Regional Cooperation in Promoting Low-Carbon Energy Development in CAREC: Challenges and Opportunities

By

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Abstract

International efforts and mechanisms to address the effects of climate change are becoming stronger, pushing countries to pursue low-carbon development. Thanks to the latest technological advancements and enabling market mechanisms globally, renewables and clean fuels are proving to be financially attractive owing to the long-term benefits for the environment and health.

This paper provides an overview of regional collaboration on low-carbon development in the Central Asia Regional Economic Cooperation (CAREC) region and identifies relevant challenges and opportunities. Under obligations set by the Paris Climate Agreement, CAREC countries' targets to reduce greenhouse gas (GHG) emissions range from 10% to 20% by 2030 and all parties are required to regularly update on their emissions status and on implementation efforts. The study deployed an analysis of regional cooperation involving two and more countries of the CAREC region engaged in promoting renewable and energy efficiency projects (2010-2020), assessed the level of cooperation, and identified general characteristics of the projects.

The paper concludes that regional cooperation in promoting low-carbon energy development among CAREC countries is at an early stage. Recommendations include better harmonization of frameworks, such as technical standards for power connectivity and trade, development of cross-border technology transfer and knowledge exchange, greater participation of all relevant stakeholders in energy cooperation, and better integration of renewable energy into the electricity grid.

KEY WORDS: regional cooperation, low-carbon development, renewable energy, energy efficiency, greenhouse gas emissions, Central Asia Regional Economic Cooperation

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Abbreviations

ADB	Asian Development Bank
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
bcm	billion cubic meters
CAPS	Central Asian Power System
CAREC	Central Asia Regional Economic Cooperation
CASA	Central Asia-South Asia
CASAREM	Central Asia-South Asia Regional Electricity Market
CAWEC	Central Asia Water & Energy Program
CO_2	carbon dioxide
CPEC	China-Pakistan Economic Corridor
EBRD	European Bank for Reconstruction and Development
ECO	Economic Cooperation Organization
EDB	Eurasian Development Bank
EREC	European Renewable Energy Council
ETS	emission trading system
GDP	gross domestic product
GHG	greenhouse gas
GW	gigawatt
HPP	hydro power plant
ICT	Information and Communication Technology
IEA	International Energy Agency
ILO	International Labour Organization
IMAR	Inner Mongolia Autonomous Region
IPCC	Intergovernmental Panel on Climate Change
IsDB	Islamic Development Bank
kWh	kilowatt-hour
MDB	multilateral development bank
MJ	megajoule
MT	metric ton
MW	megawatt
NDCs	nationally determined contributions
OECD	Organization for Economic Co-operation and Development
PIF	Pacific Islands Forum
PM10	particulate matter 10 (up to 10 micrometers in diameter)
PM2.5	particulate matter 2.5 (up to 2.5 micrometers in diameter)
PPP	purchasing power parity
PRC	People's Republic of China
SAARC	South Asian Association for Regional Cooperation
SDG	Sustainable Development Goals
SE4ALL	Sustainable Energy for All
TAPI	Turkmenistan-Afghanistan-Pakistan-India (TAPI) gas pipeline
Toe	ton oil equivalent
TPES	total primary energy supply
TUTAP	Turkmenistan-Uzbekistan-Tajikistan-Afghanistan-Pakistan project
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCCC	United Nations Framework Convention on Climate Change
WB	World Bank
XUAR	Xinjiang Uyghur Autonomous Region

1. Introduction

1.1. Rationale

A few decades ago, the concept of a green economy was still a myth; hence, the idea of realizing clean energy development was regarded by many countries as an expensive dream to pursue. However, today's global growth trend has completely changed the picture.

On the one hand, international efforts and mechanisms to address the alarming effects of climate change are becoming stronger, pushing countries to adopt environmentally friendly technologies. On the other hand, owing to the latest technological advancement in renewables, cleaner fuels have become a financially viable option considering the long-term benefits for the environment and health for the growing population.

Owing to growing concerns over the effects of global warming and the need for concerted efforts in addressing the adverse impact of climate change on the planet, leaders of all countries eventually agreed on a few important global development agendas. The most recent one, known as the Paris Agreement ratified in 2015, set the ambitious target of limiting the increase in the global average temperature to 1.5 degrees Celsius to 2 degrees Celsius above pre-industrial level. This was the result of generations-long efforts that started way back in 1992 with the establishment of the United Nations Framework Convention on Climate Change (UNFCCC). Under the Paris Agreement, countries are required to act on both climate change adaptation and mitigation activities through their own nationally determined contributions (NDCs) that should result in the reduction or avoidance of greenhouse gas (GHG) emissions, such as the transition to renewable energy, more energy efficiency, and sustainable transport.

Another global agenda for 2030 is sustainable development goals (SDGs), which were successfully adopted by UN member states in 2015. Aimed at helping countries to solve their development challenges, the SDGs consist of 17 goals, and among these the seventh and 13th have direct links to climate change targets. SDG7 ensures access to affordable, reliable, sustainable, and modern energy. SDG13 takes urgent action to combat climate change and its impacts.[1]

According to the United Nations Environment Programme (UNEP), clean energy action has already been accelerated in many parts of the world with total estimated investments dedicated to renewable capacity development reaching US$2.6 trillion between 2010 and 2019.[2]

Asia and the Pacific, being the most populous region with fast-growing economies, undoubtedly needs to shift from a fossil economy towards a low-carbon economy to manage its GHG emissions. This is particularly relevant for the CAREC region, which is rich in oil and natural gas. Under the obligations set by the Paris Climate Agreement, CAREC countries' targets to reduce GHG emissions range from 10% to 20% by 2030, and all parties are required to regularly update on their emissions status and on implementation efforts.

With an annual population growth in the range of 0.4% to 2.4%, annual GDP growth of up to 6% to 7% in some countries, and growing urbanization, the demand for energy resources in Central Asia is expected to grow annually by 1.9% until 2030.[3] In addition, energy intensity in Central Asia is high (0.35 [TPES/GDP] toe/thousand US$), which is substantially higher than the global average (0.2) and

[1] The Sustainable Development Goals, https://sustainabledevelopment.un.org/sdgs
[2] UNEP Press Release, September 2019: https://www.unenvironment.org/news-and-stories/press-release/decade-renewable-energy-investment-led-solar-tops-usd-25-trillion
[3] World Bank Open Data and Doi T and Natsumoto T: *Energy Outlook for Central and West Asia*, 2010, The Institute of Energy Economics, Japan.

in the Asia and Pacific region (0.29).[4] GHG emissions, the side effect of high energy intensity, population growth, and growing demand for energy from fossil fuels are deteriorating air quality, which has been observed in many major cities of the region. According to the latest available data, 2017, mean annual exposures to air pollution PM2.5[5] was in Pakistan (58µg/m3), Afghanistan (57µg/m3), the People's Republic of China (PRC) (52µg/m3) and Tajikistan (46µg/m3), which is four to five times higher than the World Health Organization's (WHO's) air quality guideline concentration of 10µg/m3.[6] This means that only 8% of people living in major urban areas in Asia could breathe clean air.

Low-carbon energy development can achieve a reduction in GHG emissions, through development of renewables, improvement in energy efficiency, shifting to low-carbon technologies, and carbon storage. Since CAREC countries are highly energy-intensive and largely dependent on fossil sources of energy, there is significant potential for promoting cooperation on low-carbon energy that will bring economic, social, and environmental benefits to CAREC countries. The region has great potential in promoting low-carbon technologies owing to its abundant potential renewable energy resources, such as hydropower, wind, and solar. The experience of many countries shows that increased competition, technological advancement, and policy support for low-carbon development has led to an increased share of renewable energy in the energy mix.

The overall picture shows that the share of renewables in global electricity generation increased to 28% in the first quarter of 2020 from 26% in the first quarter of 2019 and that almost 75% of new electricity capacity installed in 2019 was from renewables.[7] According to the International Energy Agency (IEA), renewable energy has been comparatively resilient during the COVID-19 lockdown owing to lower operational cost, plus being dispatched before other sources of energy.[8]

Energy systems, energy security, and energy cooperation in CAREC are well studied, considering the diversified and expansive nature of energy systems within the CAREC countries and ongoing regional cooperation initiatives within the framework of the CAREC Program.[9] With the adoption of the new CAREC Energy Strategy (2020-2030) in November 2019 in Tashkent, Uzbekistan, CAREC seeks a smarter, efficient, green, sustainable, and resilient energy system for regional development.

1.2. Aim, objectives, and scope of the study

The CAREC Energy Strategy 2030 provides an overall strategic framework (Figure 1) for the energy sector of the region. Inspired by the ambitious vision of achieving a reliable, sustainable, resilient, and reformed energy market by 2030, the strategy is guided by the overarching principle of common borders, common solutions, and a common energy future.

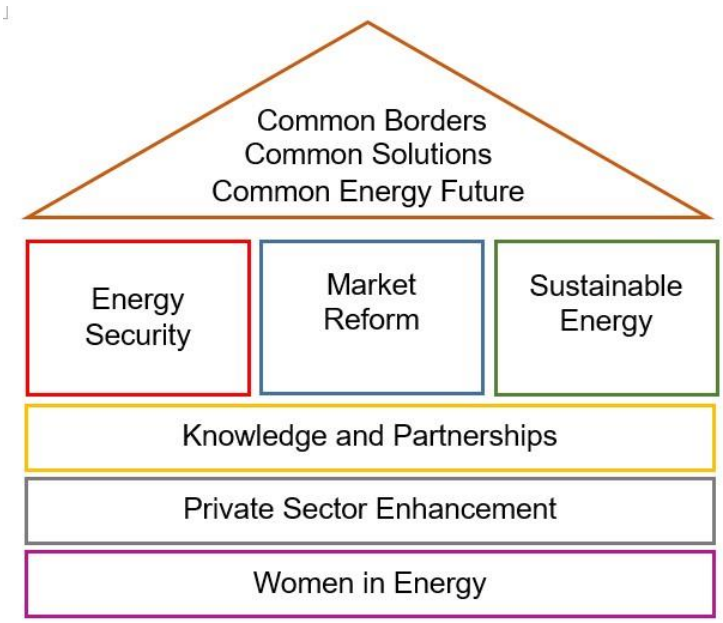
This new strategy identifies the following three major pillars:

Pillar 1: Better energy security through regional interconnections.
Pillar 2: Scaled-up investments through market-oriented reforms.
Pillar 3: Enhancing sustainability by greening the regional energy system.

[4] Total Primary Energy Supply (TPES) / GDP or Tons of oil equivalent/thousand USD, International Energy Agency Data.
[5] The mean annual concentration of particulate matter (PM) is a common measure of air pollution. PM2.5 (PM with less than 2.5 microns in diameters) and PM10 (PM with less than 10 microns in diameters) are major indicators.
[6] Brauer, M. et al. 2017, for the *Global Burden of Disease Study* 2017.
[7] IEA Global Energy Review 2020—flagship report, April 2020: https://www.iea.org/reports/global-energy-review-2020/renewables
[8] IEA Press Release, 30 April 2020: https://www.iea.org/news/global-energy-demand-to-plunge-this-year-as-a-result-of-the-biggest-shock-since-the-second-world-war
[9] CAREC Energy Strategy 2030 and CAREC Energy Plan through regional mechanisms of CAREC Energy Coordinating Committee, CAREC Energy Investment Forum, CAREC Energy Ministers' Dialog, CAREC Program: https://www.carecprogram.org/?page_id=16

This paper focuses on the 3rd pillar. Within Pillar 3, while acknowledging the region's high vulnerability to climate change, the CAREC Energy Strategy 2030 highlights that achieving energy efficiency and the rapid deployment of cost-competitive renewable energy are key tools in responding effectively to climate change and for the greening of the regional energy system to enhance its long-term sustainability.[10]

Figure 1: CAREC 2030 Energy Strategy pillars



Source: CAREC Energy Strategy 2030.

