CENTRAL ASIA REQUIRES MORE EFFORT.

Sustainable and clean energy plays a key role for countries in the subregion to achieve more ambitious climate goals in the context of the Paris Agreement, and it can be a key driver for countries to achieve the 2030 Agenda. Governments play a central role in the effort to achieve a more sustainable energy transition through regulation and policy implementation, providing financial incentives and promoting research and innovation. A multistakeholder approach is also needed to ensure buy-in from the private sector, research institutions and society to fully realize the desired outcomes for sustainable development. Elaborated below are five policy considerations to further advance sustainable and clean energy in the subregion.

Leverage the interlinkages of sustainable and clean energy with other development goals to maximize the impact of energy transition strategies.

Results of mapping the interlinkages between sustainable and clean energy variables and other SDG indicators show strong correlations between affordable and clean energy (Goal 7) with no poverty (Goal 1), quality education (Goal 4), industry, innovation and infrastructure (Goal 9), climate change (Goal 13) and partnerships for the goals (Goal 17). Regression analysis also shows the significant relationship of renewable energy consumption with carbon dioxide emissions and GDP per capita. These results identify the interactions between different sectoral targets and can support a more integrated policymaking process. For example, resource-rich countries have a negative interaction between fossil fuel subsidies and the growth of renewable energy capacity, which is linked in turn to social protection and assistance measures through renewable energy consumption. Countries in North and Central Asia have attracted investments to expand renewable energy capacity, yet fossil fuel subsidies remain high and distort the actual economic costs of fossil fuels and thus create an uneven playing field. Policy measures must strike a good balance to yield better outcomes. The subregion should develop a concrete plan to phase out fossil fuel subsidies for energy transition strategies to be more effective.

Prioritize investment and financing to improve energy efficiency alongside renewable energy adoption.

The development of renewable energy has attracted increased interest from domestic and foreign investors in the subregion. However, for energy transition strategies to be fully effective, significant additional financing is also needed to speed up energy efficiency improvements from both the supply side and the demand side. As highlighted in IRENA’s World Energy Transition Outlook (2021), energy efficiency drives broad socioeconomic development.

Specific areas from the energy supply side that can be targeted include energy production, transportation and transmission infrastructure, considering the significant energy loss in this process. Areas from the energy demand side that can be targeted include cities and buildings, as well as the transportation sector, both of which are significant consumers of energy in the subregion. Improvements in energy efficiency are also expected to decrease emissions levels, contributing to the environmental agenda.

A key factor that can drive improvements in energy efficiency and the adoption of renewable energy is technology. Countries in the subregion can benefit from technological transfer in the energy sector. It is possible to save up to 50 per cent on energy consumption by adopting the best energy-efficient practices and technologies available globally. In addition, this can contribute to building local expertise and in turn lower the cost of production, yielding economic benefits.

Increase renewable energy capacity by exploring alternative sources of renewable energy.

Hydropower is the main source of renewable energy in North and Central Asia. Energy diversification needs to be a priority, and more importantly, diversification to new sources of renewable energy. Currently, the capacity of renewable energy resources such as solar and wind is underutilized in the subregion. As the cost of renewable energy continues to decrease, countries in the subregion should prioritize new renewable energy infrastructure instead of non-renewable energy. New renewable energy infrastructure projects are expected to positively impact employment by creating more new jobs than non-renewable projects. New jobs created from renewable energy projects are also expected to contribute to more equal employment opportunities for men and women.[21]

It would be beneficial to have stable alternative energy sources to ensure energy security and move away from the dependence on hydrocarbons. Given the commitments by North and Central Asian countries and their neighbours to decarbonize their economies by 2050–2060, efforts to transform the energy sector to achieve carbon neutrality must begin now.

Enhance local institutional and human capacity through trainings and skill building.

Aligning national energy targets with a low- or zero-carbon future will require fundamental changes and investments in national and human capacities. To deal with this, government administration and offices have to be adapted, strengthened or created. Local institutions need to be equipped with knowledge and personnel that can facilitate the energy transition process. Aside from upskilling existing institutions and personnel, relevant courses and curriculum need to be introduced to ensure the next generation of the workforce has an appropriate skill set. The creation of a local knowledge base is essential to effectively administer this process. Investments in institutional and human capacity can be leveraged to build robust and climate-resilient economies, technological capacity and jobs that can deal with a transition to clean energy sources. This in turn will introduce a shift from dependence of fossil fuels and foreign companies to the sustainability of national economies and expertise.

