Sustainable Pathways to Energy Transition in the CAREC Region: A Governance Perspective

GOVERNANCE ATLAS
FINAL REPORT

March 2022

Anna Arkhangelskaya, Manasi Bhopale, Prathyusha Asundi, Ramachandra Pai, Roshini Josepherson, Shruthi Rao, Sunderasan Srinivasan, Vamshi Krishna Reddy Kottam

CAREC Institute
Asian Development Bank

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Abstract

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Abstract

Limited progress with the evolution of competitive energy markets in the CAREC region and the evident need to rejuvenate or build the associated institutional and regulatory frameworks from a low base might continue to deter investments into the region's energy transition. The means to creating a more favorable investment climate across the region could include the advancement of stronger regional coordination to try and exploit economies of scale and scope, and the rollout of stable governance frameworks to facilitate such coordination. Effective management of demand and supply patterns could lead to enhancing efficiencies of asset use while minimizing market and regulatory risks faced by prospective investors. This research has defined policy objectives and identified opportunities for regional cooperation to optimize the use of renewable energy (RE) resources and grid networks, to better balance demand and supply across the region and across time zones and bridge gaps in the governance structures to try and achieve such objectives.

Assuming that the fleet of generating assets were to continue to operate at efficiency factors observed *circa* 2018, and if each country in the region were to attempt to attain self-sufficiency in generation, the region would require the addition of an estimated 192,000MW in incremental capacity by 2030 to replace some 80,000MW of fossil fuel fired generation and to meet emission reduction commitments. Meeting regionwide aggregated demand necessitates the addition of about 153,000MW of non-hydro RE options. In this scenario, China is presumed to serve as the *ultimate* residual consumer and supplier, absorbing surpluses and bridging deficits in the region, thereby pre-empting the build-up of large storage capacity on the one side and the construction of peaking plants on the other.

Regionwide institutions would be required to achieve regionwide optimization. Real-time matching of regionwide demand and supply would be expected from the regional load dispatch center. In addition, a specially constituted regional counterparty could facilitate and implement the RE procurement and contracting processes and execute emission reduction contracts. This entity could then serve to distribute accruing emission reduction revenues to help subsidize the vulnerable sections of populations across the region.

Key words: regionwide optimization; efficiency of asset use; total cost recovery; emissions reduction;

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List of acronyms and abbreviations

ACE	Army Corps of Engineers
ADB	Asian Development Bank
AZE	Azerbaijan
B2B	business to business
BAU	business as usual
CAGR	compound annual growth rate
CAREC	Central Asia Regional Economic Cooperation
CATCA	Central Asia Transmission Cooperation Association
CEO	chief executive officer
CLDP	Commercial Law Development Program
CO_2	carbon dioxide
EBRD	European Bank for Reconstruction and Development
EE	energy efficiency
ESCO	Electricity System Commercial Operator
ESCo	energy service company
EU	European Union
GDP	gross domestic product
GEO	Georgia
GHG	greenhouse gas(es)
GIS	geographic information system
GMT	Greenwich Mean Time
INDC	intended nationally determined contributions
IPP	independent power producer(s)
IRENA	International Renewable Energy Agency
JICA	Japan International Cooperation Agency
KAZ	Kazakhstan
KGZ	Kyrgyzstan
KW	kilowatt
LED	light emitting diode
LHP	large hydro plant
MNG	Mongolia
MW	megawatt
NDC	nationally determined contributions
NGO	non-governmental organization
PAK	Pakistan

PLF	plant load factor
PPA	power purchase agreement
PPP	purchasing power parity
PV	photovoltaic(s)
RE	renewable energy
RES	renewable energy sources
RECC	Renewable Energy Coordination Committee
SHP	small hydropower plant
SME	small and medium size enterprise
TJK	Tajikistan
TKM	Turkmenistan
TSO	transmission system operators
TWh	terrawatt hour
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
US	United States of America
USAID	United States Agency for International Development
USD	United States dollar(s)
UZB	Uzbekistan
WEF	World Economic Forum

Sustainable Pathways to Energy Transition in the CAREC Region: A Governance Perspective

EXECUTIVE SUMMARY

Introduction

In the past, energy transitions have been inherently lengthy processes that have unfolded over decades or even across generations. Several factors come together to determine the technical difficulty of such change, the money costs and ultimately the social and environmental impacts from the transition. In recent decades, however, conscious efforts have been invested into expediting such transitions, and into the pace of the technical innovation and growth in mainstream production of alternative technologies needed for the transition from an electricity system dominated by fossil fuel combusting plants to a world relying increasingly on renewable energy (RE) technologies—predominantly wind energy generators, solar photovoltaic (PV) systems, run of the river hydropower plants, and biomass and municipal waste incinerators, among others. Yet, given the likelihood of slower than projected progress towards achieving committed climate goals across countries, the energy transition would need to be 'pushed' by policy, while also being 'pulled' by changes in technology, price, or consumer preference, and such a rapid transition could impact various sections of society in different ways. Even if such energy transition were likely to be measured, path dependent, accretive, punctuated, and evolutionary, the transition would need to be invigorated through effective governance structures and through providing appropriate incentives tailored to suit specific sections of society within the prevailing circumstances.

Governance of energy transition

Governance practices to shift markets towards more intermittent as well as more distributed generation would need to articulate alternative visions for long term objectives, while simultaneously building in adequate flexibility to accommodate significant variability in demand as well as in supply in the short term. In the process, aligning the interests of policy makers, government personnel, industry, and the consumer could help to ease the transition. Managing the energy transition, however, does not happen in isolation: research institutions, educational establishments, civil society organizations, industry and political bodies contribute to the movement from the prevailing state of affairs to the desired state of the sector. As a result, transition management, in general, might appear more like policy as usual, albeit with minor and frequent adjustments and revisions as opposed to a 'one time' dramatic shift.

Energy transition in the CAREC region

The absence of advanced institutional and regulatory frameworks is still a cause for concern among investors and might continue to deter investments into individual countries within the CAREC region. Some of the energy sector objectives could therefore be met through regional coordination and effective management of demand and supply patterns, which would lead to enhancing efficiencies of asset use while minimizing market and regulatory risks faced by prospective investors. The present research effort and the assessment of countries' policies and governance in the energy transition has aimed at identifying opportunities for regional cooperation to optimize the use of RE resources and grid networks while attempting to **balance demand and supply across the region**.

Electricity demand in the CAREC region is projected to rise on the back of expanding electricity based services, uptake of electric transportation and shared mobility, and following low and medium temperature heat applications. By some estimates, electricity demand is projected to grow in the CAREC region excluding China from an index value of 100 in 2015 to an index value of 228 in 2050, representing a compound annual growth rate (CAGR) of 2.4 percent over this time period. Assuming that the fleet of generating assets were to continue to operate at efficiency factor levels close to efficiency factors observed in 2018, and if each country were to attempt to attain self sufficiency in generation, the region would require the addition of an estimated 192,000 MW in incremental capacity by 2030 to replace some 80,000MW of fossil fuel fired generation.

The present study has developed an alternative scenario to demonstrate the beneficial effects of regionwide optimization of electricity demand and supply. Demand is aggregated across time zones to smoothen the so called 'duck curve' observed for individual member countries. Supply is presumed to continue from hydropower and non-hydropower plants and from wind energy generation and solar PV plants that are optimally located within the region with a view to maximizing the efficiency of asset use. Such regionwide optimization of supply to meet regionwide aggregated demand necessitates the addition of about 153,000MW of non-hydro RE options to replace some 80,000MW of fossil fuel fired generation. In this scenario, larger energy markets in the region, including Pakistan and Kazakhstan, are presumed to serve as *intermediate* residual consumers and suppliers, while China is presumed to serve as the *ultimate* residual consumer and supplier, absorbing surpluses and bridging deficits in the region, and thereby pre-empting the build-up of large storage capacity on the one side and the construction of peaking plants on the other.

Conclusions and recommendations

The study has provided observations related to the legislative frameworks of individual countries and on the roles and responsibilities of the agencies involved. While countries of the region have formulated policy frameworks and have promulgated specific laws to help formalize and implement specific aspects of energy generation and supply, and while some of the countries already trade electricity with neighboring member countries, there is an evident and urgent need for the region as a whole to come together to coordinate electricity generation and supply policy frameworks, governance structures, pricing schemes, and attendant technical infrastructure. Among other things, policy frameworks need to provide stability and assurances of compensation through appropriate remedial measures and suitable payments to ward off any adverse consequences emanating from the curtailment of supplies, from premature and unilateral termination of the power purchase agreements (PPAs) (by counterparties executing such PPAs), against changes in the policy principles and regulatory frameworks implemented subsequent to the execution of the PPAs, currency and repatriation risks, and against other such factors over which project investors have little control.

Realtime matching of regionwide demand and supply could be brought under the purview of the regional load dispatch center. Likewise, a distinct legal entity could be created to serve as the counterparty to implement the procurement and contracting process and to meet the legal and commercial obligations within the PPA, including ensuring periodic payments against the power supplied by the independent power producers (IPP). As a corollary to this, emission reduction contracts and revenues would also have to be channeled to such a regional entity, and such revenues flowing from meeting emission reduction commitments might help subsidize the vulnerable sections of populations across the region. In addition to developing regionwide network expansion plans, harmonizing governance structures and standards, and implementing transmission projects, the proposed Central Asia Transmission Cooperation Association (CATCA) could potentially play a part in coordinating between the load dispatch center and the procurement and contracting agency as envisaged herein.

Report Authors
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CAREC Institute
Asian Development Bank

MAIN REPORT

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February 2022

Sustainable Pathways to Energy Transition in the CAREC Region: A Governance Perspective

It is vital that we mobilize all the forces of the Fourth Industrial Revolution towards a green energy transformation, including innovative ways to finance this shift.

Remi Eriksen
Group President and CEO at DNV
September 2021

1. CHAPTER 1: INTRODUCTION

A. Background

Over the past decade or thereabouts the evidence of the effects of changing climates has been vividly manifest—rampant wildfires, dangerous mudslides, and increasingly severe and frequent droughts and flash floods—with the costs of *inaction* on climate change mounting all along, and quite rapidly so. The Secretary General of the United Nations has sought to convey the urgency of the situation to member nations[1] while also highlighting the proximate causes. It has been known for a while that fossil fuel—coal, oil, gas—dominated energy systems, and the legal frameworks and incentive structures that reinforce such dominance, have left harmful environmental effects on land, on water, and, above all, on the air.