The overall aim of this study is to contribute to the enhancement of existing mechanisms of the promotion of regional collaboration on low-carbon development. Thus, in the context of CAREC countries, the objectives for this paper are twofold:

The first objective is to map out energy cooperation programs among CAREC member countries by focusing on their low-carbon development strategies by analyzing current situations including relevant challenges and opportunities.

The second objective is to provide recommendations to policy makers for scaling up low-carbon initiatives. Based on these objectives, this paper addresses the following key questions:

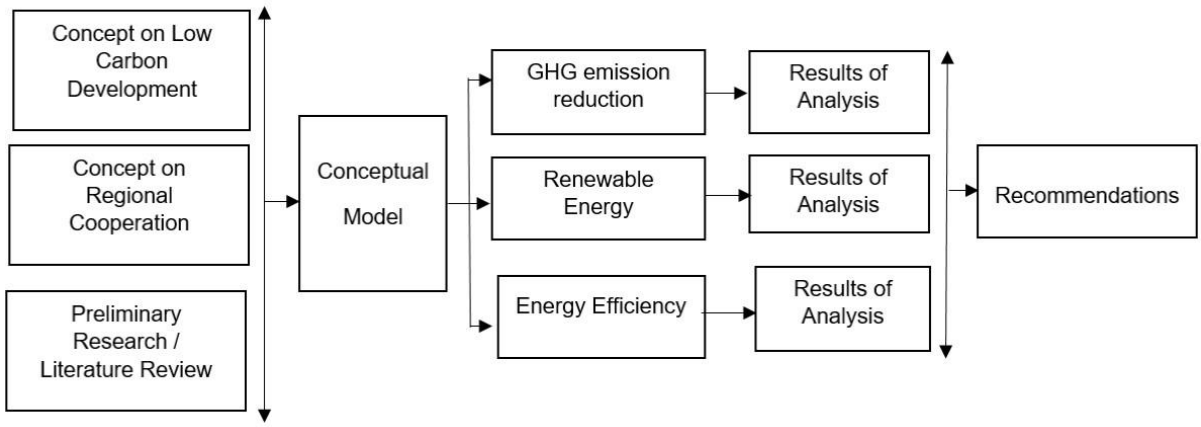
a) What are the current energy cooperation practices among CAREC countries?
b) To what extent is low-carbon development implemented in the region?
c) What are the challenges and opportunities for low-carbon energy cooperation in the CAREC region?

The research framework of the study (Figure 2) illustrates the methodology of the study. The review of relevant concepts on low-carbon development and regional cooperation results in a conceptual model. The paper provides a detailed analysis of current policies, programs, and projects and their

[10] CAREC Energy Strategy 2030 focuses on greater regional interconnection to improve in energy security; more competitive, market-oriented approaches to deliver greater benefits to consumers; sustainable and green energy system; new knowledge and partnerships to deepen and foster long-term regional relationships; greater participation from the private sector; and equal opportunity for women in energy sector.

progress on the promotion of low-carbon energy development (namely, renewable energy and energy efficiency). This leads to policy recommendations for strengthening the design of energy cooperation initiatives in CAREC.

Figure 2: Research framework



Note: Author's proposed research framework, based on Verschuren and Doorewald, 2010.

The report is structured as per the following sections:

Section One provides an introduction as to why the study is focused on low-carbon development and lays out the overall aim and relevant objectives. It also provides information about the research strategy describing the approach, the conceptual framework, the research questions, and key activities.

Section Two reviews the literature and research on relevant concepts of low-carbon development and regional cooperation.

Section Three provides a contextual description of the region and a brief overview of the energy cooperation in CAREC.

Section Four zooms into climate change commitments, such as policies and respective targets for low-carbon development. With the application of the conceptual model derived from Section Two, it provides an analysis of the current status by looking into relevant policies, programs, and their progress on low-carbon energy development in CAREC.

Section Five summarizes the lessons learned from the current situation by shedding light on key characteristics including challenges and opportunities, and recommendations for stronger regional cooperation in the low-carbon energy sector in CAREC.

2. Conceptual background

This section focuses on the review of the literature on concepts for low-carbon development, regional cooperation and success factors of regional cooperation in the energy sector.

2.1. The concept of low-carbon development

The terms 'low-carbon,' 'low-carbon economy,' and 'low-carbon development' started to come in use in the 1990s with the growing awareness of climate change. The concept of low-carbon development

is rooted in the UNFCCC, which aims at stabilizing GHG concentrations in the atmosphere. The term 'low-carbon development' is used interchangeably with 'low emission' or 'low-carbon development strategies' or 'low-carbon growth plans.'

Similar in definition to low-carbon development, the terms 'green growth' and 'green economy' have been used widely in the mid-2000s by policy makers and development practitioners, despite its much earlier appearance in one of the first economic studies to make the connection between sustainable development and green economy (*Blueprint for a Green Economy*, Pierce et al. 1989). UNEP defined a green economy as one that results in 'improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities.' In other words, a green economy can be realized through low-carbon, resource efficient, and socially inclusive development, which is driven by public and private investments that reduce carbon emissions and pollution, improve energy efficiency, and prevent the loss of biodiversity and ecosystem services (UNEP, 2011).[11]

'Low-carbon development' or 'low-emission development strategy' is generally used to describe forward-looking national economic development plans or strategies that encompass low-emission and/or climate-resilient economic growth (OECD, IEA 2010).[12]

Low-carbon development is defined as substituting fossil fuels with low-carbon energy based on preserving economic growth and rising residential welfare (EREC, 2008).[13] In the PRC, 'low-carbon economy' is defined as 'a form of the economy with low energy consumption and low pollutants and emissions' (Zhang, Pan, and Cui, 2008).[14] An ILO study defined low-carbon development as a mode of development that aims to achieve a low-carbon economy through a process of de-carbonization, while contributing to sustainable development and tackling climate change.

There is global debate on whether 'natural gas' is part of 'low-carbon' energy resources. Since 'low-carbon' fuel should consider the amount of CO_2 over the emission lifecycle, the Intergovernmental Panel on Climate Change (IPCC) estimated the median lifecycle emission per kWh electricity generated by fuel is for coal 820g CO_2 and for gas 490g CO_2. In contrast, solar PV utility emits 41g CO_2, and wind energy 11g to 12g CO_2.[15] Another study by Vattenfall (2017) concluded that grams of CO_2 per kWh of electricity by nuclear source is (5), hydroelectric (9), wind (15), natural gas (503), peat (636), and coal (781).[16] Even though natural gas is considered a clean fuel compared with coal and oil, it emits ten times more CO_2 than solar and 40 times more CO_2 than wind-powered power plants. Natural gas can be regarded as a 'transition fuel' from coal to renewables since its lifecycle emission is almost two times lower than that of coal.

Considering the low-carbon emission of nuclear fuel in both IPCC and Vattenfall studies, there have been contradicting views and studies about real lifecycle emissions of nuclear energy, such as studies undertaken by Sovascool[17] and Ethan Warner and Garvin Heath.[18] After reviewing 103 published lifecycle analysis studies, Sovascool found that the nuclear power median lifecycle varies between 3g and 200g CO_2/kWh, and after studying 274 papers containing nuclear lifecycles, Ethan Warner and Garvin Heath concluded that the data ranged from 4g to 220g CO_2/kWh.[19] Given the contradicting views and facts on nuclear energy, this study does not consider nuclear power development as within its scope.

[11] UNEP, *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication*, 2011.
[12] OECD, *Low Emission Development Strategies (LEDS): Technical, Institutional and Policy Lessons*, November 2010.
[13] EREC. *Energy (R)evolution: A Sustainable Global Energy Outlook*. European Renewable Energy Council. 2008.
[14] Zhang Kunmin, Pan Jiahua, Cui Dapeng, 2008, *On the Low Carbon Economy*, China Environmental Science Press.
[15] UN Inter-Government Panel on Climate Change: AR5 Climate Change 2014: Mitigation of Climate Change.
[16] Vattenfall: https://group.vattenfall.com/what-we-do
[17] Benjamin K. Sovacool, *Energy Policy*, 36, 2940, (2008).
[18] Ethan S. Warner and Garvin A. Heath, *Journal of Industrial Ecology*, 16, S73, (2012).
[19] The Ecologist, *False solution: Nuclear power is not 'low carbon*,' February 2015.

Low-carbon development can be achieved i) by reducing the share of fossil fuel based sources of energy and enhancing the supply of clean energy, and ii) by reducing the demand for energy based on fossil fuel sources, in particular through measures and policies for energy efficiency. The study thus focuses on two low-carbon development options: renewable energy development and energy efficiency.

2.2. The concept of regional cooperation

Regional cooperation and integration (RCI) is defined as a process by which national economies become more interconnected regionally (ADB).[20] It refers to the political and institutional mechanisms that countries in a geographic region devise to find and strengthen common interests as well as promoting their national interests through cooperation and dialog (Rajamanickam, 2016).[21]

Regional cooperation brings many of the same benefits as multilateralism but on a smaller scale. First, given the small size of their domestic market, countries can achieve economies of scale and greater specialization in production that increase the competitiveness of their products. Second, access to a bigger market gives countries an opportunity to set up new export industries, diversifying exports and reducing vulnerabilities to impediments of a specific product market. Third, it enhances the capacity of developing countries to meet emerging challenges, including new technologies. Fourth, regional trade facilitation measures offer significant benefits by reducing the costs of transactions across borders and removing non-border obstacles (UNESCAP).

Regional cooperation may help to provide better and efficient resource allocation across the region based on the principle of comparative advantage. Regional collaboration brings many benefits to partnering countries, such as access to and expansion of the market for goods and services, for both output and inputs. It should lead to higher economic growth and improved welfare; more efficient resource allocation across the region in line with respective comparative advantages; and reduced income inequality between countries and risk-sharing (ADB, 2013).[22]

Despite these advantages, finding equitable ways to share the burdens and benefits of regional cooperation is not easy. Political strains or mistrust hinder cooperation and countries may be unwilling to meet high coordination costs or to accept asymmetric distribution of costs and benefits from their obligations on a particular issue if they are not satisfied that their perceived interests are served. Also, regional cooperation may not be successful because of weak institutions and a lack of proper enforcement mechanisms to ensure that countries live up to their commitments (UNESCAP, 2004).[23]

Despite such problems, countries are showing increasing interest in forming regional groups to exploit the opportunities they offer for market expansion, creation of new industries, technology transfer, and human resources development.[24]

[20] ADB, ADB's Focus on Regional Cooperation and Integration: https://www.adb.org/themes/regional-cooperation/main
[21] Rajamanikam S., *Exploring Landscapes in Regional Convergence: Environment and Sustainable Development in South Asia*, 2016, Handbook of Research on Global Indicators of Economic and Political Convergence.
[22] ADB, 2013. *Regional cooperation and integration in a changing world*. Manila: Asian Development Bank.
[23] UNESCAP, *Regional Cooperation: Conceptual Framework and Asia-Pacific Experience*.
[24] M. Schiff and L.A. Winters, 'Regional cooperation, and the role of international organizations and regional integration,' World Bank Policy Research Working Paper 2872 (2002).

2.3. Factors for successful regional cooperation in the energy sector

What are the critical factors for successful regional cooperation in the energy sector?

UNESCAP provided a model emphasizing that regional cooperation in different sectors is interlinked. Cooperation in trade, investment, technology transfer, transport, and infrastructure development enhances regional growth. Financial cooperation contributes to growth and reduces the impact of volatile financial markets, thereby providing macroeconomic stability. Cooperation in research, training, and academic exchange helps the regional development of human resources. Capacity building has a positive impact on the development of energy infrastructure and energy efficiency.