[21] Based on presentation by IRENA during the expert group meeting on "Sustainable and clean energy in North and Central Asia". Available at www.unescap.org/sites/default/d8files/event-documents/Session%202_Prasoon%20AGARWAL_Global%20energy%20transformation%20prospects.pdf.

Strengthen regional cooperation for energy trade and transboundary energy infrastructure centred on renewable energy.

The landlocked status of most North and Central Asian countries highlights the need for transboundary cooperation on energy matters. While some countries have potential for solar or wind, some have more hydropower possibilities, thus cooperation in the energy landscape is key. Given their similar focus on developing sustainable and clean energy, countries in the subregion can strengthen cooperation to encourage knowledge sharing and standardization of technicalities which could better facilitate energy trade, maintenance of transboundary energy infrastructure and technology transfer. Additionally, countries in the subregion can take advantage of their geographical location between China and Europe, and between the Russian Federation and South Asian economies to facilitate energy supply chain resilience. Countries can also leverage existing intergovernmental platforms, such as the ESCAP Committee on Energy, among others, to facilitate effective cooperation mechanisms for the subregional energy agenda.

5. Conclusion

THE COMMON ENERGY HERITAGE IN NORTH AND CENTRAL ASIA IS A FOUNDATION FOR COOPERATION AND LEARNING FROM THE EXPERIENCE OF OTHERS.

Thanks to the inherited power network from pre-independence times, countries in the subregion have almost completely achieved universal access to energy services. The way forward now must be guided by three key motivations to realize energy transition strategies and larger ambitions, such as the 2030 Agenda – improving energy efficiency from both the supply side and the demand side, developing strong alternative sources of renewable energy and strengthening cooperation for transboundary energy matters.

COVID-19 created challenges for economies and societies that must function in tandem with the environment. Fiscal packages introduced by governments in response to the impact of COVID-19 present an opportunity to align recovery measures with cleaner industries and the jobs of the future. As countries adapt to a new normal, new modalities and technologies can contribute to a better balance of the different aspects of sustainable development. The 2030 Agenda is made up of an interlinked network of goals. Results of mapping the relationship between Goal 7 and other SDGs in North and Central Asia show strong interlinkages with no poverty (Goal 1), quality education (Goal 4), industry, innovation and infrastructure (Goal 9), climate change (Goal 13) and partnerships for the goals (Goal 17).

Reviewing the results for different country groupings reveals strong interlinkages with good health and well-being (Goal 3) and responsible consumption and production (Goal 12) for resource-rich countries; while strong interlinkages are found with industry, innovation and infrastructure (Goal 9) and life on land (Goal 15) for hydro-reliant countries. The regression results show how sustainable and clean energy indicators, combined with other factors – such as income distribution, education and access to basic amenities – can affect economic, social and environmental variables. This calls for coherent policies when countries implement energy transition strategies, which leverage the interlinkages between different SDG indicators. Further development of the energy sector will also need to look beyond what has been proven to be significant – such as electricity access and the share of hydropower in the energy mix – to identify other areas for improvement.

Sustainable and clean energy can be a driver for North and Central Asian countries to achieve their climate ambitions for the Paris Agreement, national targets for climate change adaptation and mitigation, and the 2030 Agenda. Stakeholders in the subregion need to better coordinate efforts in this area of work to complement national and regional strategies. Achieving sustainable energy transition needs to be a priority now.

References

Adams Jr., Richard H. (2004). Economic Growth, Inequality and Poverty: Estimating the Growth Elasticity of Poverty, in World Development Vol. 32, Issue 12, December. pp. 1989–2014. Available at https://doi.org/10.1016/j.worlddev.2004.08.006.

Asian Development Bank Institute (ADBI) (2019). Renewable energy in Central Asian economies: Role in reducing regional energy insecurity. www.adb.org/sites/default/files/publication/522901/adbi-wp993.pdf.

ESCAP (2016). Promoting regional energy connectivity in Asia and the Pacific. www.unescap.org/sites/default/files/pre-ods/CE_1_2_EnergyConnectivity_0.pdf.