> 'The alarm bells are deafening, and the evidence is irrefutable: greenhouse gas emissions from fossil fuel burning and deforestation are choking our planet and putting billions of people at immediate risk. Global heating is affecting every region on earth, with many of the changes becoming irreversible.'
>
> Antonio Guterres
> Secretary General of the United Nations, August 2021

Power plant emissions from burning fossil fuels are toxic to life forms on the planet to the extent that the power sector in general, and the combustion of coal in particular, are often held largely responsible for climate change. Additionally, the transboundary flows of such pollutants—especially of polluted air and water—underscore the extra local effects of human activity. Worse, the acutely adverse effects of climate change on the poor and the most vulnerable is projected to aggravate global inequality.[2]

Governments from around the world have demonstrated their commitments towards achieving climate change mitigation focus and, more recently, adaptation related objectives from time to time. Among others, such commitments have been coordinated and structured through the Intended Nationally Determined Contributions (INDC), for instance, through commitments recorded as part of the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties (COP) held in Paris, France, in 2015: commonly referred to as the 'Paris accord.' Among other things, such commitments have entailed the introduction of new technologies and the creation of new market mechanisms to lower greenhouse gas (GHG) emissions from the electricity sector. Such commitments include providing appropriate incentives for research organizations and companies to develop new technologies and to encourage electricity utilities to adopt and deploy such new technology options on a meaningful scale. Complementary regulatory frameworks, financing mechanisms and fiscal incentives, and, perhaps most significantly, structured information sharing channels would be required to foster an environment that would empower government agencies and companies involved along the value chain, starting from research and new product development, through to deployment, and all the way to end-of-life disposal.

All these activities form part of a managed 'energy transition.' Energy transitions are frequently understood to comprise the shift from dominant resources of the day to new sources of supply—for instance, from coal through hydrocarbons to cleaner sources that use water, wind, sunlight, and biologically derived fuels, and from the direct use of fuels to the use of electricity. Such transition also bears implications for the diffusion of new prime movers, including, for instance, from steam engines to steam turbines or to diesel engines and internal combustion engines as witnessed over the past 150 years or longer. Ultimately, changes at the upstream end and changes in intermediate processes are also influenced by new final energy converters, as from incandescent lamps to fluorescent lights to light emitting diode (LED) based lamps, for instance. Such a transition to newer technology options requires evolution in regulations, tariffs and pricing regimes, and above all, in the behavior of users and adopters.[3]

In the past, such transitions have been inherently lengthy processes that have unfolded over decades or across generations.[4] Several factors come together to determine the technical difficulty of such change, the money costs, and ultimately the social and environmental impacts. In recent decades, however, conscious efforts have been invested into expediting such transition, and into the pace of the technical innovation and growth in mainstream production needed for the shift from the world dominated by fossil fuel combusting plants to a world relying increasingly on RE technologies—predominantly, wind energy generators, solar PV systems, small hydropower plants and run of the river hydropower plants, and biomass and municipal waste incinerators (used interchangeably in this report with sustainable energy, cleaner energy, or simply 'green' energy). Additionally, research efforts have also gone into evaluating the likely costs and investment needs of such a transition, and have weighed the incremental environmental benefits, particularly in terms of lower CO_2 emissions from the electricity sector against such money costs.

In reality, however, over the years, the gap between climate pledges by individual nations and the actual mitigation needed to meet global temperature goals has persisted. The UN Environment's *Emissions Gap Report* (2017) observed[5] that global GHG emissions would need to stabilize at about 52 $GtCO_2e$ through to 2020 and then to fall to 42 $GtCO_2e$ by 2030 and further to 23 $GtCO_2e$ by 2050. Further, to enhance the likelihood of containing warming to 1.5 degrees Celsius, the annual emissions would need to drop to 36 $GtCO_2e$ by 2030. In the years following the Paris accord, the inadequacies in the actual performance by the community of nations measured against their own (self determined) targets have led to the call for an 'urgent need to increase the ambition, scope, and scale of carbon mitigation efforts worldwide.'

The transition from fossil fuel combustion to cleaner sources of electricity generation on the supply side, and the launch of initiatives to enhance the efficiency of electricity use on the demand side, is clearly found to be too slow to stall global warming. This is, in part, attributed to the sheer scale of the task at hand combined with the 'path dependency' of existing systems, including long term supply contracts, and the like. Shorter 'takeover times' among energy technologies (of the order of 25 years) are consequently observed in the context of end use technologies such as water heaters and refrigerators, relative to upstream end technologies[6] (takeover times of the order of 70 years or more) which inherently involve the creation of nationwide or regionwide infrastructure. A second facet of such transition relates to the fact that large sections of the populations across many of the low income countries lack access to modern energy services. The nationally determined contributions (NDC) for such countries have implied leapfrogging polluting technology options and have included focusing directly on expanding the deployment of RE options and EE efforts towards addressing poverty; generating employment; and towards improving social, health, and educational outcomes.

Across countries, therefore, the energy transition would need to be 'pushed' by policy, while also being 'pulled' by changes in technology, price, or consumer preference, and such transition could benefit different sections of society differently. Faced with 'carrying capacity' constraints of the geophysical environment, energy transitions in the near term, in high income and low income countries alike, would need to be expedited not just to deliver the projected environmental benefits, but also to avoid the social costs associated with the heightened pollution and other negative consequences flowing from runaway climate change. In all, even if such energy transition is likely to be path dependent, accretive, punctuated, and evolutionary, the transition would need to be invigorated through effective governance structures and through providing appropriate incentives tailored to suit the prevailing circumstances.

Given the urgency of the present situation, one strategy suggested to help expedite the transition involves viewing longer term net zero pledges as a series of short term goals that might be achievable with proven technologies. At each such stage, remaining climate targets could be progressively achieved as presently nascent technologies such as carbon capture and storage stabilize and mature. Such a progressive transition might also provide just enough time to adequately reskill the workforce while also minimizing the losses to investors from stranded assets.[7] Global efforts apart, some assessments[8] suggest that 'whether the climate can ever be stabilized depends largely on Asia.'

In 2003, the Government of Ontario, Canada, resolved to retire all coal fired electricity generation in the province by 2007. The coal plant closure target was eventually achieved in 2014. In addition to the climate benefits, shifting away from coal brought coal pollution related deaths down from 700 persons to under six persons and reduced pollution related illnesses from about 330,000 complaints to a mere 2,460 cases. This saved the province CAD 4.40 billion per year in healthcare and related costs. Over the same time period, Ontario invested CAD 21 billion in developing cleaner sources including wind energy, hydroelectricity, solar PV and nuclear power, in addition to investing CAD 11 billion in transmission and distribution upgrades and into improving efficiency. These measures were projected to save electricity costs for all segments of end users.

Summarized from Sovacool (2016)

B. Governance for energy transitions

Governance practices to shift markets towards more intermittent as well as more distributed generation would need to articulate alternative visions for long term objectives, while simultaneously building in adequate flexibility to accommodate significant variability in demand as well as in supply in the short term. In the process, aligning the interests of policy makers, government personnel, industry, and the consumer could help to ease the transition.[9] Such 'demand responsive' electricity services would, by definition, be more *interactive* and this might, in turn, lead to services designed to meet the specific needs of subgroups of consumers.[10] Central to managing the transition is, therefore, developing interactive processes where groups of stakeholders could come together to develop problem definitions, offer differing perspectives, and proceed to develop practical activities. Allied to this process is the need for developing pilot projects to assess the potential for, and the limits of, different approaches to governance practices and technology applications.

⏩

Transition management starts with clearly defined goals. Governance processes are better advised to begin with the end objective in view. This could include:

a) The movement away from a fossil fuel based (or dominated) electricity system towards a non-fossil fuel based (or dominated) electricity system: this change in fuel source and conversion technology could be an end objective in itself;
b) As a corollary, the change in fuel sources could enable the shift from a carbon emitting energy system to a carbon neutral (or more realistically, a lower carbon) electricity system;
c) Further, subsidiary objectives could include decentralized generation to lower transmission and distribution (T&D) losses and the design of robust mini grid networks around such nodes to help isolate local area networks from the main distribution grid if necessary.

Different transitions would mean and imply different development trajectories and consequently different governance structures. Practitioners and researchers alike have suggested that transitions need not necessarily represent passage from one established state to arrive at another steady state. Given that incumbent technologies enjoy substantial advantages from pre-established infrastructure, from familiarity with investors, lenders, risk underwriters, and consumers, and from embedded technical standards and standardized training protocols, in reality, **transitions, in general, might be more progressive with no definite points of origin or 'arrival.'** The electricity sector transition presently under way may be no different. Regulatory structures, therefore, need to evolve gradually to encourage 'mutual adaptation' of subsystems including the policy making processes, incumbent regulatory agencies, investors and lenders, and end use consumers, through offering incentives or demonstrating benefits at each stage. Managing the transition, however, does not happen in isolation: research institutions, educational establishments, civil society organizations, and industry and political bodies contribute to the movement from the prevailing state of affairs to the desired state of the sector.[11] As a result, transition management, in general, might appear more like policy as usual, albeit with minor and frequent adjustments and revisions as opposed to a 'one time' dramatic shift.

> 'Some 400 gigatons of carbon dioxide: that's how much carbon the UN's Intergovernmental Panel on Climate Change (IPCC) forecasts the world has left to spend, in order to stand a likely chance (67 percent) of limiting global warming to the 1.5°C ambition set under the Paris Agreement. The world is burning through this carbon budget, and the earth is burning as a result—from extreme heat events to unprecedented forest fires. Emissions must fall by around half by 2030 for a 1.5°C future, but we forecast they will fall by just 9 percent. We find that the world will exhaust the 1.5°C budget already in 2029.'
>
> Ditlev Engel
> CEO, Energy Systems, DNV

Unlike in the past, when energy sector transitions are reported to have materialized over several generations, at the present time, such a transition would have to be accomplished in a matter of years to meet global emission mitigation targets. Despite the daunting scale of the task at hand, achieving such transition within the recommended time window might be eminently feasible, given that unlike the uncoordinated and evolutionary transitions of the past, the present transition is governed by a wide variety of highly qualified and specialized agencies[12] and given that alternative technologies have achieved adequate maturity to play mainstream roles within the sector.

C. Purpose and orientation of the present study and report

Evidently, 'energy insecurity' in the countries of Central Asia is caused by multiple factors including the geographic context, natural features, environmental influences, international factors, and market circumstances. These factors are aggravated by significant conflicts of interest among the Central Asian countries themselves, which have deterred cross border energy cooperation in recent years, threatening energy security in the region[13] as a whole. Although, in recent years the situation has improved and momentum has been building towards increased regional cooperation within the energy sector. Fortuitously, in addition to hydropower and fossil resources, these countries are also known to have been endowed with solar and wind energy resources that could be explored and exploited rapidly through deploying solar PV, wind energy generators, and other proven technology options.

Some countries in the region have already commenced non-hydro RE project implementation, including, for instance, the 21.0MW Qartli onshore wind energy project in Georgia, which has reported efficiency factors in excess of 45 percent for several years in a row. Given such efficiencies of asset use, if an effective framework for cross border electricity trade were to be implemented, intermittency in RE generation could be managed to meet demand more effectively, leading to regionwide optimization of peak generation and peak consumption patterns, while minimizing the need for investments into energy storage capacity.

All countries in the region have announced INDC as a part of the commitments made under the Paris Agreement of 2015 as listed within **Table 1.1**. Strong targets on national contributions to reducing GHG emissions demonstrate the commitment of the governments to make a measurable contribution to sustainable development and the willingness to continue working together to combat climate change. These NDCs were revised during the 26th Conference of the Parties to the UNFCCC in Glasgow (COP26). A fair transition to clean energy and a rapid phaseout of coal has been the focus of the COP26 presidency as part of its efforts to minimise temperature rise in line with the Paris Agreement. At this convention, all five Central Asian countries—Kazakhstan, Kyrgyzstan, Uzbekistan, Tajikistan, and Turkmenistan—were presented with their own pavilion as a platform for discussion and presentation of their strategies to achieve carbon neutrality.