The energy sector offers diverse forms of regional cooperation, such as electricity trading, energy sector financing, management, investment, energy technology innovation, research and development, knowledge sharing, education, and training.

A paper on energy policy cooperation or competition around the North Sea by Meulman et al., 2012, proposes the following levels of cooperation in the energy sector:[25]

1) Information sharing—sharing of information and looking at the impact on neighboring countries before new policies are instigated
2) Coordination—knowledge and information could be developed jointly on issues such as energy storage facilities, and tendering processes for offshore wind and investment
3) Coordination plus—a process could be instituted, encouraging neighboring countries to search for common policy considerations
4) Joint instruments—joint approach and support system
5) Joint policy—a maximum approach of common goals and policies in energy and electricity across the whole region.

By analyzing regional energy cooperation institutions in North-East Asia, Korneev highlighted that the presence and participation of all key stakeholders are crucial, and that it should not be limited to representatives from public administration and private sector companies, but also include others such as energy technology experts, research and development, media and non-profit organizations. Also, the successful implementation of energy cooperation depends on the effectiveness of the mechanisms that are created to manage it (Korneev et al, 2019).[26]

In analyzing the cooperation on renewable energy sources in Europe, Caldes et al. analyzed more than 40 factors and stressed political and economic factors as the most important ones. They highlighted the significance of information provision, legislative initiatives, access to finance, public awareness campaigns, and international cooperation as key recommendations for driving renewable energy cooperation in the European Union (Caldes et al, 2018).[27]

The Benelux Secretariat developed a toolbox for regional energy cooperation in 2016.[28] The underlying research suggests that it is difficult to assess the respective success of each form of cooperation objectively and that there is no one-size-fits-all approach. However, based on past regional experiences, seven overarching principles for successful cooperation were determined:

[25] Leonie Meulman, Pieter Boot, Coby van der Linde, Jacques de Jong and Luc Werring, *Harvesting Transition? Energy Policy Cooperation or Competition around the North Sea*, 2012, Clingendael International Energy Programme.
[26] Korneev A. et al, *Institutions of international energy cooperation in North-East Asia region*, Regional Energy Policy of Asian Russia 2018.
[27] Caldes, A. *Renewable Energy Cooperation in Europe: What Next?* Drivers and Barriers to the Use of Cooperation Mechanisms, 2018.
[28] General Secretariat of the Benelux Union, *The toolbox for regional energy cooperation*, 2016.

1) Clear political vision guiding the process—that is, a shared understanding between the involved member states' governments regarding objectives of cooperation
2) Participation of all relevant stakeholders, particularly market participants, to ensure pragmatic and practical solutions
3) A step-by-step approach, in which member states can develop concrete solutions to challenges they commonly face
4) Continuity, provided by permanent staff with a clear mandate, who can facilitate the cooperation and follow up the progress made
5) Communication of potential gains and achieved results to political leaders and the public in the involved countries to facilitate political and public acceptance
6) Appropriate geographic composition, dependent on the scope and intensity of the cooperation as well as the existence of other regional initiatives
7) Regional orientation, namely working towards greater regional market integration and complementarity to relevant legislation

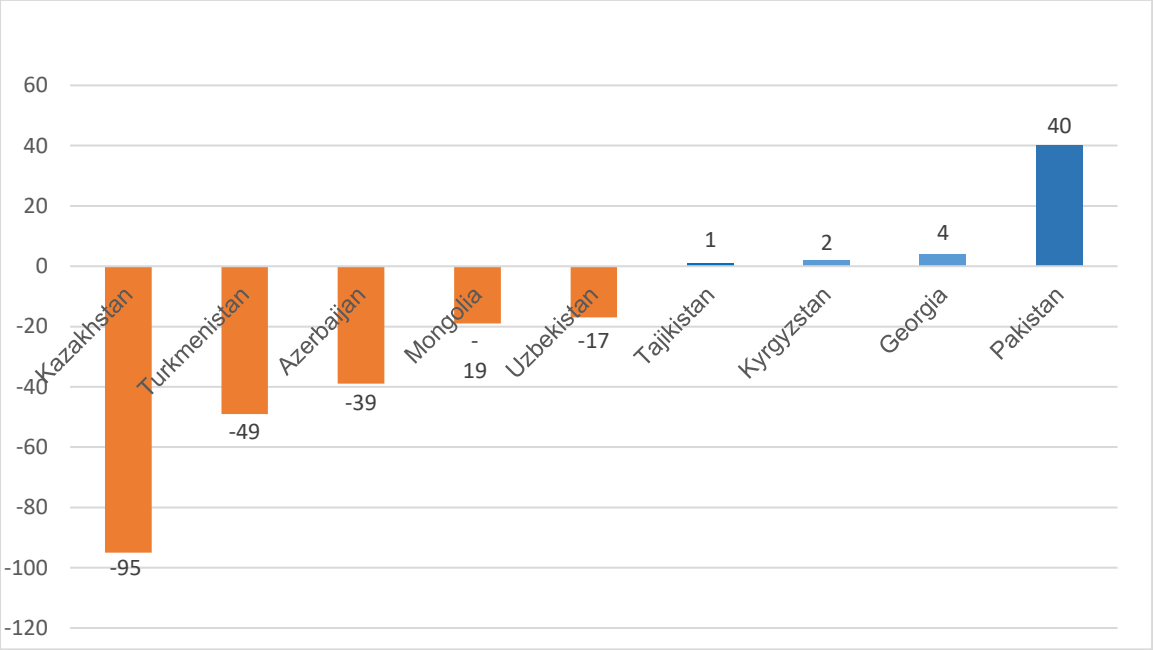
3. Energy sector cooperation in the CAREC region

This section provides an overview of energy cooperation in CAREC and its key characteristics.

Historically, the CAREC region is characterized by high-carbon energy sources dominated by coal, oil, and gas and low energy efficiency owing to aging infrastructure and lack of policy and regulatory support.[29] The main motives for regional energy cooperation are the imbalanced distribution of energy resources within Central Asia and their seasonal complementarities.[30]

The majority of CAREC countries are net energy exporters (Figure 3), with Kazakhstan being the largest one. Tajikistan and Kyrgyzstan can barely meet their energy needs, Pakistan is the largest net energy importer.

Figure 3: Net energy imports, CAREC countries, 2017, (million toe)



Source: Author's calculation, IEA World Energy Balances 2019
Note: excluding the PRC owing to scale and Afghanistan owing to unavailability of data. The latest available data is for 2017.

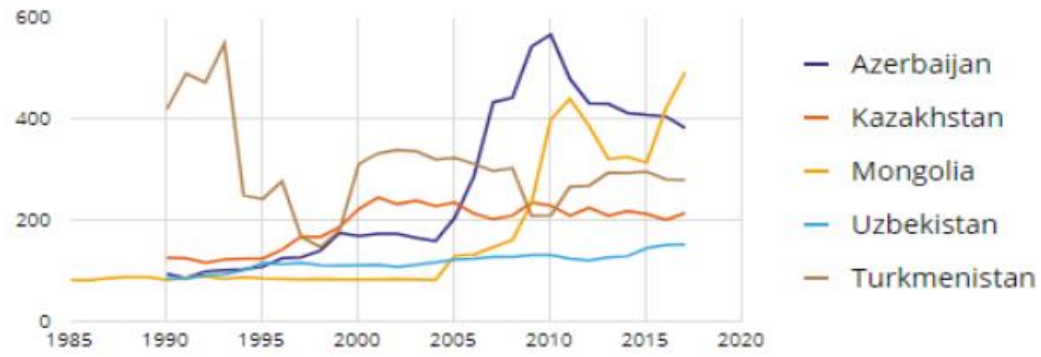
[29] CAREC Energy Strategy 2030.
[30] Ashok Bhargava, A new era of clean energy cooperation along the old Silk Road, ADB Blogs, https://blogs.adb.org/blog/new-era-clean-energy-cooperation-along-old-silk-road

The central Asian countries have abundant resources of fossil fuels and hydropower, while Pakistan and Afghanistan have large and growing energy needs without adequate local resources. Mountainous Tajikistan, Kyrgyzstan, and Georgia have abundant sources of hydropower, while Azerbaijan, Kazakhstan, Turkmenistan, and Uzbekistan are rich in oil and gas. Since the majority of CAREC countries can meet their own domestic energy needs, regional energy cooperation is mainly focused on connecting Central Asia with Afghanistan and Pakistan.

Energy self-sufficiency is an important factor in ensuring a country's energy security; therefore, for the countries with less energy self-sufficiency having a reliable energy supply from energy rich CAREC neighbors is critical. Figures 4 and 5 illustrate the degree of energy self-sufficiency of CAREC countries.

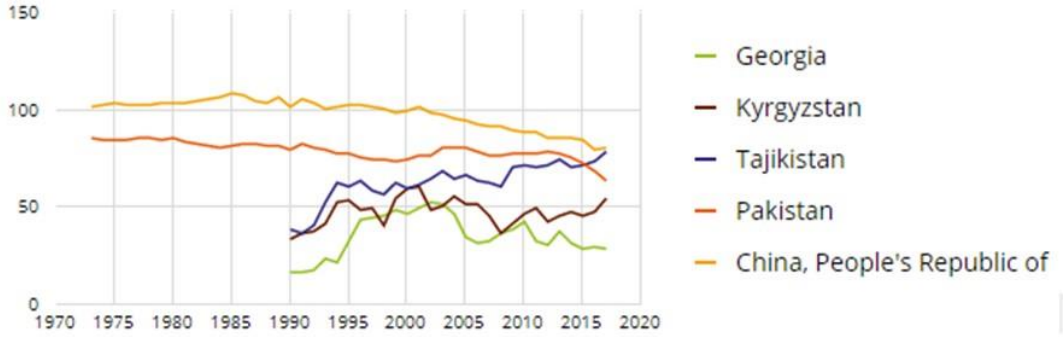
Mongolia, Azerbaijan, and Turkmenistan produce 4.9 times, 3.8 times and 2.8 times, respectively, the energy resources they need domestically, which make them highly energy self-sufficient. Kazakhstan and Uzbekistan have 2 times and 1.5 times their own needs (Figure 4).

Figure 4: Energy self-sufficiency: energy rich CAREC countries, (% of total energy production/TPES)



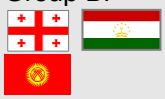
In terms of energy self-sufficiency, the PRC and Tajikistan have about 80%, whereas Georgia has about 30%, which is mostly supplied by hydropower generation (Figure 5).

Figure 5: Energy self-sufficiency: low energy resource CAREC countries, (% of total energy production/TPES)



Based on their difference in energy resources, the CAREC countries can be grouped into five categories (Table 1) according to energy demand and generation potential:

Table 1: Energy characteristics of CAREC countries

Group A. 	Fossil-fuel rich countries (Kazakhstan, Turkmenistan, Uzbekistan, and Azerbaijan) have sufficient energy resources for exports, and access to export markets, and they earn export revenues to support their oil, gas, electricity, and coal export-led growth.
Group B. 	Hydropower-rich countries (Georgia, Tajikistan, and Kyrgyzstan) face electricity shortages during the winter months to power their heating systems. They are rich in hydropower resources but lack fossil fuels. They have access to export markets for hydroelectricity and earn export revenues to secure the import of fossil fuels to meet their winter energy deficits.
Group C. 	Transit countries (Mongolia and Afghanistan) earning valuable transit and transmission fees. Mongolia can become an alternative energy transit route between Russia and China. Mongolia exports coal and possibly electricity in the future to China.
Group D. 	Afghanistan and Pakistan have enormous demand for and lack of access to reliable power supplies. Afghanistan has ongoing energy imports from Uzbekistan, Tajikistan, Iran, and Turkmenistan.
Group E. 	China imports oil and natural gas from Kazakhstan, Uzbekistan, and Turkmenistan as an alternative source for energy security.