IEA (2020a). SDG7 data and projections. www.iea.org/reports/sdg7-data-and-projections.

IEA (2020b). World energy investment 2020. www.iea.org/reports/world-energy-investment-2020#introduction.

IRENA (2019). Renewables readiness assessment of the Republic of Azerbaijan. www.irena.org/-/media/Files/IRENA/Agency/Publication/2019/Dec/IRENA_RRA_Azerbaijan_2019.PDF.

IRENA (2020a). Global renewables outlook: Energy transformation 2050. https://irena.org/publications/2020/Apr/Global-Renewables-Outlook-2020.

IRENA (2020b). Renewable energy and jobs – Annual review 2020. www.irena.org/publications/2020/Sep/Renewable-Energy-and-Jobs-Annual-Review-2020.

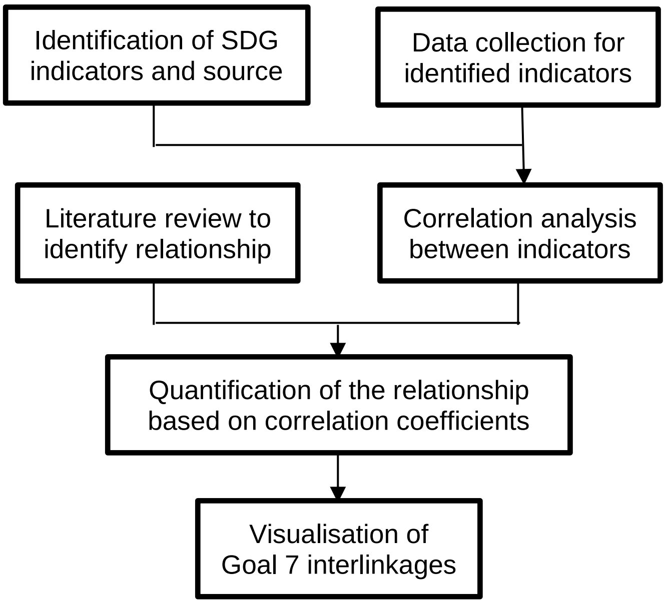
IRENA (2021). World Energy Transitions Outlook: 1.5°C Pathway, International Renewable Energy Agency, Abu Dhabi. www.irena.org/publications/2021/Jun/World-Energy-Transitions-Outlook.

World Bank (2016). Enhancing regional power trade in Central Asia. https://openknowledge.worldbank.org/bitstream/handle/10986/26047/ACS21198-WP-P147021-PUBLIC-EnhancingRegionalPowerTradeinCentralAsiaReport.pdf?sequence=1&isAllowed=y.

Appendix

Methodology to identify the interlinkages of Goal 7

Steps to identify interlinkages of Goal 7



The figure shows an overview of the methodology. The first steps are to conduct a literature review to identify the relationship between indicators of Goal 7 and other SDG indicators, to identify relevant indicators and collect data for them. The data are mainly gathered from the Asia Pacific SDG Gateway, databases of United Nations agencies, Organisation for Economic Co-operation and Development (OECD) and the World Bank. Data are then checked for stationarity and correlation analysis is conducted only with stationary variables. Both balanced and unbalanced panel data are used to perform the analysis based on data availability of the indicators. Based on these analyses, the relationship and interlinkages between the indicators of Goal 7 and other SDG indicators can be quantified and visualized. To make the interlinkages display more clearly, only correlation coefficients larger than 0.5 are captured in the graph. The interlinkages and relationship are classified as significant positive, significant negative, insignificant positive and insignificant negative, with 0.05 cut-off p-value to determine significance.

Given that energy resources are unevenly distributed in the subregion, the development of and reliance on renewable energy vary based on resource endowment in the countries. The patterns of interlinkages between Goal 7 and other goals are likely to differ for different country groupings. Hence, analysis was performed for four different country groupings: (i) the resource-rich countries, comprising Azerbaijan, Kazakhstan, the Russian Federation, Turkmenistan and Uzbekistan; (ii) the hydro-reliant countries, comprising Armenia, Georgia, Kyrgyzstan and Tajikistan; (iii) the whole subregion excluding the Russian Federation, as it tends to skew results of the analysis due to its size; and (iv) the whole subregion.