These climate goals might flow from the projected (rapid) growth in electricity demand for non-China CAREC between 2015 (index value = 100) through to 2050 (index value = 228), representing a CAGR of 2.4 percent. To put this figure in context, global aggregate electricity demand was projected to rise at 2.0 percent per annum (CAGR) over the same period (albeit over a much larger base value). Further, by 2030, wind energy generation (75 TWh of electricity) and solar PV (52 TWh of electricity) are projected to make respectable contributions to the total demand (434 TWh of electricity) in non-China CAREC, while gas (159 TWh), hydropower (81 TWh), coal (41 TWh), oil (19 TWh) and nuclear power (6 TWh) are projected to meet the estimated demand.[14]

The inherent technical challenge posed by the large scale deployment of such renewable sources of energy relates to balancing the intermittency in generation with meeting the variable energy demand over a 24 hour period. In recent years, the deployment of energy storage capacity at specified nodes has helped bridge the intermittency in generation and variability in consumption to a limited extent, even as storage technology continues to evolve rapidly and ever larger energy storage projects are frequently proposed for implementation across markets.

In addition to intermittency over a 24 hour period, RE options often pose challenges related to seasonal availability in supply as well. Given the lower desirability of fossil fuel use, and given the challenges intrinsically associated with RE options, the transition to sustainable options calls for detailed planning and meticulous optimization. Closer to the context of the present study, Central Asian countries such as Kyrgyzstan and Tajikistan, for instance, are endowed with hydropower resources that could be tapped to generate significant amounts of electric power to meet domestic demand as well as to provide for exports. However, these countries experience severe shortages in electricity during winters[15] during the low water flows. On the other hand, the countries of Turkmenistan and Kazakhstan, and, to a lesser extent Uzbekistan, are rich in hydrocarbon resources (fossil fuels). Exploiting these fossil resources is projected to add to the carbon footprint of the countries themselves, and could leave an adverse impact on the global climate, and might therefore be a less desirable option. In addition to adding new RE generation capacity to augment supplies, the energy sector transition in the region therefore needs to provide for the progressive replacement of fossil fuel based power plants with cleaner alternatives that could serve the countries of the region across the seasons.

In principle, when markets work in isolation, the surplus energy produced during hours of peak generation from solar PV plants, wind energy generators, and perhaps to a lesser extent from small hydro plants (SHPs) and other RE options might have to be stored to achieve 'energy time shifting' required to meet peak demand. Conversely, additional generation capacity ('peaker plants' or 'peaking plants') might be needed in markets that are otherwise unable to meet peak demand. The present study, therefore, explores the possibility of exploiting time zone differences to try and meet peak demand in one market through surplus supply in another through the cross border transfer of such a surplus. Governance structures could then be optimized to achieve such policy objectives.

'With various energy challenges to face, most of the seven countries[16] of this project have set themselves targets in increasing the level of renewable energy use; they have, however, made uneven progress in creating the necessary regulatory frameworks and adopting specific policies and regulations. Along necessary grid development or adaptation, in order to build sustainable and resilient energy systems offering reliable energy, it remains an important challenge to set a regulatory framework that will be both attractive for foreign investment and practicable for future grid users, whether private or public, while guaranteeing energy security and power system flexibility.'[17]

Most of the countries of the Central Asian region rely on external investments to facilitate the energy transition and to achieve GHG reduction goals while augmenting energy supplies. In spite of the ambitious goals set by the countries, it is widely recognized that the absence of advanced institutional and regulatory frameworks is still a cause for concern among investors and might continue to deter investments. Some of these objectives could be met through regional cooperation and effective management of demand and supply patterns enhancing efficiencies of asset use while minimizing market and regulatory risks faced by prospective investors. The starting point for achieving such goals, including mobilizing the necessary investment, is therefore the establishment and development of an adequate institutional, regulatory, and regionwide governance framework for transitioning to the deployment and utilization of RE (used in this report interchangeably with cleaner sources, green sources, or sustainable sources of energy and includes run of the river hydropower projects, solar PV technology options, solar thermal power plants and heaters, wind energy generators, biomass/biogas plants and other such technology options routinely classified as climate friendly/RE options).

Table 1.1: Intended Nationally Determined Contributions announced by CAREC member countries within the framework of the implementation of the Paris Agreement and the updated NDCs based on the COP26 pledges

Country	INDC (First NDC)	Updated NDC
Azerbaijan	Reduce GHG emissions by 35 percent by 2030 compared to 1990.	No new target submitted. Signed Global Coal to Clean Power Transition Statement.
China	Lower CO_2 emissions per unit of GDP by 60 percent to 65 percent from the 2005 level; To increase the share of non-fossil fuels in primary energy consumption to around 20 percent.	Aims to have CO_2 emissions peak before 2030 and achieve carbon neutrality before 2060; to lower CO_2 emissions per unit of GDP by over 65 percent from the 2005 level, to increase the share of non-fossil fuels in primary energy consumption to around 25 percent, and to bring its total installed capacity of wind and solar power to over 1.2 billion KW by 2030.
Georgia	Unconditionally reduce GHG emissions by 15 percent below the BAU scenario for 2030. This is equal to reduction in emission intensity per unit of GDP by approximately 34 percent from 2013 to 2030.	Unconditional limiting target of 35 percent below 1990 level of its domestic total GHG emissions by 2030; Georgia is committed to a target of 50 percent to 57 percent of its total GHG emissions by 2030 compared to 1990, in case of international support.
Kazakhstan	By 2030 reduce GHG emissions by 15.0 percent unconditionally or 25 percent conditional to international support compared to 1990 level.	No new target submitted. Signed Global Coal to Clean Power Transition Statement.
Kyrgyzstan	By 2030 reduce GHG emissions by 11.49 percent to 13.75 percent compared to 2010 levels; additionally, by 2030 with international support, a reduction of 29.0 percent to 31.0 percent compared to 2010.	Reduction of GHG emissions by 15.97 percent of the emissions in the BAU scenario and, with international support, by 43.62 percent by 2030 compared to 2010.
Mongolia	By 2030, a 14.0 percent reduction in GHG emissions compared to business BAU scenario.	Mongolia intends to curtail its GHG emissions by 22.7 percent by 2030, compared to the BAU scenario, excluding LULUCF. In addition, if conditional mitigation measures such as the carbon capture and storage and waste-to-energy technology were to be implemented, then Mongolia could achieve a total 27.2 percent reduction in total national GHG emissions.
Pakistan	By 2030: reduction of up to 20.0 percent in the projected emission figures would require an investment of approximately USD40 billion; a reduction of 15.0 percent in GHG emissions amounts to USD15.6 billion; whereas a 10 percent reduction is calculated as USD5.5 billion.	Pakistan intends to set a cumulative ambitious conditional target of overall 50 percent reduction of its projected emissions by 2030, with 15 percent from the country's own resources and 35 percent subject to provision of international grant finance that would require USD101 billion just for energy transition.
Tajikistan	By 2030 reduce GHG emissions by 23.0 percent to 35.0 percent to 1990 level.	Subject to significant international financing and technological exchange, emissions will not exceed 50 percent to 60 percent of 1990 levels by 2030.
Turkmenistan	By 2030, the goal is to reduce the growth rate of GHG emissions in relation to GDP growth; reduce energy consumption and CO_2 production per unit of GDP; after reaching 135.8 million tonnes of GHG emissions in CO_2-eq ensure stabilisation at this level.	No new target submitted.
Uzbekistan	By 2030, achieve a 10 percent reduction in GHG emissions per unit of GDP from the 2010 level.	By 2030, achieve a 35 percent reduction of GHG emissions per unit of GDP from 2010 level.

Source: Compiled by report authors from countries' policy documents

(Given the prevailing social and economic circumstances at the time, and given that as a result of such circumstances, the emissions for 1990 might have been uncharacteristically low, observers have expressed reservations about the appropriateness of choosing 1990 as a base year to benchmark emission reduction commitments)[18]

D. Study methodology

In all, the report explores the possible means of expediting the energy transition in the region and recommends measures that could incentivize industrial and societal adoption of greener options.

The current assignment helped identify policy pathways to optimize CAREC's effective green energy transition in alignment with the CAREC Energy Strategy 2030: the present research effort has essentially involved identifying opportunities for regional cooperation to optimize the use of RE resources and grid networks while trying to match demand and supply across the region, to reduce emissions from the energy sector, and to enhance the efficiency of asset use. Regionwide institutional and governance structures could then be optimized to achieve such objectives. In order to achieve these objectives, the research team undertook extensive desk reviews to collect, organize, and analyze country specific data in sufficient detail to make informed recommendations. Among others, the research team assessed the current energy governance policies in the CAREC region countries and observed the positive aspects as well as the gaps that might deter potential investors.

- The study was limited to analysing the green electricity sector and included coverage of the energy-for-cooking and energy-for-transportation subsectors to the extent that such loads for cooking and transportation were already included within the aggregate demand projected for individual countries.
- Likewise, the study was limited to cooperation among CAREC region countries and did not seek to explore the scope for trade in green energy between CAREC and non-CAREC countries.
- Further, the study was limited to recommending measures to enhance cooperation among the CAREC region countries and did not seek to explore the scope for trade in green energy among non-CAREC countries that might involve the use of CAREC region transmission or other infrastructure.
- The study commenced with providing alternative definitions for the energy transition to be achieved including a discussion on environmental outcomes to be targeted (see introduction section above).
- The study went on to collect aggregate electricity demand data in each country, across the 11 countries and across the CAREC region.
- The study reviewed the 24 hour load curve for each country to study peak and lean hour consumption patterns and to identify surpluses or deficits in each country over a 24 hour cycle.
- The study collected projected aggregate RE electricity supply in each country, across the 11 countries and across the CAREC region.
- The study projected RE generation in keeping with country specific targets and reviewed data on aggregate demand and supply for CAREC region as a whole, and for non-China CAREC.
- This led to the review of the possibility of matching the peak demand with peak supply across the 11 countries and perhaps trading energy across time zones.
- Having defined such objectives for the transition and for the optimal utilization of RE resources and project assets, the study reviewed current recent and relevant policy frameworks for each country, including current state of governance, utilities involved, investments and regulations that could facilitate or deter such investments.
- An important part of the research effort was the review of the electricity tariff structures in each country to the extent that such data was accessible to the research team.
- The research effort documented mini case studies involving RE projects that could highlight specific aspects of electricity sector governance and features that appealed to RE investors or those that had deterred investments in the past.

- Based on the foregoing, the report went on to discuss the policy/governance/regulation related challenges and opportunities specific to each country.
- The research effort involved limited stakeholder consultation at various stages including during data acquisition, analysis, and report preparation and submission.
- The study has analyzed data/information and has identified desired technical and economic outcomes and the report recommends policy frameworks and governance structures that could help achieve such outcomes.
- It is to be noted that the current study does not consider the implications of the COVID-19 pandemic.
- Given the political instability in Afghanistan, the present report does not analyse details of the governance structures in the country. However, the report does consider the demand and the technical RE potential in Afghanistan in aggregating regionwide data.