There are three key characteristics of the CAREC regional energy cooperation: i) a regional electricity trading mechanism based on the Soviet energy cooperation, ii) strong links between water and energy, and iii) abundant regional resources of natural gas.

Firstly, the five Central Asian countries, Kazakhstan, Uzbekistan, Turkmenistan, Tajikistan, and Kyrgyzstan, were part of the unified energy grid under the Soviet Union—the Central Asian Power System (CAPS). In this aspect, the regional energy cooperation in CAREC is not new, considering the similar and synchronized energy infrastructure, and social and cultural aspects inherited from the Soviet Union. Aided by ADB and the WB, such as technical assistance grants to support an increase in regional power trade, CAPS is trying to regain importance through small scale projects.[31] There are projects aimed at allowing Tajikistan to reconnect to CAPS[32] and expanding CAPS membership to Afghanistan and Turkmenistan and other partners.[33] In addition to the longstanding CAPS cross-border energy infrastructure projects, including the Central Asia and South Asia (CASA)-1000 power transmission line and the Turkmenistan-Uzbekistan-Tajikistan-Afghanistan-Pakistan (TUTAP) project, new power transmission projects will increase market opportunities in electricity trade between CAREC countries.

Secondly, there is a strong link between water and energy systems, because of the transboundary rivers connecting the territories of the Central Asian countries and Afghanistan (and the PRC), and important hydropower resources in Tajikistan and Kyrgyzstan. After gaining independence, the Central

[31] ADB, Regional: *Regional Cooperation on Increasing Cross-Border Energy Trading within the Central Asian Power System*.
[32] ADB, Tajikistan: *Reconnection to the Central Asian Power System Project*.
[33] ADB, Regional: *Regional Cooperation on Increasing Cross-Border Energy Trading within the Central Asian Power System - Expansion of Membership in Central Asian Power System* (Subproject 3).

Asian countries signed a number of intergovernmental agreements aimed at providing a mechanism for the exchange of resources.[34] The agreements were directed towards the upper riparian countries continuing to provide a free flow of water to their neighbors according to the established quota during the growing season and, in exchange, relying on the supply of natural gas, heat, and electricity in the winter. However, water-energy conflicts showed the weakness of these agreements in regulating energy relations and the absence of a strong commitment. The recent development in Tajikistan, Uzbekistan, and Kyrgyzstan in resolving transboundary water-energy system conflicts promises a good start in regional energy cooperation. There are several large hydropower projects under construction in the region, including the Rogun Hydropower Dam and the Nurek Hydropower Plant (HPP) in Tajikistan.[35] Kyrgyzstan is also planning to complete the long-awaited Kambarata 1 HPP.[36]

Thirdly, the CAREC region has abundant natural gas reserves, as Turkmenistan, Kazakhstan, the PRC, and Uzbekistan rank among the top 20 in the world in terms of their reserves of natural gas.[37] The PRC's Ordos Basin (with reserves of 15.5 bcm [billion cubic meters]) is partially located in the Inner Mongolia Autonomous Region (IMAR), and the Tarim Basin (with reserves of 12 bcm) is located in the Xinjiang Uygur Autonomous Region (XUAR), which are members in the CAREC program. Currently, there is ongoing cooperation on a large scale within CAREC on major gas and oil pipelines, including the Central Asia-China gas pipeline (Turkmenistan to Xinjiang, China), the 50-year-old Bukhara-Tashkent-Bishkek-Almaty gas pipeline, the Kazakhstan-China oil pipeline (from the Caspian Sea to Xinjiang, China) and the Baku-Tbilisi-Ceyhan oil pipeline (from the Caspian Sea to Georgia and Turkey). In the future, the natural gas trade will remain one of the most important objects of regional cooperation in the energy sector in the CAREC region, considering the ongoing development of the Turkmenistan-Afghanistan-Pakistan-India (TAPI) gas pipeline.[38] Other large-scale developments are the Central Asia Gas Pipeline[39] and the Trans-Caspian Gas Pipeline.[40] The Central Asia Gas Pipeline has Kyrgyzstan[41] and Tajikistan[42] segments scheduled to be commissioned in 2020.

Based on the above characteristics of ongoing energy cooperation, Table 2 illustrates how CAREC countries are interlinked in terms of energy trading, energy investments, and energy project development. It shows that the PRC is an active partner in the region, cooperating with seven CAREC member countries. Being on the crossroads of CAREC, Uzbekistan, Kazakhstan, and Tajikistan also play an important role in energy cooperation in the region. The role of Uzbekistan is important as CDC Energiya has a crucial role in CAPS. Kazakhstan is the largest energy supplier and Tajikistan plays an important role in connecting Afghanistan with Central Asia.

[34] These agreements include Nukus Declaration (1995), Protocol 566 (1997), and agreements on the use of the waters of the Syr Darya (1998) and Amu Darya (1999).
[35] Rogun HPP project is expected to boost hydropower exports and limit energy shortages and to be fully commissioned in 2032. With project cost of US$3.9 billion, it is financed by Salini Impregilo SpA and OJSC Rogun HPP. The objectives of the First Phase of Nurek Hydropower Rehabilitation Project for Tajikistan are to rehabilitate and restore the generating capacity of three power generating units of Nurek hydropower plant, improve their efficiency, and strengthen the safety of the Nurek dam.
[36] OECD, 2019, *Sustainable Infrastructure for Low-Carbon Development in Central Asia and the Caucasus: Hotspot Analysis and Needs Assessment*, Green Finance and Investment, OECD Publishing, Paris.
[36] World Energy Report, 2013.
[37] World Energy Report, 2013, https://www.worldenergy.org/assets/images/imported/2013/10/WER_2013_3_Natural_Gas.pdf
[38] With a length of 1,814km, which will have a capacity to carry 22 billion cubic meters of gas from Turkmenistan's Galkynysh field through Afghanistan, Pakistan, and India. US$7 billion project is financed by Turkmengas (85%), Afghan Gas Enterprise (5%), Inter State Gas Systems (5%), GAIL (5%).
[39] The project is the largest gas transmission system in Central Asia running from Turkmenistan to China through Uzbekistan and Kazakhstan. Currently, there are three lines of 1,830km from Turkmenistan to China through Uzbekistan and Kazakhstan. A fourth line (D) of around 1,000km is expected to be completed in 2020. The project is financed with US$7.5 billion by CNPC; Türkmengaz; Uzbekneftegas; KazMunayGas.
[40] The project involves the construction of a 300km-long pipeline that will transport 10 billion cubic meters of gas from Turkmenistan to Russia via Kazakhstan. US$3 billion project is financed by the Government of Azerbaijan.
[41] The project involves the construction of a 215km gas pipeline, which is a part of line D of the Central Asia-China gas pipeline network. It will have an estimated annual capacity of 30 bcm. Despite being a significant cross-border infrastructure project, it is not yet clear whether the country will receive or supply gas to the pipeline or play only a transit role.
[42] The fourth line, Line D, whose construction started in 2014 and is expected to be completed in 2020, will run 1,000km from Turkmenistan to China via Uzbekistan, Tajikistan, and Kyrgyzstan.

Table 2: Existing energy interlinks between CAREC countries

	AFG	AZE	PRC	GEO	KAZ	KGZ	MON	PAK	TAJ	TKM	UZB
AFG								√	√		√
AZE				√	√						
PRC					√	√	√	√	√	√	√
GEO		√									
KAZ		√	√			√			√		√
KGZ			√		√				√		√
MON			√								
PAK	√		√								
TAJ	√		√		√	√					√
TKM			√								√
UZB	√		√		√	√			√	√	

Source: Author's assessment
Note: AFG=Afghanistan, AZE=Azerbaijan, PRC=the People's Republic of China, GEO=Georgia, KAZ=Kazakhstan, KGZ=Kyrgyzstan, MON=Mongolia, PAK=Pakistan, TAJ=Tajikistan, TKM=Turkmenistan, UZB=Uzbekistan.

Georgia, Mongolia, and Pakistan are least integrated in energy cooperation with other CAREC countries owing to physical distance and connectivity constraints. Pakistan is putting high expectations on TAPI, TUTAP and CASA-1000 for being connected through Afghanistan. So far, the PRC has invested over US$12 billion in energy projects for combined capacity of 7,240MW under the China-Pakistan Economic Corridor (CPEC) cooperation,[43] including notable projects in Sahiwal in Punjab, Port Qasim at Karachi, HUBCO in Hub Balochistan, and SSRL Thar Coal Block-I.[44] For Mongolia, there are ongoing discussions with its neighbors on the development of a Russia-China gas pipeline through Mongolia. Mongolia concluded a memorandum of understanding with Russia on a feasibility study for the pipeline in December 2019.

4. Low-carbon energy development in the CAREC region

This section provides an overview of the current situation of the CAREC countries in terms of their targets, efforts, and progress on reducing GHG emissions, and promoting renewable energy and energy efficiency.

Deployment of renewable energy helps to reduce not only energy intensity in the region, but also helps the countries to secure national energy independence.[45] As part of the commitment to the UNFCCC, all CAREC countries set their GHG emission targets by outlining their NDCs. In addition, all CAREC countries set their objectives for renewable energy and energy efficiency, and establishing the necessary legal and regulatory frameworks for their efforts to achieve low-carbon growth.

[43] China-Pakistan Economic Corridor: China made total US$12 billion investment in 12 energy projects under CPEC: http://www.cpecinfo.com/
[44] All four projects are with estimated average capacity of 1,340MW and average cost of US$1.9 billion.
[45] Anatole B, 2019. *Energy Security along the New Silk Road Energy Law and Geopolitics in Central Asia*, Cambridge University Press.

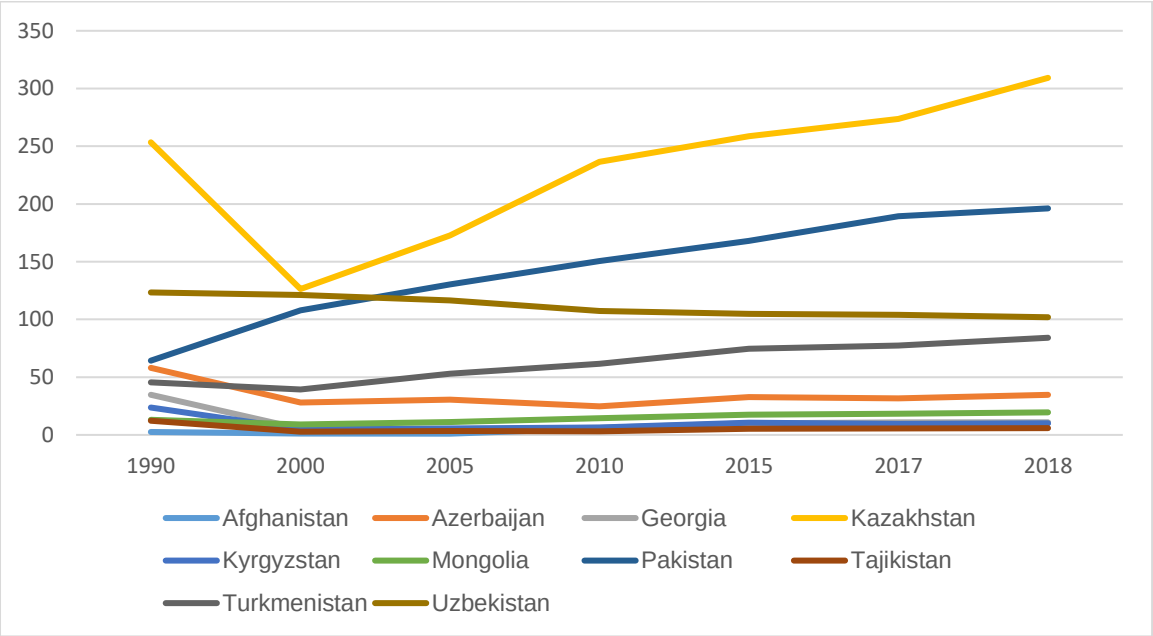
4.1. GHG emission in CAREC countries

Energy-related CO_2 emissions in Central Asia are driven mainly by economic activity and population growth.