The interlinkages between Goal 7 and other goals are mapped for each of the four-country groupings using the network structure, where the nodes are the SDGs, and the edges are the correlation between Goal 7 and other goals. Goal 7 indicators are defined as central nodes in the network in this manner. It needs to be noted that the network is defined as an undirected structure as the interlinkages between the nodes are of a symmetrical relationship instead of a causal relationship. The lack of data for certain indicators could also distort the significance and correlation coefficients.

Conceptual framework and methodology to analyse relationship between clean energy and sustainable development

The panel regression $SDG_{it}=c_0+c_1 E_{it}+cov_{it}+\mu_{it}+\tau_{it}+\epsilon_{it}$ is used to analyse the relationship between clean energy and sustainable development, where SDG_{it} = SDG indicator, E_{it} = sustainable energy-related indicators, cov_{it} = covariates, μ_{it} = country fixed effects, τ_{it} = time fixed effects, ϵ_{it} = error term.

Description of the data

Data was mainly accessed through the United Nations Statistical Division, the World Bank database and the Asia Pacific Energy Portal. Data availability and quality vary greatly over the years and across the countries, thus the presented analysis tried to maximise statical representativeness by choosing variables that are most commonly available.

Renewable energy consumption is given in percentage of final energy consumption and was used to measure clean energy development in the region. The data for this variable was accessed from the United Nations Statistics Division. Renewable energy consumption includes consumption of energy derived from hydro, wind, solar, solid biofuels, liquid biofuels, biogas, geothermal, marine and renewable waste.

The hydropower share is the amount of electricity produced from hydropower plants divided by total electricity production. The data is retrieved from the World Bank database.

Intraregional trade as measured by intraregional energy trade is calculated based on data obtained from the Asia Pacific Energy Portal. It is the sum of energy traded with other North and Central Asian countries divided by total energy traded and consist of all types of energy trade.

Governance is measured by the governance indices obtained from the World Bank database as reported by the Worldwide Governance Indicators project. This indicator is an additive aggregate for six dimensions of governance including voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law and control of corruption.

Furthermore, GDP per capita is another macroeconomic factor that was included as a covariate in the analysis. The data was retrieved from World Bank database. The log form of GDP per capita is used in the regression.

Further covariates include: percentage of the population living in urban centres; agriculture forestry, and fishing, value added (% of GDP); fossil fuel rents (% of GDP); primary education completion rate; net official development assistance (ODA) received (% of gross capital formation); trade (% of GDP); unemployment (% of total labour force); industry (including construction) value added (% of GDP); energy intensity level of primary energy (MJ/$2011 PPP GDP) and water stress measured as freshwater withdrawal as a proportion of available freshwater resources. All these are taken from the World Bank database.

Dependent variables consist of sustainable development indicators representing various aspects of environmental, social and economic progress. The data description below only includes variables that are included in the results table. Some variables have been omitted from the results table due to the lack of statistical significance and insufficient data.

Environmental variables used are carbon dioxide emissions as measured in kilograms per value of GDP and as measured in metric tons per capita. The data were retrieved from the United Nations Statistical Division and World Bank database.

Social variables used are poverty rates, as measured by the percentage of population living below the national poverty line, the percentage of population with access to electricity, percentage of people with safe water access, and the percentage of moderate or severe undernourishment. The data were retrieved from the United Nations Statistical Division.

The economic variable is GDP per capita measured in current United States dollars with data obtained from the United Nations Statistical Division.

Description of the methodology

The method used for the quantitative analysis is panel regression for unbalanced panel data. This is combined with fixed effects for years and country entities and weighted by the respective total populations. Additionally, to correct for heteroskedasticity and autocorrelation, standard errors are robust and clustered by country. Regression using panel data may mitigate omitted variable bias when there is no information on variables that correlate with both the regressors of interest and the independent variable. Fixed effects are used to control for unobserved variables that are constant across countries but vary over time and also for variables that vary across countries but not over time.

Independent variables are chosen after careful deliberation on their potential influence on the respective SDG indicator and also according to their data availability. The resulting coefficients and p-values are used for discussing the correlation between the indicators and the variables, and not any causal link per se.