E. The Regional Economic Cooperation Program

The Central Asia Regional Economic Cooperation (CAREC) Program is a group of 11 countries and the program works in collaboration with development partners, working towards accelerated economic growth and poverty reduction within the member countries. The partnership of 11 countries includes the original eight members: Afghanistan,[1] Azerbaijan, the People's Republic of China (Xinjiang Uygur Autonomous Region joined in 1997); Kazakhstan, Kyrgyzstan, Mongolia (Inner Mongolia Autonomous Region joined in 2008), Tajikistan, and Uzbekistan; Pakistan and Turkmenistan joined in 2010; Georgia joined in 2016.

Since its inception in 2001, the program proactively facilitates practical, regional projects, and policy initiatives crucial to achieving sustainable economic growth in the region. Cooperation is guided by the overarching vision of 'Good Neighbors, Good Partners, and Good Prospects.'[19] As of December 2020, investments that have helped establish, build, and operate transportation networks have increased energy trade and security, and have facilitated free movement of people and freight, thereby laying the groundwork for economic corridor development. However, continuing progress in the region requires redesigning schemes both for local and foreign investments, along with the development of capital markets. The region also needs to focus on better coordination of sector specific policies and priorities by measures for collaborative policy formulation and implementation, alignment of national and regional planning, and regulatory convergence in the region.[20] In view of this, CAREC has proposed the CAREC Energy Strategy 2030.

F. CAREC Energy Strategy 2030

A reliable energy system is considered the fundamental building block of a modern economy and is essential for the wellbeing of its citizens. The world over, the electricity sector in particular and the energy sector in general are undergoing a challenging period of rapid growth and transition, with new dynamics increasingly changing the context in which CAREC countries would require to operate over the next several years. The vision for 2030 seeks to establish a smarter, efficient, green, sustainable, and resilient energy system for the region. Therefore, the CAREC Energy Strategy seeks to offer smart solutions and new approaches, with the aim of staying consistent with a rapidly changing environment. The strategy's ambitions set out for achievement by and through to 2030 seek to build on the achievements of the past: CAREC member countries are increasingly regionally interconnected and integrated and therefore are projected to benefit from increases in cross border energy trade as well. The region also aims to deploy cleaner energy technology options and to exploit the available technical capacity among governments and institutions. Clearly, the energy

[1]Note: In mid August 2021, ADB paused its operations in Afghanistan.

sector in the region is at an important inflexion point, with a need to keep up with global trends while providing for an adequate, affordable, and climate friendly electricity supply to households and businesses.

It is evident that the CAREC countries are different in their size, geographic location and climatic conditions, political situation, energy mix, energy infrastructure, regulatory frameworks, sector structure, composition of the economy and so on. The electricity tariff structures for households and industry/business reflect governance priorities and resource endowments. Georgia, for instance, is reported to charge households higher tariffs compared to businesses (see **Table 1.2**). Further, it is not immediately apparent whether these tariffs charged to end users would be consistent with total cost recovery for private investors seeking to invest into RE assets (or EE initiatives) in the region. To put these numbers in perspective, the European Bank for Reconstruction and Development (EBRD) announced in September 2021 that the first competitively procured wind power project in Uzbekistan to be implemented under the public–private partnership law witnessed tariffs[21] of 2.5695 US cents per kWh (at plant gate). *Retail* electricity tariffs offered to end users in Kyrgyzstan, for instance, are lower than this *wholesale* price of 2.6 US cents per kWh. *Retail* electricity tariffs offered to end users in host country Uzbekistan—at 2.8 US cents per kWh for households and 4.2 US cents per kWh for businesses—barely exceed this *wholesale* purchase price of 2.6 US cents per kWh. Retail electricity tariffs on offer in some of the other member countries might rule below the landed cost of electricity (generation + transmission and distribution related costs + network management and upgrade costs).

Table 1.2: Representative end user electricity tariff levels across the CAREC region

	Electricity tariffs on offer in December 2020	
	Household	Business
	(US cents per kWh)	
Azerbaijan	4.10	5.30
China	8.50	10.3
Georgia	5.90	5.30
Kazakhstan	4.10	5.20
Kyrgyzstan	1.00	3.00
Mongolia	4.10	4.90
Pakistan	5.4	14.80
Tajikistan*	2.03	3.50
Turkmenistan	0.71	1.79
Uzbekistan	2.80	4.20

*from 1 September 2021

Source: https://www.globalpetrolprices.com/electricity_prices/, last accessed 24 September 2021.

Further comparison of retail electricity tariff rates in CAREC countries (Table 1.2) with the tariff rates applicable in high income economies (Table 1.3), demonstrates the relative levels of the tariffs in the CAREC region countries, and the consequent inability of the utilities to recover the full cost of generation and electricity service delivery.

Table 1.3: Representative end user electricity tariff levels in advanced economies

	Electricity tariffs on offer in December 2020	
	Household	Business
	(US cents per kWh)	
Australia	21.7	16.1
Austria	23.6	16.4
Finland	18.0	11.2
France	20.2	14.2
Germany	36.0	23.6
Japan	24.5	18.4
Switzerland	22.5	16.7
United Kingdom	26.8	23.3
USA	15.0	10.9

Source: https://www.globalpetrolprices.com/electricity_prices/, last accessed 26 November 2021.

To deliver meaningful recommendations for the region as a whole, the study therefore identified cross cutting themes and analyzed data in sufficient detail to benefit individual countries, and to simultaneously benefit a significant subgroup of countries in the region.

Case Study

Case Study: Kazakhstan—Auctions and solar PV power plants

In 2009, the Government in Kazhakstan enacted the *Law on Support for the Use of Renewable Energy Sources* (the RES law). The RES law guaranteed purchase of all electricity generated, introduced 15 year tariff stability guarantees, guaranteed connections and access to the national supply network, and provided exemption from service fees for electricity transmission.[22]

Kazakhstan receives between 2,200 and 3,000 hours of sunshine each year which yields an estimated 1,200 kW/m^2 to 1,700 kW/m^2 demonstrating its great potential for solar power. In order to incentivize investors to develop the RE sector, the Government permitted RE producers to sell electric power centrally via the *Financial Settlement Center for Renewable Energy Sources* (FSC) at fixed feed-in tariffs that were higher than the tariffs for traditional energy (RES Law, Article 7.1, 2009). For solar powered plants, the tariffs were established at KZT 34.61 (USD0.09)/kWh.

The feed-in tariff measure had its limitations, because of the lack of tariff flexibility in response to inflation and the fluctuation of the local currency value in relation to the US dollar. There was an attempt to remedy this in 2014 when the Government introduced 'annual indexation of fixed tariffs' through the Government Resolution of the Republic of Kazakhstan No. 271, 2014. In 2017, the Government further revised the tariff indexation to fix the exchange rate at 70 percent for inflation and 30 percent for foreign currency (Government Resolution of the Republic of Kazakhstan No. 925, 2017).[23] These annual increases in the fixed tariffs increased the financial burden of the Government subsidization of electricity purchases from RE sources. Therefore, amendments were introduced in the Law on Support for the Use of Renewable Energy Sources, providing for the organization of reverse auctions for new RE projects (this mechanism did not apply to existing facilities or projects under construction already using fixed tariffs).

Kazakhstan's first successful solar auction (in October 2018) was conducted by the Kazakhstan electricity and power market operator JSC KOREM (as per the order of the acting Minister of Energy of the Republic of Kazakhstan of 7 August 2017 No. 280).[24] The auction in 2018 was the first part of a series of RE tenders planned by the Kazakh Government and supported by the EBRD to promote competitive pricing, encourage private sector participation, and stimulate investments into renewable.[25] The auction mechanism was introduced for selecting the most effective RE projects at the lowest prices. This auction mechanism replaced the fixed tariffs that were in effect until 2018.

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Case Study

The winner and the FSC entered into an agreement for purchase of **all electricity produced** for a period of 15 years, at a price determined during the auction. Investors undertook to start construction and commission the facilities within the timeframe established by law and the regulations of the auction. Auction winners provided collateral in the amount of KZT 10,000 (USD26) per kW of their project capacity. The failure to meet the deadlines for construction commencement or plant commissioning entailed a penalty of 30 percent or 70 percent of the collateral.[26] Land plots and grid connection points were reserved for auctions.[27] The first auction held in 2018 proved to be an efficient and transparent selection mechanism and resulted in a substantial reduction in the cost of RE support: the average reduction in the cost of a kWh of electricity at solar power plants was estimated at 34 percent relative to a project directly allotted for implementation.

The first auction awarded four solar PV projects aggregating 170MW in capacity to energy companies *Shell*, *Avelar Solar Technology* (a unit of the Russian PV company Hevel Solar), and *JSC Hydroenergy Company*. The lowest bid was USD0.05170/kWh (KZT 18.6), submitted for a 50MW project proposed by *JSC Hydroenergy company.*[28] The two projects submitted by *Avelar Solar Technology*, saw bids of USD0.05115/kWh and USD0.06187/kWh, respectively. Another project submitted by *Shell Kazakhstan BV Branch*, the local unit of multinational oil company Shell, offered a price of USD0.06297/kWh. Analysis of the prices proposed during auctions in 2018 to 2019 for solar PV based power generation showed a significant discount relative to the auction ceiling prices. In the 2018 SPP auctions, the auction ceiling price was KZT 34.61/kWh with the lowest proposed price of KZT 18.00/kWh).

The 50MWp Kaskelen Solar Power Plant

In June 2018, *Mistral Energy LLP* won the bid for a 50MWp solar PV plant at a tariff of KZT 25.8/kWh demonstrating the working of the auction mechanism in lowering the cost of RE in the country.[29] The ceiling price at the solar PV auctions in 2018 was KZT 34.61/kWh which was approximately equivalent to the tariff paid to plants like the 100MWp Saran plant. Mistral Energy LLP was the subsidiary of *Universal Energy*, an international company that focused on the RE industry and specialized in investing, constructing, and operating wind power and solar PV projects across countries. The company has gone on to progressively add projects[30] to achieve a total installed capacity of 380MWp.