Undoubtedly, the PRC is the largest GHG emitter in the CAREC region and the world, given its population size and fast-growing economy. According to the IEA, the PRC's emission levels reached 11,255 million metric tons (Mt) of CO_2 in 2018, which accounts for 29.7% of total global CO_2 emissions.

CO_2 emission levels have been uneven (Figure 6) in CAREC. Kazakhstan is the 22nd largest carbon emitter in the world. Its emission levels continuously declined until 2000; but went up again and reached 309 million Mt by 2018. CO_2 emissions in Pakistan increased by three times from 64.31 million Mt in 1990 to 196.18 million Mt in 2015, whereas emission levels in Azerbaijan, Georgia, and Tajikistan gradually decreased. Georgia's CO_2 emission levels fell four times from 34 million Mt in 1990 to 11 million Mt in 2018. Tajikistan, Georgia, and Kyrgyzstan have the lowest CO_2 emissions, 5.93 million Mt, 11 million Mt, and 10.13 million Mt, respectively.[46]

Figure 6: CO_2 emission levels in CAREC countries (million Mt)

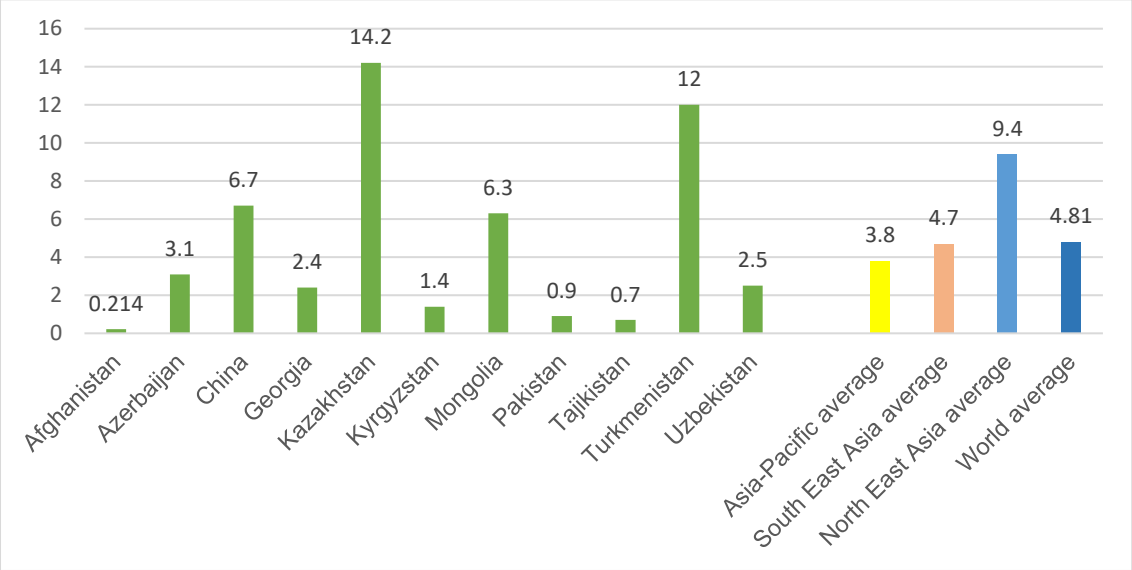


Source: Author's comparison, IEA World Energy Balances 2019 and BP Statistical Review of World Energy
Note: Excluding the PRC. The latest available data is for 2018.

In terms of CO_2 emissions per capita (Figure 7), Kazakhstan (14.2) and Turkmenistan (12) stand far above the rest of CAREC countries owing to extensive use and export of fossil fuels, the PRC (6.7) and Mongolia (6.3) are above the Asia-Pacific average (3.8) and the global average (4.81). Afghanistan, Pakistan, Tajikistan, and Kyrgyzstan have the lowest emissions per capita in the region.

[46] Data from International Energy Agency Statistics and Data: https://www.iea.org/data-and-statistics

Figure 7: CO_2 emissions per capita of CAREC countries in comparison to other Asia-Pacific subregions (Mt CO_2 per capita)



Source: Author's calculation, IEA World Energy Balances 2019, WB data, and UNESCAP statistical database
Note: The latest available data is for 2017.

The largest share of the Asia-Pacific region's emissions came from the energy sector, which was responsible for 50% of CO_2 emissions. The energy sector's contribution to CO_2 emissions within CAREC varies owing to the difference in the energy mixes of the countries. Dominated mainly by fossil fuels in many countries, the share of the energy sector, including electricity and heating, in domestic CO_2 emissions reaches up to 60% in Mongolia and Kazakhstan. The low level of CO_2 emissions per capita in Tajikistan, Kyrgyzstan, and Georgia is because of the high share of hydropower in overall energy generation.

4.2. GHG emission reduction policies and actions in CAREC countries

Under the obligations set by the Paris Climate Agreement, CAREC countries' targets to reduce GHG emissions range from 10% to 20% by 2030 (Table 3). All parties to the agreement are required to regularly update their emissions status and implementation efforts.

The PRC's total CO_2 emissions from fuel combustion increased by almost 340% between 1990 and 2014. The adoption and implementation of a number of national policies, such as the National Plan on Climate Change (2014-2020)[47] and the Action Plan for Energy, Conservation, Emission Reduction, and Low-Carbon Development (2014-2015), aim to reduce GHG emissions in stages. The PRC lowered its CO_2 emissions per unit of GDP by 45.8% in 2018 from 2005 levels, meeting the target of 40% to 45%.[48] In 2014, the PRC started carbon emission trading in seven major cities and provinces, covering more than 1,900 emission-control enterprises and units and allocating about 1.2 billion tons of carbon emissions quota. By the end of 2020, the PRC aims to establish a nationwide emission trading system (ETS).[49]

Table 3: Emission targets of CAREC countries

COUNTRIES	NDC TARGETS
AFGHANISTAN	13.6% reduction in GHG emissions by 2030 compared to 2005 and conditional to external support.
AZERBAIJAN	35% reduction in GHG emissions by 2030 compared to 1990.
CHINA	60% reduction of CO_2 emissions per unit of GDP against 2015 by 2030.
GEORGIA	15% reduction in GHG emissions by 2030 compared to 2013. Supported by technical cooperation including financial resources and technology transfer, the target would be raised to 25% by 2030.
KAZAKHSTAN	15% reduction in GHG emissions by 2030 compared to 1990, which could reach 25% if supported by international investments, access to technologies, and green climate funds.
KYRGYZSTAN	11.49%-13.75% reduction in per capita GHG emissions by 2030 compared to 2010 BAU levels. Limiting per capita GHG emissions to maximum of 1.23 t/CO_2, or 1.58 t/CO_2 in 2050 to achieve the below 2°C objective, with a probability of 66% and 50% respectively.
MONGOLIA	Reduction of GHG emissions from the energy sector by 7.3Mt CO_2-equivalent by 2030, corresponding to a 14% reduction compared to the 2014 level.
PAKISTAN	20% in GHG emissions reduction by 2030 compared to baseline 2015 with conditional international financial support estimated at about US$40 billion at current prices.
TAJIKISTAN	Flexible target not exceeding 80%-90% of its GHG emissions as of 1990 levels by 2030, which could be lowered to 65%-75% of GHG emissions conditionally to international support.
TURKMENISTAN	Unconditional target of stabilizing GHG emissions per unit of GDP growth by 2030.
UZBEKISTAN	10% reduction of GHG emissions per unit of GDP by 2030 against 2010 levels. Solar energy deployment to reduce carbon emissions from 5.3Mt CO_2-equivalent (worst case scenario) up to 14.4Mt CO_2-equivalent (best case scenario) by 2030.

Source: All based on national determined contributions (NDCs) and nationally appropriate mitigation actions (NAMA) by countries, Asia Pacific Energy Portal.

[47] The National Development and Reform Commission, *China's Policies and Actions on Climate Change*, 2015.
[48] China beats annual target for cutting carbon emissions in 2018, Xinhua, 2019-11-27. http://www.xinhuanet.com/english/2019-11/27/c_138587179.htm
[49] Reuters, *China to make national carbon trading 'breakthrough' by year-end: official*, 14 January 2020.

Kazakhstan is planning to become one of the 30 most developed countries in the world by 2050. The 2012 law on energy saving and energy efficiency, the 2009 law on the promotion of renewable energy sources and the concept on transition to green economy are key national policies to achieve low-carbon development. Kazakhstan launched an ETS in January 2013 through amendments to its environmental legislation in 2011.[50] The current national allocation plan runs through 2018 to 2020 with a cap of 485.9Mt CO_2 (162Mt CO_2 on annual average), with 225 participating installations belonging to 129 operators.[51]

Kyrgyzstan started developing the concept of low-carbon development in 2016, which determines a plan of actions on CO_2 emissions reduction and supports the development of the legal and monitoring basis.

Mongolia adopted the 2014 National Green Development Policy to respond to the need for a green development model across social, economic, and environmental spheres, as well as to reduce GHG emissions.

Pakistan is working on a strategy to ensure energy security, to save energy, and to improve energy efficiency that also reduces GHG emissions. Under its NDC, Pakistan intends to reduce up to 20% of its 2030 projected GHG emissions, subject to international financial support estimated at US$40 billion at current prices. Pakistan is also considering market-based climate policy instruments, including an ETS, to tap into low-cost abatement opportunities and leverage low-carbon investments.

Given the country's massive use of hydropower resources, Tajikistan's contribution to CO_2 emissions from fossils is considerably smaller than in other countries. In its NDC, Tajikistan committed to a soft target of not exceeding 80% to 90% of its 1990 GHG emissions levels by 2030, which could be lowered to 65% to 75% of the 1990 GHG emissions.

Turkmenistan's measures for reducing GHG emissions by using energy efficient technologies and expanding the renewable energy sector are reflected in the 2011 National Program on Socio-Economic Development for 2011-2030 and the 2012 National Climate Change Strategy.

Uzbekistan is committed to reducing its GHG emissions per unit of GDP by 10% by 2030 against 2010 levels. In order to achieve the set target, a pivotal role will be played by energy efficiency and renewable energy development.

The reduction in GHG emissions is not easy and requires substantial investment in many sectors. Since the adoption of the Paris Climate Change agreement in 2015, only Kyrgyzstan and Uzbekistan achieved a reduction in GHG emission levels by 5% and 3%, respectively, in 2018. Kazakhstan's and Pakistan's GHG emission levels increased by 19% and 17%, respectively.

4.3. Renewable energy development and cooperation in CAREC countries

A recent IRENA study indicates that more than half of the renewable capacity added in 2019 achieved lower electricity costs than electricity from new coal.[52] Given the recent global progress in renewables technology, in reducing costs, and the existing wind, solar, and biomass resources (Table 4), along with the large hydropower capacities installed in the region, the CAREC countries have better opportunities now for tapping clean, cost-effective, and sustainable energy resources.

[50] EBRD and Thomson Reuters Point Carbon, 2014, *The Domestic Emissions Trading Scheme in Kazakhstan*.
[51] International Carbon Action Partnership, 03 June 2020, Kazakhstan Emissions Trading Scheme.
[52] IRENA (2020), *Renewable Power Generation Costs in 2019*, International Renewable Energy Agency, Abu Dhabi.