The Kaskelen solar PV plant is located in the Zhetygen rural district of the Ili district of the Almaty region and was connected to the grid in June 2020.The total cost of the project added up to KZT 13.37 billion, 80 percent of this project cost was financed by a loan from the state development institution Development Bank of Kazakhstan JSC, (a subsidiary of the Baiterek Holding). The 20 percent project cost was contributed in the form of owner's equity by the project developer Mistral Energy LLP.[31] UNIBLU Engineering and Contracting Co Ltd[32] built the plant on an area of 140 hectares, which included a 500kV substation[33] with 140,000 solar PV panels capable of producing an estimated 66,884 thousand kWh of electricity per year, excluding degradation. The project was projected to help reduce carbon emissions equivalent to 230,000 tonnes per year, relative to the country's electricity sector baseline.[34]

Case Study	**Fixed feed-in tariff project—Saran Power Plant** There were projects that were allotted and built 'outside' the country's auction scheme, one of which is presented for comparison. The 100MW solar PV plant in the city of Saran. The project was initially presented in the Kazakhstan pavilion at the international specialised exhibition EXPO 2017 in Astana. The project expanded[35] cooperation between the EBRD and the Ministry of Energy of the Republic of Kazakhstan on developing an RE and Kazakh emissions trading scheme (ETS) in the country in line with a memorandum of understanding (MoU) signed in 2017. The Saran Solar Power Plant located in Kazakhstan's Karangada region, costing USD105.3 million,[36] received financing from the EBRD[37] and the Green Climate Fund (GCF) in November 2018. Under the financing package, EBRD has financed USD52.7 million, while the GCF[38] committed to provide a loan of up to USD22.2 million. The solar power project was commissioned by *Solarnet Investment GmbH*, an affiliate of the German project developer Joachim Goldbeck Holding (GmbH), an international company specialising in the turnkey construction of PV plants at the commercial, industrial, and large scale level.[39] A special purpose company *SES Saran LLP* was incorporated by the GmbH in Kazakhstan to implement the solar park project. The project was built by *Enerparc* (a Singapore based company providing engineering and support services) on an area of 164 hectares with 307,000 solar PV panels (with no metal borders to minimise snow accumulation). The facility located outside Saran, home to just over 40,000 inhabitants, was expected to produce enough electricity to meet the demand of around 10 similar sized cities.[40] The project commenced operations and was expected to operate for about 40 years. The Saran project had executed an agreement to sell power to a government run entity under a 15 year PPA at KZT 34.61 (USD0.091) per kWh indexed for inflation.[41] The 100MWp solar power plant was expected to reduce carbon emissions by 93,500 tonnes per year, thereby supporting Kazakhstan's national emission reduction targets and EBRD's green economy transition strategy.[42] The SES Saran solar plant was part of the EBRD-GCF Kazakhstan RE framework, with a total GCF contribution of USD110 million which had been designed to increase investments into RE, to provide technical assistance, and to build institutional capacity for energy integration, RE, and carbon market policies and planning. Following the commissioning of the Saran project, Kazakhstan's huge potential for solar energy has led to the promotion of regional projects with the participation of European investors and the transfer of technologies from across countries.

Key strategic priorities[43] set out by the countries of the region for 2020-2030

1. Improved energy security through interconnected grid networks and coordinated network operations implemented through a regional governance system.
2. Design and implementation of structural reforms within the electricity sector to introduce new market designs, governance structures, and regulatory and institutional frameworks.
3. Rapid deployment of cost competitive RE systems to meet growing demand and replace ageing fossil fuel based generation capacity and enhanced energy efficiency (EE) to make the most of the available (greener) energy.

On the demand side, the CAREC Energy Strategy 2030 seeks to retain a clear focus on enhancing the EE to support its members in identifying and deploying suitable EE measures.

1. The energy strategy seeks to develop a regional EE scorecard that would allow individual countries to benchmark progress against international efficiency benchmarks.

2. The strategy also proposes the establishment of a new regional financing vehicle that would allow the CAREC community to mobilize finance for clean energy projects from public and private sources.

G. CAREC sustainable energy deployment, resources, and targets (2030)

The installed capacities of RE options and LHP projects across the countries of the region, and the corresponding power output as published by the International RE Agency (IRENA/as of the end of 2020) further supplemented with data from other agencies and sources are studied as a starting point. Key non-hydro RE installations include (in aggregate): some 43MWp of solar PV in Afghanistan; 66MW of wind energy generation capacity, 45MW of bio-energy installations, and 35MWp of solar PV in Azerbaijan; some 282,000MW of wind energy, 254,000MWp of solar PV, and about 19,000MW of solid bio-fuel and waste-to-energy (WtE) capacity in China; 21MW of wind energy generation capacity in Georgia; 336MW of wind energy generation and 797MWp of solar PV capacity in Kazakhstan; 156MW of wind energy generation and 90MWp of solar PV capacity in Mongolia; 1,236MW of wind energy, 432MW of bio-energy, and 713MWp of solar PV capacity in Pakistan.

The plant load factors (PLFs) are computed and analyzed as a part of the present research (based on the average installed capacity between two consecutive years). The potential for regional cooperation and interconnection of electricity grid networks to transfer surpluses (and to ensure effective frequency regulation) is assessed to study the possibility of overcoming issues relating to uneven distribution of resources and seasonal variability in energy production within the region. The study surveys literature on the cost effectiveness of providing battery storage to improve the balance between demand and supply of electricity in the region.[44]

Table 1.4: Realizable technical potential for RE deployment (MW)

Country → Technology Option↓	Kazakhstan	Kyrgyzstan	Tajikistan	Turkmenistan	Uzbekistan
Small hydro	4,800	1,800	23,000	1,300	1,800
Wind	354,000	1,500	2,000	10,000	1,600
Solar PV	3,760,000	267,000	195,000	655,000	593,000
Biomass	300	200	300	not significant	800

Source: Compiled based on UNDP Renewable Energy Snapshot for respective Central Asian countries. Retrieved from https://www.eurasia.undp.org/content/rbec/en/home/library/environment_energy/renewable-energy-snapshots.html

Despite confirming adequate RE resource availability across the region as presented within **Table 1.4** and despite commitments to curtailing GHG emissions as summarized previously, RE deployment as a part of the electricity sector transition in the Central Asian region has been slow. This is frequently attributed, at least in some countries, to abundant fossil fuel availability, dependence on low marginal cost hydropower, the inability to invest into upgrades or new projects and, above all to institutional inertia.[45] Additionally, it is believed that the landed cost of energy services plays a role in incentivising energy transitions.

In situations where the pricing might not be favorable relative to the incumbent—perhaps owing to large discounts on fuels or heavy government subsidies to the utilities—the new technology packages proposed as a part of the present report provide new characteristics of value to the end consumer.[46] Consequently, growth in RE deployment in the region should not *spontaneously* be visualized as a reduction in fossil fuel use, and therefore in the short run the energy transition in the CAREC region might be characterized by RE capacity *additions* rather than substitutions, and it is projected that older source conversion combinations might continue to operate alongside newer technologies.[47]

In recent years, just the economic costs of delivering electricity from solar PV, wind, and other RE technologies are known to be competitive relative to the incumbent fossil fuel led options.[48] These RE options become even more attractive when the environmental benefits from RE are internalized. The pace of such transition is obviously a function of the broader context—the political economy, existing institutions, cultural norms, and technical systems in place—and could be expedited through building coalitions supporting the acceleration of RE deployment, and through providing systematic feedback to strengthen policy frameworks. The creation of appropriate institutional structures and regulatory mechanisms to facilitate and regulate the transition, and facilitating information exchange could therefore help deploy low carbon technologies in the region to *meaningfully* exploit the available RE resources.[49] In addition, bringing in policy consistency and transparency could help attract investments into refurbishing and rejuvenating existing power generation assets. At the regional level, interconnecting grid networks could exploit complementarities in resource availability, enhance synergies and scale efficiencies, deliver network effects, reduce emissions and offer health benefits, and above all, generate employment opportunities for men and women alike.[50]

2. CHAPTER 2: GAP ANALYSIS OF SECTOR GOVERNANCE IN THE CAREC COUNTRIES

The legislative frameworks and electricity sector governance structures in the ten CAREC member countries (excluding Afghanistan) were analyzed as part of the current project. The detailed analysis and observations are presented in **Annexure 1** of this report. The summary of observations and the perceived gaps to be bridged in an attempt to achieve enhanced RE deployment targets and emissions reductions targets are presented in this chapter.

To illustrate the contrasts in governance mechanism in the region, two case studies have been presented in this section. The first case study is about Georgia's 20.70MW/USD32.30 million Qartli (or Kartli) wind farm. The execution of the construction of this wind farm was almost seamless, with no delays and no resistance from the local population, and it was carried out within the planned budget. In contrast, the USD188 million/50MW YeniYashma wind farm in Azerbaijan, which was expected to be inaugurated in 2011, was fraught with delays and was finally inaugurated in 2018.

Table 2.1 summarizes the existing governance frameworks in ten CAREC countries. Most countries have enacted laws governing RE and procurement: some more explicitly than others. However, given the overlap between the social objective of providing electricity services and ensuring investment attractiveness of the sector, the frameworks do not explicitly highlight the need for the utility to recover the total costs of generation and service delivery. **Table 2.2** summarizes the specific gaps that were identified in the governance structure for each of the ten countries.

Case Study

Case Study: Georgia Qartli Wind Farm

In December 2016 the 20.70MW/USD32.30 million Qartli (or Kartli) Wind Farm—also referred to as the Gori Wind Power Project (WPP)—became the first wind farm to be built in Georgia. The plant is located in the Shida Kartli region of Georgia, close to regions with high electricity consumption in the country. The capital cost of project implementation stood at USD1.56 million per MW, on average, setting a benchmark for projects that followed in Georgia and in the region as a whole. The EBRD provided a syndicated loan of USD21.72 million and the rest was funded through equity capital invested by the Georgian Energy Development Fund and the Georgian Oil and Gas Corporation. Equipment for the wind farm was supplied by Danish manufacturer *Vestas* (https://www.vestas.com) and the farm was built and commissioned by China Nuclear Industry 23rd Construction Co. Ltd. *Vestas* was also responsible for the operations and maintenance (O&M) of the project equipment. UK based company Mott Mcdonald (https://www.mottmac.com) was responsible for supervising project construction and the company continues to monitor and serve as the technical advisor for the project. The project was estimated to offset 27,187 tonnes of CO_2 each year.

The Georgian National Energy and Water Supply Regulatory Commission routinely determines the tariff for the power plants based on the *Return on Assets Base* (RAB) method.[51] Wholesale power was sold under direct physical contracts and any uncontracted energy was cleared each month at monthly weighted average balancing prices by the Electricity System Commercial Operator (ESCO), the Government owned electricity market operator in Georgia. ESCO had executed a power purchase agreement (PPA) with the Gori project, and the project began supplying power to the national grid in January 2017. The PPA was originally signed for a ten year period, confirming a tariff of USD69/MWh. In September 2019, however, a new PPA revised tariffs downward to USD65/MWh but extended the validity through to February 2030.

'This may be the most boring energy project we've ever invested in, but that's what makes it so great… The wind farm was delivered on time and within budget, it has no negative impact on the environment, did not generate any complaints from the local population and has been working properly for four years now… It's completely boring because everything went according to plan.'

Gerrit—Jan Brunink
Triodos Investment Management
May 2020

In practice, the PPA is structured to offer the wind farm open access supply options for a part of the year. Under the PPA, the Gori WPP is obligated to sell power exclusively to Georgia during the winter months[52] (when demand is higher and supply is lower) but the farm was free to choose the buyer—and the market—for the rest of the year subject to the relative attractiveness of other market opportunities, including possibly exporting power to neighboring Turkey.

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Case Study	Having borne the construction and commissioning risks, in July 2019, the Georgian Government decided to sell its entire equity stake in the Qartli WPP through an open auction.[53] A UK based holding company, *Georgia Capital Plc* won the auction on a bid of USD14.40 million. The project continued to operate under the revised PPA.[54] In 2019, the project is estimated[55] to have operated at a PLF of about 47 percent, producing about 1 percent of the country's total energy output.