Table 4: Potential for installed renewable resources in CAREC countries

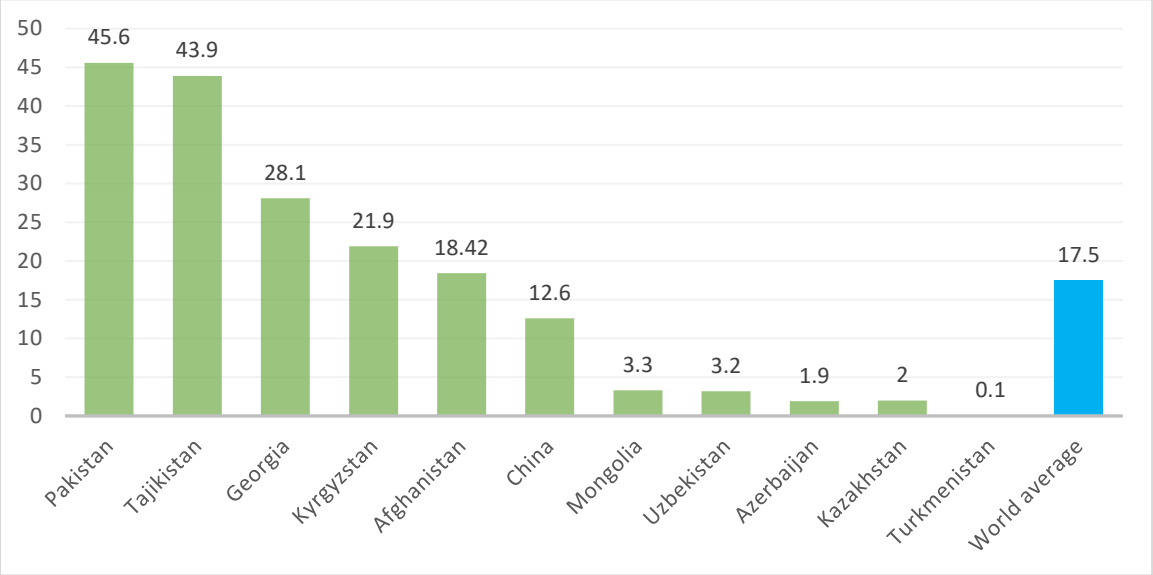
COUNTRY	SOLAR	WIND	HYDRO	BIOMASS
AFG[53]	222,000MW	66,700MW	23,000MW	n/a
AZE[54]	23,040MW	3,000MW	520MW (small hydro)	380MW
PRC (XUAR ONLY)[55]	20% of the PRC	134,300MW	15,670MW	n/a
GEO[56]	108MW	1,450MW	15,630MW	n/a
KAZ[57]	3,760,000MW	354,000MW	170 billion kWh	300MW
KGZ[58]	267,000MW	1,500 MW	18,500MW	200MW
MON[59]	4774TWh/year	1,113,300MW	3,800MW	
PAK[60]	20,000MW (Sindh and Baluchistan only)	340,000MW	n/a	1,844MW (bagasse only)
TAJ[61]	195,000MW	2,000MW	23,000MW	300MW
TKM	n/a	n/a	n/a	n/a
UZB[62]	593,000MW	1,600MW	1,700MW	800MW

Note: For potential technically exploitable renewable energy resources. Data is not for comparison, since some is available based on capacity (MW) and some is available on output (MWh)
AFG=Afghanistan, AZE=Azerbaijan, PRC=the People's Republic of China, GEO=Georgia, KAZ=Kazakhstan, KGZ=Kyrgyzstan, MON=Mongolia, PAK=Pakistan, TAJ=Tajikistan, TKM=Turkmenistan, UZB=Uzbekistan.

All CAREC countries highlighted the role of renewable energy development and energy efficiency for reducing GHG emissions in their national strategies and energy sector policies. The share of renewable energy consumption in total energy consumption (Figure 8) is higher than the global average of 17.5% in Pakistan, Tajikistan, Georgia, and Kyrgyzstan owing to the deployment of hydropower resources. Mongolia, Uzbekistan, Azerbaijan, Kazakhstan, and Turkmenistan are way behind. Pakistan and Afghanistan also have extensive use of biomass for energy in rural areas.

[53] WB, 2018. *Afghanistan Renewable Energy Development Issues and Options*.
[54] IRENA, 2019. *Renewable Readiness Assessment, Republic of Azerbaijan*.
[55] Power Magazine, *The Energy Industry in Xinjiang, China: Potential, Problems, and Solutions*, 31 December 2015.
[56] Chomakhidze D, Melikidze M (2018) *Renewable Energy Potential and Its Utilization in Georgia*. J Envir Sci Renew Res 2(2): 105.
[57] Vakhguelt, Anatoli. (2017). *Renewable Energy Potential of Kazakhstan*. Defect and Diffusion Forum. 379. 189-194.
[58] Presentation of the Ministry of Energy of the Kyrgyz Republic, 2010, Astana Forum, Sept 2010.
[59] IRENA, 2016. *Renewable Readiness Assessment: Mongolia*.
[60] IRENA, 2018. *Renewable Readiness Assessment: Pakistan*.
[61] ADB: *Tajikistan Partnership strategy*, 2016-2020.
[62] Shadrina, E. 2019. *Renewable Energy in Central Asian Economies: Role in Reducing Regional Energy Insecurity*. ADBI Working Paper 993. Tokyo: Asian Development Bank Institute.

Figure 8: Share of renewables in final energy consumption, 2016

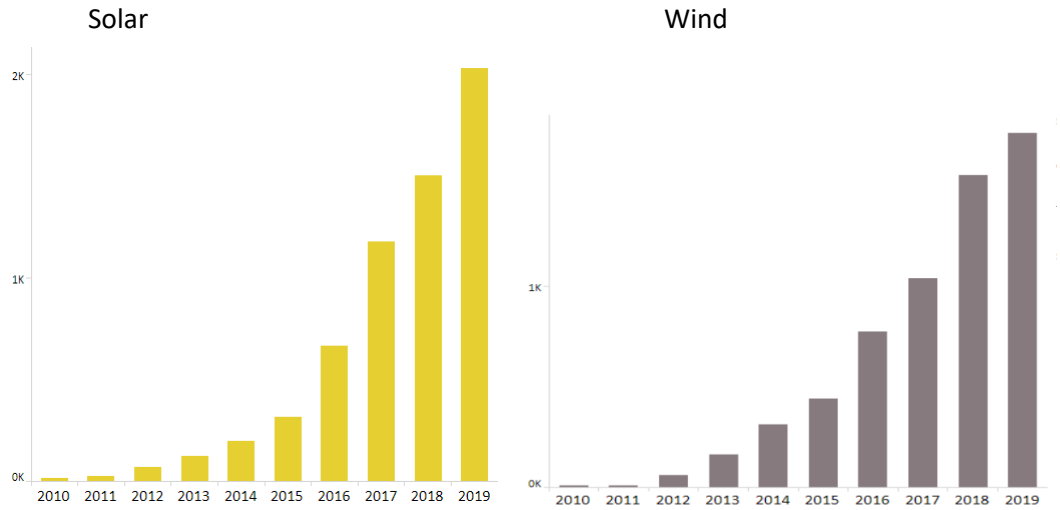


Source: Author's comparison, IEA data
Note: The latest available data is for 2016.

Except for the existing hydropower capacities in Tajikistan, Georgia, Kyrgyzstan, and Kazakhstan, the development of 'new' or 'non-hydro' renewables in the CAREC region is still at a very early stage (except for the PRC). However, Figure 9 depicts the significant progress in installed capacity of solar and wind energy generation in the CAREC region from 2010 to 2019, excluding the PRC.

Although the current combined installed capacity of CAREC solar power surpassed 2GW only in 2019 and wind power is still below 2GW today, the pace of new renewable energy development has been remarkable in the last decade. With almost negligible solar and wind power capacity in 2010, the combined new renewable capacity in the CAREC region will soon reach 4GW.

Figure 9: Installed solar and wind energy capacity in the CAREC region, (excluding PRC), 2010-2019 (MW)



Source: Author's calculation, IRENA data.

Advancement in the production and costs of renewable energy technology in the PRC, and with the belt and road initiative routes crossing the CAREC region, the PRC will play a major role as investor and developer of renewable energy resources in Central Asia. In addition, the PRC can share its vast

expertise in terms of technology, project development, and resource mobilization. In 2011, the PRC produced 63% of the world's solar panels. The PRC's success in the production of solar panels[63] is characterized by setting national targets, strong enforcement mechanisms, reduced cost and higher efficiency bringing down the average cost of solar power in the PRC, and revenue-driven business models.[64]

Not only the PRC, but all CAREC countries set renewable energy targets within its NDC commitments (Table 5), with ambitious targets of reaching a 30% of renewable energy share by Kazakhstan and Mongolia and a 20% share by Azerbaijan and Tajikistan by 2030.

Table 5: Renewable energy targets of CAREC countries

COUNTRY	NDC TARGETS
AFGHANISTAN	Electricity production from hydropower, solar, wind, and biomass, as well as deployment of alternative and renewable energy sources for 25% of the rural population above existing levels (15%) at an estimated cost of US$105 million.
AZERBAIJAN	By 2020, 20% of electricity consumption of Azerbaijan must be met by electricity generated from renewable energy sources. Azerbaijan aims to reach a cumulative renewable power capacity of 2GW by 2020.
CHINA	Increasing the share of non-fossil fuels in primary energy consumption to around 20% in 2030, and to increase installed renewable power capacity to 680GW by 2020.
GEORGIA	To leverage on its unexploited renewable energy potential, especially focusing on hydropower through local and international investment support. Georgia's NDC does not mention specific renewable nor does it include renewable energy targets.
KAZAKHSTAN	Renewable and alternative sources of energy in the form of solar, wind, and nuclear power are targeted to form 30% of power generation capacity by 2030 and 50% by 2050 over 2008 levels.
KYRGYZSTAN	To construct 28 small hydropower plants with the total cumulative capacity of 495MW by 2012.
MONGOLIA	Achieving 20% of electricity generation from renewables by 2020 and 30% by 2030.
PAKISTAN	To achieve a minimum of 9,700MW of renewable energy supply by 2030.
TAJIKISTAN	To increase the energy production from renewable energy by 20% by 2030 from 2013.
TURKMENISTAN	Turkmenistan's NDC does not include quantified renewable energy targets.
UZBEKISTAN	Achieve share of renewable energy from 12.7% (2016) to 19.7% by 2025 in the total energy mix, including the growth of hydropower energy up to 15.8%, solar up to 2.3%, and wind power by 1.6%.

Source: IRENA, 2017, Untapped-potential-for-climate-action-NDC and UNFCCC.