Case Study

Case Study: Azerbaijan—YeniYashma Wind Farm

The USD188 million/50MW YeniYashma Wind Farm, also known as *Wind Farm Baku*, inaugurated in 2018, was the largest wind farm in the South Caucasus region at the time. The authorities concerned in Azerbaijan began mobilizing funds for this project way back in 2005. In 2009, the International Bank of Azerbaijan, with the support of Euler Hermes (https://www.eulerhermes.com), a German export credit agency, secured funding for the project from *Landesbank Berlin* (https://www.lbb.de/landesbank/de/index.html) and Société Générale (https://www.societegenerale.com/en) of France. About USD165 million was provided in the form of buyer credit with a tenor of 14 years, and the remaining USD23 million in investment was provided as a commercial loan with a tenor of 1.5 years. The project was originally[56] proposed for completion by the first half of 2011.

The project was divided into two areas: one managed by *Aztorq LLC*, and the other by the sister company *Caspian Management Systems LLC*. Both companies were controlled by the holding company *General Construction Holding*. Reportedly, the splitting of the wind power project into two legal entities was necessitated by local regulations and this arrangement implied that separate accounts were set for all project phases: from securing project related permissions to the sale of the energy generated.[57]

The project was designed to install 20 wind turbines of 2.5MW each, for a total installed capacity of 50MW, and an estimated net electricity generation of 196,000 MWh/year. At the time, the PLF for the project was estimated at 44.75 percent. It is to be noted that in 2009 when construction of the wind farm began, the regulatory framework did not explicitly promote the development of wind farms and continued to offer a low tariff for wind energy projects. The tariff rate at the time was 4.5 copeck/kWh (4.0€ cents/kWh), equivalent to 5.6 US cents/kWh. According to the International Energy Agency (IEA), the threshold tariff had to be around 7€ cents/kWh equivalent[58] to around 10 US cents/kWh.

The project developers, Aztorq and Caspian Management Systems, had no technological knowhow and no previous experience in implementing a wind farm project. The group's core business operations included exposure to construction, hydropower, agricultural, and tourism sectors. Owing to the inadequate exposure to the wind energy sector, the project developers relied heavily on overseas vendors for all aspects of project implementation, ranging from logistics to quality assurance. It is estimated that a total of 15 German and other European companies were involved in the design, engineering, logistics, and manufacturing of the equipment, along with 10 companies from Azerbaijan which were involved in construction and local logistics.

Aztorq and Caspian Management Systems were the designated owners of the wind farm, who, upon commissioning of the project, would manage operations, maintenance, and electricity supply. However, during the construction phase, the German company Mitaki Project GmbH assumed the role of the 'energy partner' in charge of the entire project, including overseeing financial and legal consulting activities; Airwerk was in charge of overseeing the engineering and logistics activities.[59]

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The project began as a pilot with two wind turbines each of 850kW capacity supplied by Vestas of Denmark, which were connected to the Baku electricity grid. The electricity generated was sold[60] to Bakielektrikshebeke, a government entity, at 5.6 US cents/kWh. A third turbine, of 500kW capacity, was not connected to the grid but was installed at a training center. The employees of project developing companies involved in the project underwent extensive training on the functioning of wind turbines and turbine foundation works at Conferdo and Fuhrlander in Germany. Project implementation appears to have made slow progress between 2010 and 2015: the 18 turbines proposed for installation were not connected to the grid and the wind farm was still testing the turbines[61] in 2015.
Det Norske Veritas (DNV), in its validation report to the CDM Executive Board, had noted that apart from the creation of the State Agency of Alternative and Renewable Energy Resources in 2009, Azerbaijan had not created a concrete plan or policy towards harnessing RE resources in the country. Azerbaijan's economy was heavily dependent on crude oil exports and the sharp drop in crude oil prices in 2014 affected the country's finances adversely. After two sharp devaluations of the Azerbaijan currency, the copeck, in 2015, the Central Bank of Azerbaijan (CBA) expended around two thirds of its foreign exchange (FX) reserves in an attempt to avoid de-pegging of the currency to the USD. A banking sector crisis ensued after this, forcing the International Bank of Azerbaijan, the state owned bank involved in the YeniYashma Wind Farm, to file for a large scale restructuring of its debt[62] to the project. The lack of interest from the Government together with the financial crisis in the country might have caused the delays in wind farm implementation.
The YeniYashma wind farm was inaugurated[63] in 2018, generating 60 million kWh of electricity during the remainder of 2018 and 80 million kWh during all of 2019. The Government of Azerbaijan has also proposed expanding[64] the wind farm by adding another 30 to 40 wind turbines at a cost of approximately USD25.0 million.
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Table 2.1: Comparison of governance structure for the 10 CAREC countries

	Institutional governance			Legal governance		Commercial governance		Technical governance (power quality and efficiency)
Country	**Ministry/competent authority**	**Tariff regulation body/independent statutory body**	**State owned corporate body**	**Prevailing/ amended laws on energy**	**Laws on participation of private equity investors**	**Cross border trade**	**Cost recovery/balance between social objectives of the Government and viability of services**	**Adoption of energy efficiency policies**
Azerbaijan	Ministry of Energy (MoE) & Energy Regulatory Agency	Tariff Council & Azerbaijan Energy Regulatory Agency (AERA)	Azalternativenergy LLC—operates and manages hydropower, solar, wind, and biogas facilities; Azerenergy OJSC—responsible for electricity generation and transmission, Azerishiq OJSC—responsible for distribution of electricity	Law on the Use of Energy Resources (1996) Law on Electric Power Industry (1998) Law on Heat and Electric Power Plants (1999)	Pending approval	Imports from Russia, Iran, Georgia; exports to Russia, Iran, Turkey, Georgia	Electricity service provision is primarily viewed as a social objective of the state	National Energy Efficiency Action Plan (NEEAP)—the draft law 'On the Rational Use of Energy Resources and Energy Efficiency' (adopted at 1st reading)

	Institutional governance			Legal governance		Commercial governance		Technical governance (power quality and efficiency)
Country	**Ministry/competent authority**	**Tariff regulation body/independent statutory body**	**State owned corporate body**	**Prevailing/ amended laws on energy**	**Laws on participation of private equity investors**	**Cross border trade**	**Cost recovery/balance between social objectives of the Government and viability of services**	**Adoption of energy efficiency policies**
China	The National Development and Reform Commission (NDRC) & The National Energy Administration (NEA)	Provincial governments determine 'benchmark' feed in tariffs, to be approved by the Central Government	The State Grid Corporation of China (SGCC), The China Power Southern Grid (CSG) company & The Inner Mongolia Electric Power Company	The Electric Power Law of 1995 and The Renewable Energy Law of 2005	No specific law, although private sector participation is permitted	Russian Federation, Kazakhstan, Pakistan, and Mongolia	Comparatively cost effective, although electricity sector is of 'public interest'	Energy conservation and emission reduction 12th five year plan and such others
Georgia	Ministry of Economy and Sustainable Development (MoESD)	The Georgian National Energy and Water Supply Regulatory Commission (GNERC)	The Georgian Energy Development Fund	Law on Energy and Water Supply (2019), Electricity Market concept design (2020), Law on Promoting the Production and Use of Energy from Renewable Sources (2019)	No specific law, although private sector participation is permitted.[65]	1) Russia and Armenia/Iran, 2) Azerbaijan and Turkey, 3) Russia and Turkey, and 4) Armenia/Iran and Turkey	Electricity service provision is primarily viewed as a social objective of the state	National EE Action Plan (NEEAP)—passed in 2019

	Institutional governance			Legal governance		Commercial governance		Technical governance (power quality and efficiency)
Country	**Ministry/competent authority**	**Tariff regulation body/independent statutory body**	**State owned corporate body**	**Prevailing/ amended laws on energy**	**Laws on participation of private equity investors**	**Cross border trade**	**Cost recovery/balance between social objectives of the Government and viability of services**	**Adoption of energy efficiency policies**
Kazakhstan	Ministry of National Economy, Ministry of Energy, and Ministry of Industry and Infrastructure Development	The Committee for the Regulation of Natural Monopolies under the Ministry of National Economy of the Republic of Kazakhstan	Samruk Energy JSC—generation, transmission, and distribution of electricity, Kazakhstan Electricity Grid Operating Company ('KEGOC') JSC and JSC Kazakhstan Wholesale Electric Power Market (KOREM)	The Electric Power Law (2004), Law on Support for the Use of Renewable Energy Sources (the RES law—2009)	The PPP Law (2015, amended in 2021) 'Restrictive mechanisms predominate in the legal framework, with virtually no investment encouraging provisions or incentives'[66]	Exports to Kyrgyzstan, Russia, Uzbekistan; imports from Russia, Kyrgyzstan	Electricity service provision is primarily viewed as a social objective of the state.	Law 'On Energy Saving and Energy Efficiency' (2012), Concept of development of the fuel and energy complex until 2030 (EE priorities)

	Institutional governance			Legal governance		Commercial governance		Technical governance (power quality and efficiency)
Country	**Ministry/competent authority**	**Tariff regulation body/independent statutory body**	**State owned corporate body**	**Prevailing/ amended laws on energy**	**Laws on participation of private equity investors**	**Cross border trade**	**Cost recovery/balance between social objectives of the Government and viability of services**	**Adoption of energy efficiency policies**
Kyrgyzstan	State Agency for Regulation of the Fuel–Energy Complex (SARFEC) under Ministry of Energy	Ministry of Energy	National Energy Holding Company (NEHC)	The Electric Power Law (1997, amended in 2019), Renewable Energy Law, 2008 (Amended in 2019)	1. The Law 'On PPP' (2021) 2. Govt Decree No. 327 of 16 June 2016 'On Approval of the Program for Development of PPP in Kyrgyzstan for 2016-2021' 3. Govt Decree of 17 March 2014 No. 147 'On Financing of Preparation of PPPProjects' 4. Govt Decree of 21Feb, 2020 № 111 "On some issues in the field of PPP".	Import from Tajikistan, Turkmenistan, Uzbekistan, and Kazakhstan. Exports to Kazakhstan, Uzbekistan, Tajikistan.	Medium term tariff policy ensuring breakeven for the period 2019-2023	The Law on Energy Conservation (1997, amended in 2019)

	Institutional governance			Legal governance		Commercial governance		Technical governance (power quality and efficiency)
Country	**Ministry/competent authority**	**Tariff regulation body/independent statutory body**	**State owned corporate body**	**Prevailing/ amended laws on energy**	**Laws on participation of private equity investors**	**Cross border trade**	**Cost recovery/balance between social objectives of the Government and viability of services**	**Adoption of energy efficiency policies**
Mongolia	Ministry of Energy (MOE)	Energy Regulatory Commission (ERC)	No mention of a state owned body, but the whole power system is state owned	Laws for Energy, Licensing, Renewable Energy (2007), *Energy Conservation Law (2015)*	Mongolia Investment Law (2013), Mongolia Concession Law (2010)	Import from China and Russia	Single use tariffs and time of use tariffs are levied. Cost recovery not explicitly mentioned.	A regulatory framework on energy efficiency is operative.
Pakistan	The National Electric Power Regulatory Authority (NEPRA)	The National Electric Power Regulatory Authority (NEPRA) for tariffs & Water and Power Development Authority (WAPDA) for development of hydropower resources	The Pakistan Electric Power Company (PEPCO)	Regulation of Generation, Transmission and Distribution of Electric Power Act, 1997 also known as the 'NEPRA Act, 1997'	The Policy Framework for Private Sector Transmission Line Projects 2015	Imports energy resources of about one third of the country's energy demand[67]	'Circular debt' problem, creating a cashflow constraint for producers owing to non payments by utilities.	The National Electricity Policy 2021 & The National Energy Efficiency and Conservation Act 2016 (NEECA Act, 2016)

	Institutional governance			Legal governance		Commercial governance		Technical governance (power quality and efficiency)
Country	**Ministry/competent authority**	**Tariff regulation body/independent statutory body**	**State owned corporate body**	**Prevailing/ amended laws on energy**	**Laws on participation of private equity investors**	**Cross border trade**	**Cost recovery/balance between social objectives of the Government and viability of services**	**Adoption of energy efficiency policies**
Tajikistan	Ministry of Energy and Water Resources (MoEWR)	MazhilisOli Republic of Tajikistan ('RT') & State Agency for Standardization, Certification of RT (certification)	Joint stock holding company *BarkiTojik,* Energy Company Pamir-energy JSC Sangtuda HPP-1	Constitution of the Republic, The Law 'On Energy,' The Law 'On Energy Conservation'	The Law on PPP (2012)	Import from Turkmenistan, Kyrgyzstan, Uzbekistan. Exports to Uzbekistan, Kyrgyzstan and Afghanistan.	Electricity tariffs, on average, are barely above 50 percent of the cost recovery level and do not reflect the annual increase in debt service costs of the utilities concerned.	The National Development Strategy (NDS) for the period up to 2030 (2016), The Law 'On Energy Savings and Energy Efficiency' from September 2013
Turkmenistan	Ministry of Energy and Industry	Ministry of Finance	Turkmenenergo State Electric Energy Corporation	The Law on Electrical Energy (2014), RE Law (2021)	No specific law. According to the Law on Electrical Energy (2014) power system facilities in Turkmenistan are state property.	Exports to Iran, Turkey, Afghanistan, Tajikistan, Kyrgyzstan	Energy sector is almost fully subsidised, not cost effective	The National Strategy on Climate Change (15 June 2012) & The EE Program for 2018 to 2024 (21 February 2018)

	Institutional governance			Legal governance		Commercial governance		Technical governance (power quality and efficiency)
Country	**Ministry/competent authority**	**Tariff regulation body/independent statutory body**	**State owned corporate body**	**Prevailing/ amended laws on energy**	**Laws on participation of private equity investors**	**Cross border trade**	**Cost recovery/balance between social objectives of the Government and viability of services**	**Adoption of energy efficiency policies**
Uzbekistan	Ministry of Energy	Ministry of Finance	Thermal Power Plants JSC and Uzbekhydroenergy JSC are responsible for generation of electricity, while National Electric Networks of Uzbekistan JSC is responsible for transmission of electricity, Regional Electric Grids JSC is responsible for distribution of electricity	The Law on the Rational Use of Energy, amended in 2020 Law No. ZRU-225 on electric power industry	1. The Law on PPP № ZRU-537 (2019); 2. Decree of the Cabinet of Ministers 'On measures to accelerate the implementation of public–private partnership projects and further improve their financing' № 509 (2021)	Exports electricity to Afghanistan, Kyrgyzstan, Tajikistan. Imports electricity from Kyrgyzstan, Kazakhstan, Tajikistan.	Tariffs set by the Ministry have remained significantly below the levels that would be consistent with full cost recovery for the utilities concerned.	Resolution of the President of the Republic of Uzbekistan on accelerated measures to improve the EE of industries and the social sphere, the introduction of energy saving technologies and the development of RES #PP 4422 (2019)

Table 2.2: Gaps in governance structures across CAREC countries

Country	Existing scenario	Perceived gaps	Recommendations
Azerbaijan	• The Soviet era power sector infrastructure in many districts is less reliable, resulting in more frequent outages and increasing losses. • *Azalternativenergy* LLC, implements RE projects, generates, transmits, and distributes electricity. • The current network tariffs for electricity are based on a 'cost plus' methodology that does not seem to enhance efficiencies. • Given the RE potential available in Azerbaijan, the country requires more investments for power sector development. • The AERA and Tariff Council are currently both involved in determining tariffs. A new law currently under review might eliminate the Tariff Council in the future.	• Absence of an explicit regulatory framework for monitoring power quality. • Need for investments to boost RE capacity. Need for implementation of cost effective tariffs that facilitate cost recovery for participating entities. • The state owned T&D bodies, *Azerenrji* and *Azerishiq*, also reported to MoE. If the independent *Tariff Council* were to be eliminated and if an agency reporting to the MoE, such as the AERA, were to decide tariffs to be collected by other entities also reporting to the MoE, this might represent a situation with implicit conflicts of interest.	• A regulatory framework for monitoring power quality is required to be set up. • Telescopic tariff structures (block tariffs) could be implemented based on predetermined thresholds to offer low prices for low end consumption, while charging higher end consumers premium rates. • The country needs to develop a transparent electricity tariff setting methodology that will incentivize investment in efficient power sector development. • Attracting long term power purchase agreements (PPA) might serve as an RE capacity booster. • The possible existence of the Tariff Council and its functions need to be explicitly stated to avoid conflicts and distinguish the roles and responsibilities of the Tariff Council from the State owned T&D bodies.
China	• Adverse weather conditions lead to rising power demand. • The energy system in China is dominated by fossil fuels.	• Need to enhance the efficiency of RE asset use while also focusing on improving upon the balance between peak generation and peak demand. • China has massive build-up of	• The possibility of achieving optimization through building adequate grid network capacities, appropriate pricing mechanisms, and through increased interprovincial transfer of surpluses

Country	Existing scenario	Perceived gaps	Recommendations
		hydropower, solar PV, and wind energy capacity which can supply within China as well as to other parts of the CAREC region.	could be explored. • Significant scope for enhancing the efficiency and sustainability of the energy sector could be utilized.
Georgia	• The Georgian power system endures acute shortage of operating reserves resulting in low power quality in isolated regimes. • PPA tariffs do not appear to vary in response to seasonal demand. • Wind farms are reported to operate at high PLF.	• RE generators in Georgia may not always be adequately incentivized to supply within the country. • Rigid tariffs do not respond to seasonal demand • Scope for exploiting the wind resource in the country.	• Sufficient operating reserves need to be provided through construction of regulated hydropower plants to deal with load shedding situations. • The PPA tariffs could be made more flexible to respond to demand patterns. • The present study proposes the addition of 2,272MW of wind energy capacity in Georgia by 2030.
Kazakhstan	• Renewable Energy Law in Kazakhstan has primary focus on the support for the use of RE. • RE projects in Kazakhstan are implemented with basic regulatory requirements	• Kazakhstan has an opportunity to exploit the potential in international power transmission. • Absence of mechanisms for continuous/periodic reviews, reporting and assessment of utility performance is observed.	• The Renewable Energy Law remains silent regarding the transmission of power to other countries during times of lower demand and higher supply within Kazakhstan. • Realtime performance of the RE projects in Kazakhstan through reporting data requirements provides for continuous assessment of the existing regulatory measures in comparison with the ideal practices prescribed/to be prescribed for further improvements in the

Country	Existing scenario	Perceived gaps	Recommendations
			energy sector.
Kyrgyzstan	• Ministry of Energy is currently responsible for tariff regulation in Kyrgyzstan. • Hydropower and fossil fuels are the major resources for power generation in the country	• Absence of a specific regulatory authority for tariff regulation is observed. • Power shortage is observed during the colder months and there is scope for exploiting the wind resource in the country which might serve the population in the winter months and allow to meet the growing demand and to fulfill the export commitments under the CASA-1000 project. • Lack of a long term energy sector development strategy. • Lack of EE strategy	• A regulatory body focusing on energy tariff policy could help the determining tariffs at levels compatible with recovering costs of generation and service delivery. • A long term energy development program and EE strategy should be developed and approved, taking into account the implementation of climate commitments. • The present study has recommended the addition of 1,500MW of wind energy generation—operating close to 33 percent PLF on average over the year.
Mongolia	• Mongolia generates most of its power from coal fired plants and diesel generators	• RE sector growth in Mongolia is limited by the availability of skilled manpower; the country has huge potential for exploiting both solar and wind energy resources.	• The agencies concerned need to develop requisite institutions and provide access to relevant training programs in other countries with the help of international financial institutions and mutual assistance programs build and increase the capacity of local RE specialists. • As the local personnel are acquainted with the terrain and the institutions, training them could result in expedited installation and disciplined maintenance of the wind power plants.

Country	Existing scenario	Perceived gaps	Recommendations
			• Owing to the low temperature the Gobi Desert could be a great source of solar PV electricity and, hence, Mongolia could emerge as a significant RE producer owing to the Gobitec project.
Pakistan	▪ Pakistan has diligently worked on adoption, improvisation, and implementation of significant laws and regulations in the power sector, and holds adequate experience in cross border trade.	▪ There is excess installed capacity but not enough cashflow in the system to run it. ▪ 'Circular debt' in the power sector from the non payment of obligations by consumers, distribution companies, and the Government. ▪ Tariff anomalies, including a significant difference between cost recovery and notified tariffs. ▪ High T&D losses coupled with low recoveries; ▪ Delays in tariff notification as well as release of tariff subsidy/cash infusion by the Government.[68] ▪ Scope for improvement in efficiencies of T&D.	▪ Pakistan has a matured governance framework in place and could provide requisite guidance to fellow members of the CAREC region if required and agreed among the countries (Grid Code, RE institutions, grievance redressal mechanisms, etc). ▪ Moving from the current state led, single buyer model (monopsony) to a competitive, multiplayer market with the private sector in the lead. ▪ While electricity tariffs to be brought to cost recovery levels, efficiency improvements are likely to lead to more sustainable progress in reducing circular debt in the power sector. ▪ Reduce generation, transmission, and distribution costs by checking technical and financial losses, and improving governance in the sector
Tajikistan	▪ Tajikistan possesses vast reserves of hydropower	▪ Exploiting hydropower reserves generally requires significant initial	▪ A well structured public–private partnership law and tendering

Country	Existing scenario	Perceived gaps	Recommendations
	resources that could be exploited during many months of the year.	investments to develop requisite infrastructure. ▪ Absence of a clear long term energy sector development strategy. ▪ Absence of a focused EE strategy	infrastructure projects in a transparent manner with regular and structured audits would help encourage private sector participation. ▪ A long term energy development program and EE strategy should be developed and approved, taking into account the implementation of climate commitments
Turkmenistan	▪ The Government has been continuously investing in the oil and gas sector, to modernize and expand the electricity supply and heat provision in the country. ▪ Turkmenistan has been unable to develop alternative and corridors to diversify its hydrocarbon exports.	▪ Need for exploring possibilities to boost the national energy budget with the additional fuel export revenues. ▪ Implementation of EE strategies to have larger scale generation and increase the share of RE in electricity generation.	▪ The expansion of the electricity grid network in Turkmenistan could follow in the footsteps of the negotiations held in the context of gas export networks. ▪ The country could use gas as a bridge until all of the projected non-fossil fuel generation capacity and the network links are commissioned.
Uzbekistan	▪ The country has high RE potential and has adopted significant regulations to improve upon EE.	▪ End use tariff structures may not be adequate to implement the requisite regulatory mechanism. ▪ Implementation of the adopted regulations to improve EE requires further guidance, monitoring and evaluation methodologies.	▪ EE decrees need to define technical standards that set energy performance limits for end use categories and specify testing procedures and baselines to assess compliance with such standards.