Currently, there are notable renewable energy projects under way involving CAREC countries' partners, such as the construction of a 200MW wind farm in the Caspian Sea part of Azerbaijan, with US$510 million financed by China's Export Import Bank. Another large renewable energy project is Pskem HPP in Uzbekistan, financed by China's Export-Import Bank. The Pskem HPP will be the second largest HPP in Uzbekistan with the capacity to produce 900 million kWh of electricity per year. In Kazakhstan, there were 83 renewable energy facilities with an installed capacity of 936.8MW,

[63] The study by researchers at the Massachusetts-based MIT and the Energy Department's National Renewable Energy Laboratory.
[64] Solar Feeds, https://solarfeeds.com/solar-power-statistics-in-china/

including 18 wind, 27 solar, 35 hydroelectric power plants, and three bioelectric power plants as of the end of 2019.[65]

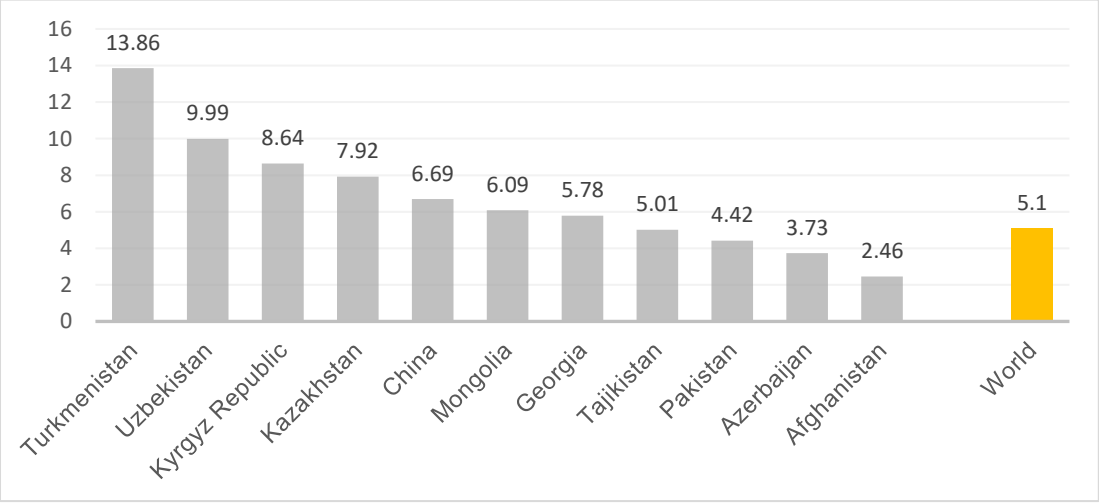
Georgia is one of the most advanced countries in terms of renewable energy development in the CAREC region. Georgia is currently undertaking the Tskhenistskali cascade of HPP, the Shuakhevi HPP project, the Oni cascade HPP project, and the Adjaristsqali HPP project, which are financed by multilateral financial institutions and private multinational companies; however, the involvement of CAREC partners is limited. The Georgian Co-investment Fund plays an important role in financing the development of large-scale hydropower projects in Georgia. With a combined capacity of over 2,000MW, these projects will significantly increase the current renewable energy capacity.[66]

4.4. Energy efficiency policies in CAREC countries

Energy efficiency improves the economic competitiveness of countries and businesses, makes energy more affordable for consumers and reduces GHG emissions. The CAREC Energy Strategy 2030 highlights that regional energy efficiency continues to be low because of old and aging infrastructure, low energy pricing, and the lack of necessary policy and regulatory support.

Figure 10 illustrates the energy intensity level of primary energy in CAREC countries. On average, the energy intensity (level of primary energy per unit of GDP) levels of the CAREC countries are higher than the global average.[67] Turkmenistan was almost three times higher, whereas Uzbekistan, Kyrgyzstan, and Kazakhstan were twice higher than the world average in 2015. Energy intensity in Azerbaijan, Pakistan, and Afghanistan is below the world average of 5.1 (MJ/$2011 PPP GDP). Since 2000, the CAREC countries have made considerable progress in reducing their energy intensity. For example, Uzbekistan's energy intensity level of primary energy consumption fell from 35 in 2000 to 9.99 in 2015. Turkmenistan's energy intensity decreased from 25 in 2000 to 13.86 in 2015.

Figure 10: Energy intensity level of primary energy in CAREC countries, 2015 (MJ/US$2011 PPP GDP)

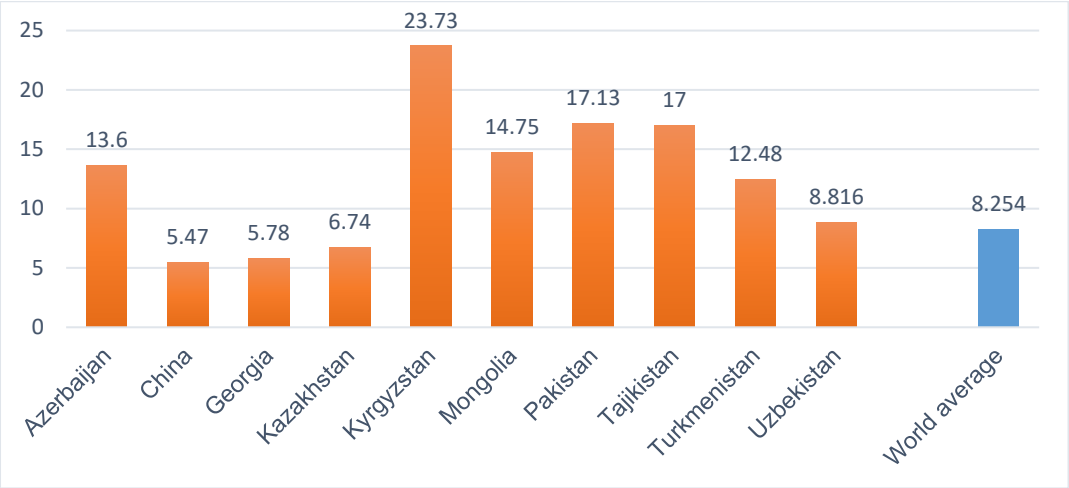


Source: World Bank, Sustainable Energy for All (SE4ALL) database
Note: Latest data available for 2015.

[65] Prime Minister's Office of the Republic of Kazakhstan.
[66] OECD, 2019, *Sustainable Infrastructure for Low-Carbon Development in Central Asia and the Caucasus: Hotspot Analysis and Needs Assessment*, Green Finance and Investment, OECD Publishing, Paris.
[67] Energy intensity indicates energy efficiency of an economy. Energy intensity measured in terms of primary energy and GDP. The CAREC energy intensities are measured in megajoules per US dollar 2011 purchasing power parity GDP (MJ/$2011 PPP GDP).

Energy efficiency in electricity transmission and distribution is low in the CAREC region (Figure 11) because of the outdated electricity infrastructure. Despite having substantial hydropower resources, electric power transmission losses are the highest in Kyrgyzstan (23%), Pakistan (17.13%), and Tajikistan (17%).

Figure 11: Electricity transmission and distribution losses (%), 2014



Power sector reforms and modernization of electricity grids helped Georgia and Kazakhstan to reduce its electricity transmission and distribution losses substantially. Georgia achieved a loss reduction from 16% of the electricity transmitted and distributed in 1995 to almost 5% in 2014.

In terms of energy efficiency policy, CAREC countries set policy targets, and mandatory and enabling policy actions in different sectors, such as energy, transportation, and building.

Afghanistan's 2015 National Renewable Energy Policy promotes energy efficiency in the renewable energy project cycle, in labelling of appliances, energy audits of buildings, and ratings of buildings.

Georgia's 1997 Law on Electricity and Natural Gas focuses on efficiency promotion in the areas of electricity generation, transmission, import, export, and consumption, as well as natural gas supply and distribution. The 2015 Energy Policy for Georgia enables measures to develop an integrated approach to energy efficiency and to preserve energy resources.

In 2012, Kazakhstan adopted the Law on Energy Saving and Energy Efficiency, which set out the legislative framework for energy-efficient, low-carbon development. Provisions include the introduction of energy standards across different sectors, capacity building and energy audits in industries and buildings, and the establishment of a national energy register to monitor energy consumption.

Kyrgyzstan's main legal framework is the 1998 Law on Conservation of Energy, which was amended in 2019.[68] The 2015 program on energy conservation and energy efficiency policy planning set as targets that by 2020 the saved energy should be 4.1 million toe and for the period 2015-2025 the energy intensity should be reduced by 30%, while the total annual energy consumption should decrease by up to 5%, equaling 8 million toe of saved energy.

[68] Kyrgyzstan: Law on Conservation of Energy No. 88 of 1998 (2019 Edit).

The 2015 Energy Conservation Law of Mongolia mandates energy efficiency at different administrative units. The 2014 green development policy aims to reduce power transmission losses from 13.7% in 2014 to 10.8% in 2020 and to 7.8% by 2030.

The implementation of energy efficiency initiatives is relatively new in Pakistan. Although the National Energy Conservation Center was established in 1985, it is only through the recent creation of the Energy Efficiency Authority under the 2016 Energy Efficiency and Conservation Act that the country is expected to realize energy efficiency improvements.[69] With the 2013 national power policy, Pakistan is promoting energy efficiency through a demand-side management strategy, establishing minimum efficiency standards and banning imports of non-compliant consumer appliances.

Tajikistan's 2013 Law on Energy Conservation and Energy Efficiency provides energy efficiency and conservation measures in all energy-dependent economic and residential sectors.

Turkmenistan has no specific legislation on energy conservation and energy efficiency; however, it promotes sustainable energy and efficient technologies at the household and companies' level, as described in the 2014 Power Act and the 2013 Law on Hydrocarbon Gas and Gas Supply.

Uzbekistan regulates energy saving under the 1997 Law on Rational Use of Energy Sources and the 2017 Program of Measures of Further Deployment of Renewable Energy and Improvement of Energy Efficiency in Economic and Social Sphere 2017-2021. The program aims at reducing energy intensity by 8% to 10% annually in key economic sectors.

4.5. Assessment of low-carbon energy development in the CAREC region

The cooperation among CAREC countries on low-carbon energy development is still at the infancy stage, applying 'information sharing' and 'limited coordination,' according to the classification given by the Meulman model provided in Section 2.3. However, considering the respective policy targets already set to achieve diversification of the energy mix, emission reduction, renewable energy, and energy efficiency in all CAREC countries, regional cooperation should move to the next level, which is 'coordination plus,' characterized by the search for common policy considerations for renewable energy development, investment, technology deployment, exchange of knowledge, and expertise.

An initial step forward to establishing regional cooperation on renewable energy was the release of the joint communiqué by energy ministers from Central Asia during the Astana Expo in 2017.[70] The communiqué aimed to initiate a regional platform for cooperation in developing the renewable energy potential and cooperation in various areas with support from IRENA, such as in resource assessment, integration of variable renewable energy into power grids, developing policies and regulations for renewable energy deployment, collection of renewable energy statistics and data, support for project development, and awareness-raising for decision-makers.[71]

[69] Pakistan: National Energy Efficiency and Conservation Act, 2016.

[70] The 'Astana Communiqué on Accelerating the Uptake of Renewables in Central Asia' was released at the conclusion of the Ministerial Dialog on 'Renewable Energy in Central Asia' held in the context of the Eighth International Forum on Energy for Sustainable Development and Ministerial Conference themed 'Meeting the Challenges of Sustainable Energy' Astana Expo 2017.

[71] IRENA is planning to support Central Asia in several key areas: i) resource assessments by ensuring detailed and up-to-date information on the renewable energy potential available in each country, supporting the planning process for the expansion of power generation and transmission; ii) integration of variable renewable energy into power grids by improving understanding of technical and regulatory aspects, including design, operation and planning; and facilitating the planning, construction and operation of power grids with substantial shares of variable renewables, iii) policies and regulations for renewable energy deployment by strengthening enabling frameworks for renewables, including support schemes to facilitate investments, and ensuring decision-making based on reliable data, iv) renewable energy statistics and data collection by helping to advance the collection of data for renewables and harmonizing it with international standards, as well as making the resulting information freely accessible through publications or online resources, v) project development support by engaging the private sector's involvement in renewable energy development in the region, through a range of actions, including improving the bankability of renewable energy projects, demonstrating best practices, and encouraging enhanced regional

There are a number of active players in the region that support regional cooperation in low-carbon development, renewable energy, and energy efficiency. These include the ADB-supported CAREC Program, the WB Central Asia Water and Energy Program (CAWEP),[72] the Central Asia-South Asia Regional Electricity Market (CASAREM), the European Union INOGATE Program,[73] the European Bank of Reconstruction and Development (renewable energy investment projects in Central Asia), the UNDP Europe and the CIS Sustainable Energy for All (SE4ALL), and the Eurasian Development Bank (renewable energy investment projects in Central Asia).

There is growing interest and investment in renewable energy project development by multilateral development banks (MDBs), such as ADB, WB, EBRD, EDB, and Islamic Development Bank (IsDB), and private investors. However, most of the projects are restricted to individual CAREC countries.

An analysis of the projects implemented by key CAREC development partners, such as ADB, WB, EBRD, UNDP, and IsDB between 2010 and 2020 (Appendix 1), shows that the majority of energy cooperation projects focused on electricity trading and electricity market development, such as by investing in new transmission networks and the modernization of existing electricity grids.

On renewables, most of the projects were mainly hydropower developments supported by ADB, WB, EBRD, and IsDB. There has been limited regional cooperation on energy efficiency in terms of investment, dialog, and regional knowledge sharing.

There have been a number of regional knowledge sharing activities supported by CAREC development partners: Preparing Sustainable Energy Projects in Central Asia (2019-2020) and Study for a Power Sector Financing Roadmap within CAREC, which are supported by ADB; Enhancing Regional Power Trade Study for the four Central Asian countries of Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan for 2010-2014, and the Central Asia Water and Energy Program (CAWEP), which are supported by the WB; and Europe and the CIS Sustainable Energy for All (SE4ALL) Program initiated by UNDP.

5. Conclusion

Based on the gained momentum of technological advances, declining prices, and acquired experience in exploiting solar, wind, and biomass energy over the last decade, CAREC has the potential to accelerate regional cooperation in low-carbon energy development. Investments in developing new electricity transition networks, modernization to increase the capacity and reliability of the existing electricity grids, and investments in developing alternative energy sources, such as hydro, solar, and wind, will undoubtedly support the low-carbon transition process in the region.

dialog on renewable energy finance and risk mitigation, and vi) awareness raising: advancing understanding among decision makers and the public about cost-competitiveness and related macro-economic and socio-economic benefits of renewables, along with facilitating a regional dialog to help improve the perception and visibility of renewable energy in Central Asia and beyond.

[72] The Central Asia Energy-Water Development Program (CAEWDP), initiated in 2009 and renamed as the Central Asia Water and Energy Program (CAWEP) in 2019, is implemented by the World Bank through a multi-donor trust fund. The program aims at i) improved policy frameworks that promote achievement of water and energy security adopted at national level; ii) promotion of a regional framework supporting water and/or energy security informed by the program; iii) strengthened capacity in regional and national institutions responsible for water and/or energy resources management in beneficiary countries; and iv) leveraged/informed US$2.5 billion (US$0.8 billion for the third phase) of investments contributing to water and energy security at regional level and in beneficiary countries, including regional power trade.

[73] INOGATE cooperates with 11 partner countries to support a reduction in their dependency on fossil fuels and imports, improve the security of their energy supply, and mitigate overall climate change. In Caucasus region, it supports Armenia, Azerbaijan, and Georgia with its Secretariat in Tbilisi and in Central Asia it works with Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan with its Secretariat in Tashkent.

5.1. Challenges

1) Lack of governance arrangements in the electricity trade: CAREC and other energy cooperation mechanisms lack standard energy arrangements, where a set of rules about how countries trade with each other and how to mitigate existing barriers provides the necessary mechanisms for negotiation and dispute resolution. An analysis of initiatives aimed at the reintegration of CAPS showed that neither intergovernmental agreements, nor the intervention of third parties as mediators, nor numerous reports showing the advantages of regional cooperation in the energy sector were able to ensure the stable and reliable trade of electricity in the region.

2) Reliance on fossil fuels: Fossil fuels remain a major source of budgetary income and the first choice of energy source for a number of CAREC countries. Therefore, a shift to renewable energy may take more time owing to cost considerations. Limited expertise, experience, and resources for developing renewable energy projects may present an additional challenge.

3) The inefficient and aging regional electricity infrastructure: A reliable and modern electricity grid system is critical for meeting the growing electricity demand, and the development and connection of new energy systems, particularly renewable energy. The aging electricity infrastructure both in generation and distribution and high energy losses of transmission lines in many CAREC countries may reduce the efficiency and competitiveness of the electricity trade.

5.2. Opportunities

1) Reduced cost of renewable technology: Reductions in renewable energy costs and the emerging competitiveness of renewable energy against fossil-fuel powered power plants open up opportunities for the development of renewable energy in the CAREC region. The costs of electricity generated from new solar plants were lower than the costs of electricity produced by new coal-fired power plants in Uzbekistan, India, and Cambodia in 2019.[74]

2) Global investment shift to low-carbon energy: With increased awareness over the issues of climate change and strong emphasis on low-carbon development, MDBs are moving away from typical brown energy investment and shifting their attention to more resilient and innovative solutions, such as renewables. Thus, the steady rise in green investments, green bonds, and concessional funding may push the CAREC countries to choose more renewable energy options.

3) Cost-effectiveness of cooperation in low-carbon development: Once energy-rich countries are able to connect to new energy-sharing infrastructure, it will enable them to utilize and develop new power supplies. With high population and economic growths, the CAREC region is projected to have growing energy demands. For example, in the ASEAN region a regionwide energy-sharing system enables countries with lower electricity penetration, such as Myanmar and Cambodia, to benefit from countries with excess capacity in their systems.

[74] Zhai Y, The pandemic may break value chains, but solar energy can still shine, ADB Blogs, Published: 26 March 2020, https://blogs.adb.org/pandemic-may-break-value-chains-but-solar-energy-can-still-shine

5.3. Recommendations

1) Harmonization of legal and regulatory frameworks, as well as technical standards for power connectivity and trade within CAREC: Harmonization of necessary frameworks and standards can reduce joint project costs. Collective efforts help to optimize the use of resources, data, and information.

2) Cross-border technology transfer, knowledge exchange, research, and public awareness: Shared information, awareness, knowledge, and research and development increase the likelihood of the interest and engagement of CAREC countries in low-carbon development, as well as promoting trust and cooperation within CAREC. Regional low-carbon research and development mechanisms can not only demonstrate and promote the development and application of low-carbon technologies, but also reduce the investment risk for energy development projects.

3) Participation of all relevant stakeholders in energy cooperation: Engagement and participation of all key stakeholders, particularly market participants and the private sector, ensure pragmatic and practical solutions. The cooperation between government institutions, including regulatory authorities, transmission operators, development partners, investors, and market actors increase the likelihood of successful regional cooperation.

4) Sustainable solutions for better integration of renewable energy into the electricity grid: A major challenge for the deployment and connection of large-scale renewable resources to the grid is capacity fluctuations, which are associated with the intermittent nature of solar power plants in the evening and at night. This can be resolved by improved renewable energy capacity forecasting mechanisms and battery storages based on the latest innovative solutions.

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Appendix: Projects of development partners in low-carbon energy development in CAREC, 2010-2020

Energy cooperation	ADB	WB	UNDP	IsDB	EBRD
Energy (electricity) trading and market development	Regional Cooperation on Increasing Cross-Border Energy Trading within the Central Asian Power System—Expansion of Membership in Central Asian Power System (Subproject 3) (US$0.5 million) 2019-2021 Regional Cooperation on Increasing Cross-Border Energy Trading within the Central Asian Power System—Provision of Solutions to Bottlenecks to the Regional Power Trade (Subproject 2) (US$1.5 million) 2019-2021 Regional Cooperation on Increasing Cross-Border Energy Trading within the Central Asian Power System—Modernization of Coordinating Dispatch Center Energiya (Subproject 1) (US$2.5 million) 2019-2021 Energy Supply Improvement Investment Program, Tranche 1, 306km (approximately) of 500kV transmission line from Sheberghan to Dashte Alwan operational; 66km (approximately) of 220kV transmission line from	Central Asia-South Asia Regional Electricity Market (CASAREM). The Central Asia and South Asia Regional Electricity Trade Project (CASA-1000) [75](US$1,170 million WB, EIB, ARTF, IsDB, US Government, DFID, EBRD: • 500kV AC line from Datka (in Kyrgyzstan) to Sugd-500 (477km away, in Tajikistan) • 1,300MW AC-DC convertor station at Sangtuda (Tajikistan) • 750km high voltage DC line from Sangtuda (Tajikistan) to Nowshera (Pakistan) • 1,300MW DC-AC convertor station at Nowshera (2014-2023) Electricity Supply Accountability and Reliability Improvement Project (US$25 million)—2014-2019			Investments in over 75 projects in CAREC countries, mainly in development of renewable power plants

[75] https://www.worldbank.org/en/news/speech/2016/05/10/central-asia-south-asia-electricity-transmission-and-trade-project-casa-1000

	Sheberghan to Andkhoy completed) (US$280 million) ADB, co-financed by Afghanistan Infrastructure Trust Fund and Government of Afghanistan, 2015-2021 Energy Sector Development Investment Program, Tranche 5, (US$53 million) 2013-2018, co-financed by Government of Afghanistan North-South Power Transmission Enhancement Project (formerly Power Distribution Project) (2013-2019) (US$220 million), co-financed by Afghanistan Infrastructure Trust Fund and Government of Afghanistan Energy development 2014-2023 (US$1.6 million) Power Sector Rehabilitation Project (formerly Power Transmission Rehabilitation) 2012-2019 Energy Sector Development Investment Program, Tranche 3 (US$76.5 million)				
Renewable energy investment	Toktogul Rehabilitation Phase 3 Project (US$175 million) 2016-2024, co-financed by EDB and Government of Kyrgyzstan	Rogun Hydropower Project (Tajikistan): Techno-Economic Assessment Study (TEAS) and Environmental and Social Impact Assessment (ESIA)		Modernization of hydropower stations in Tashkent, Shakhrikhan,	Sakhit wind farm in Mongolia (50MW) Enguri hydropower plant rehabilitation (100MW)

	Uch-Kurgan Hydropower Plant Modernization Project (US$160 million) 2019-2025 Access to electricity with new off-grid solar technology in Central Asia (US$2 million) 2016-2019 Toktogul Rehabilitation Phase 2 Project (US$251 million) 2012-2022, co-financed by EDB and Government of Kyrgyzstan Golovnaya 240MW Hydropower Plant Rehabilitation Project (US$170 million) 2013-2021, co-financed by Government of Tajikistan			and Kadirya (US$125 million), co-financed by Government of Uzbekistan, 2013	Development, construction and operation of Nakra, Khelra and Ipari hydro power plants (HPPs) with a combined capacity of 13.7MW in the Svaneti region (US$14 million), co-financed with TBC Bank, started 2018
Energy efficiency	Preparing MFF Power Distribution Enhancement Investment Program (US$0.8 million) 2015-2017 Oshelectro Rehabilitation Project (US$7 million) 2015	Kazakhstan Energy Efficiency Project (US$23.1 million), co-financed by Government of Kazakhstan, 2013-2019	Promotion of energy efficient lighting in Kazakhstan (US$32 million), Government of Kazakhstan, UNDP and GEF, 2012-2017		Regional Energy Efficiency Program for the Corporate Sector in Armenia, Azerbaijan, Georgia, Moldova, and Ukraine funded by EU-NIF (EUR 32,116) Dushanbe Energy Loss Reduction Project
Energy sector financing and management	Preparing sustainable energy projects in Central Asia (53222-001) (US$1.775 million) 2019-2020				

Knowledge sharing, education, and training	Preparing sustainable energy projects in Central Asia (53222-001) (US$1.775 million) 2019-2020 Study for a power sector financing roadmap within CAREC (US$1.5 million), 2014-2016 Renewable energy development in Afghanistan (US$1 million) 2014-2017	The Central Asia Water and Energy Program (CAWEP) World Bank, the European Union, Switzerland (through SECO) and the United Kingdom (through DFID) structured along three pillars: (1) energy security; (2) energy-water linkages; and (3) water security, the program pursues three components since its inception in 2009: (a) data and diagnostic analyses; (b) institutions, capacity, and dialog; and (c) supporting investments. Kazakhstan Energy Efficiency Project (US$23.1 million), co-financed by Government of Kazakhstan, 2013-2019 Enhancing regional power trade study (regional power trade for the four Central Asian countries of Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan during the period 2010-2014)	Europe and the CIS Sustainable Energy for All (SE4ALL) initiative (US$2 million) 2014-2017		