3. CHAPTER 3: SCOPE FOR REGIONWIDE OPTIMIZATION

A. Overview of the electricity sector in the CAREC region

Electricity demand in the CAREC region is projected to rise on the back of expanding electricity based services, uptake of electric transportation and shared mobility, and on the back of low and medium temperature heat applications. By some estimates, electricity demand is projected to grow (within the CAREC region excluding China) from an index value of 100 in 2015 to an index value of 228 in 2050 representing a CAGR of 2.4 percent over this time period.[69]

As presented within **Table 3.1** of this report, the efficiency factors (PLF) for electricity generation with solar PV and wind vary among the countries of the region implying that such generation assets would operate at different efficiency levels at different sites and across countries. As presented within **Table 3.2** of this report, the (power plant) fleet level efficiency factors (PLF) for electricity generation during 2018—the year with complete data sets accessed by the authors—vary between 20 percent and 53 percent among the countries of the region. Scaling up the consumption (in MWh and net of T&D losses) through to 2030 provides an estimate of the electricity consumption demand in 2030 in each country (in MWh and net of T&D losses). Assuming similar PLF levels as in 2018, this estimate of electrical energy consumption is employed to estimate the corresponding generation capacity to be operational in 2030 (implicitly including provisions for T&D losses) to project the business as usual (BAU) scenario.

In the manner of illustrating the alternative scenario where solar PV and wind energy generation capacity *progressively* replace fossil fuel plant capacity, **Table 3.2** also provides an indication of the non-hydro RE capacity to be added by 2030 to achieve a PLF adjusted capacity replacement that would be sufficient to meet the projected energy demand. For the purpose of this illustration the energy hitherto provided by fossil fuel plants is supplied by solar PV and wind energy generation in equal measure by 2030. In some countries of the region, such capacity addition is limited by the assessed wind energy resource. Replacing the approximately 80,000MW fossil fuel component of the generation mix in the countries within the region represents the addition of some 192,000MW of non-hydro RE technology capacity to achieve **self sufficiency in generation in each country** by 2030.

Table 3.3 of this report presents the fleet level efficiency factors for electricity generation during 2018—the year with complete data sets accessed by the authors. Scaling up the consumption (in MWh and net of T&D losses) through to 2030 provides an estimate of the electricity consumption in 2030 within each country (in MWh and net of T&D losses). This estimate of electrical energy demand is employed to compute the corresponding generation capacity to be operational in 2030 (implicitly including provisions for T&D losses). In this specific scenario, the proportion of generation capacity in a CAREC member country (not including China) in 2030 is **determined based on the PLF of wind and PV installations to achieve regionwide optimization**. This provides a priority listing of location for wind energy and PV installations within the generation mix design to progressively replace fossil fuel plants and is optimized to meet regionwide demand. In this scenario, replacing the fossil fuel component of the generation mix in each country within the region, aggregating some 80,000MW represents the addition of some 153,000MW of non-hydro RE technology options. This decrease in estimated capacity addition relative to countrywise capacity addition is driven by the high capacity utilization of solar PV equipment and wind energy generators within this scenario while achieving **regionwide self sufficiency**.

Central to enhancing the efficiency of RE asset use includes:

1. Prepare short and medium term plans and programs for the development of the energy sector, taking into account the dynamics and cost of new RE technologies and the achievement of climate goals.
2. Locating generating assets such as wind farms and solar PV plant in sites that are endowed with the highest RE resources within the region.
3. The energy so generated would need to be conveyed to the load centers **contemporaneously** to minimize investments into storage capacity.
4. On the demand side, the intraday load profiles of individual countries are studied to arrive at such efficiency enhancing projections and to try and match the supplies with the demand patterns.
5. The differences in time zones might prove to be a crucial factor in facilitating such contemporaneous transfer of surpluses to meet demand in other parts of the region.
6. This also helps avoid the construction of plants specifically designed and constructed to meet peak demand (peaker plants).
7. Implement measures to compensate for fluctuations in variable RES. If their share is between 3 percent and 15 percent of the total generation, consider adaptation of existing regulation resources and control methods. If above 15 percent, a deep restructuring of the power system and the introduction of new means and tools to maintain the power system, including energy storage systems, new business models, empowering consumers, transforming them from passive to active participants of the market, new rules for the operation of wholesale markets, and so on are required.

Table 3.1: Estimated plant load factors for solar PV and wind energy for CAREC region countries

Country	Solar PLF*	Wind PLF**
AFG	18.5%	No Data
AZE	**15.3%**	18.2%
GEO	15.7%	**46.2%**
KAZ	12.9%	**39.9%**
KGZ	15.5%	**32.9%**
MNG	15.2%	**33.7%**
PAK	**18.0%**	26.5%
TJK	15.3%	**32.9%**
TKM	**17.3%**	32.9%
UZB	**16.5%**	32.9%

Source: Report authors;*based on EU–GIS projection of output derived from a hypothetical 1.0MWp solar PV plant located at the major airport of the capital city of each country; **regionwide average adopted for countries where country/project specific data was unavailable.

Table 3.2: Projected business as usual capacity requirement to meet projected electricity demand in 2030 (CAREC region countries not including China)

	2018					2030					
Country	Electricity consumption[1]	Installed generation capacity	Fleet level (system) PLF	Solar PV[2] PLF	Wind generation[4] PLF	Forecast consumption (2.4% CAGR)	Capacity required to meet domestic demand with similar generation mix as 2018	Percentage of fossil in installed capacity mix	Replacing fossil fuel capacity—50% solar PV 50% wind [or limited by resource potential][3,4]		Total capacity required after replacing fossil fuel plant with RE
	MWh	MW	%	%	%	MWh	MW	%	MW	MW	MW
									Solar PV	Wind	Total
Afghanistan	6,022,950	636	20.00%	18.54%		8,005,874	4,569	44.63%	663		3,193
Azerbaijan	20,285,780	8,068	33.70%	15.29%	18.16%	26,964,427	9,133	84.17%	13,159	4,425	19,030
Georgia	11,956,100	4,215	32.29%	15.74%	46.21%	15,892,383	5,619	21.92%	-	655	5,042
Kazakhstan	91,668,270	22,533	51.53%	12.92%	39.86%	121,848,031	26,992	86.30%	47,451	15,854	67,003
Kyrgyzstan	11,740,400	3,824	45.70%	15.55%	32.88%	15,605,668	3,898	19.19%	849		3,999
Mongolia	6,932,590	1,550	45.43%	15.24%	33.66%	9,214,993	2,315	84.00%	2,767	1,641	4,778
Pakistan	120,563,757	35,144	46.77%	17.98%	26.51%	160,256,721	39,115	64.88%	34,172	20,192	68,103
Tajikistan	14,213,180	6,519	34.11%	15.30%	32.88%	18,892,557	6,323	11.03%	140	362	6,127
Turkmenistan	15,090,000	5,201	46.50%	17.30%	32.88%	20,058,050	4,924	99.98%	6,617	3,481	10,099
Uzbekistan	49,203,917	12,803	52.99%	16.49%	32.88%	65,403,224	14,091	85.59%	37,644	1,599	41,274

Source: Author estimates based on data from:

1. EIA Site (2018), Retrieved on 24 October 2021 from https://www.eia.gov/electricity/data/browser/: for 2018 consumption and capacity data.
2. European Commission Site (15 October 2019). Retrieved on 24 October 2021 from https://re.jrc.ec.europa.eu/pvg_tools/en/#PVP: solar PV PLF estimated for a hypothetical 1.0MWp plant installed at the site of the airport at the capital city within each country.
3. UNDP (23 July 2014). Renewable Energy Snapshots. Retrieved on 24 October 2021 from https://www.eurasia.undp.org/content/rbec/en/home/library/environment_energy/renewable-energy-snapshots.html: wind energy data for selected countries in the region.
4. Wind energy PLF estimated based on installed wind energy capacity and annual energy generation published by the International Renewable Energy Agency (IRENA).

Table 3.3: Projected non-fossil fuel capacity requirement to meet projected electricity demand in 2030 (CAREC region countries not including China)

	2018					2030				
Country	Electricity consumption[1]	Installed generation capacity	Share of installed clean energy capacity of member country	Solar PV[2] PLF	Wind generation[4] PLF	Forecast consumption (2.4% CAGR)	Share of fossil fuel plant in installed capacity mix	Replacing fossil fuel plants with RE and to maximize efficiency of asset use [or limited by resource potential][3,4]		Total non-hydro RE capacity replacing fossil fuel plants
	MWh	MW	%	%	%	MWh	%	MW	MW	MW
								Solar PV	Wind	Total
Afghanistan	6,022,950	636	1%	18.54%		8,005,874	44.63%	-	-	2,530
Azerbaijan	20,285,780	8,068	8%	15.29%	18.16%	26,964,427	84.17%	13,173	-	14,618
Georgia	11,956,100	4,215	4%	15.74%	46.21%	15,892,383	21.92%	-	2,272	6,659
Kazakhstan	91,668,270	22,533	22%	12.92%	39.86%	121,848,031	86.30%	-	36,383	40,081
Kyrgyzstan	11,740,400	3,824	4%	15.55%	32.88%	15,605,668	19.19%	-	1,500	4,650
Mongolia	6,932,590	1,550	2%	15.24%	33.66%	9,214,993	84.00%	-	10,619	10,989
Pakistan	120,563,757	35,144	35%	17.98%	26.51%	160,256,721	64.88%	53,840	-	67,578
Tajikistan	14,213,180	6,519	6%	15.30%	32.88%	18,892,557	11.03%	-	2,000	7,626
Turkmenistan	15,090,000	5,201	5%	17.30%	32.88%	20,058,050	99.98%	13,232	-	13,233
Uzbekistan	49,203,917	12,803	13%	16.49%	32.88%	65,403,224	85.59%	19,381	-	21,411

Source: Author estimates based on data from:

1. EIA Site (2018), Retrieved on 24 October 2021 from https://www.eia.gov/electricity/data/browser/: for 2018 consumption and capacity data.
2. European Commission Site (15 October 2019). Retrieved on 24 October 2021 from https://re.jrc.ec.europa.eu/pvg_tools/en/#PVP: solar PV PLF estimated for a hypothetical 1.0MWp plant installed at the site of the airport at the capital city within each country.
3. UNDP (23 July 2014). Renewable Energy Snapshots. Retrieved on 24 October 2021 from https://www.eurasia.undp.org/content/rbec/en/home/library/environment_energy/renewable-energy-snapshots.html: wind energy data for selected countries in the region.
4. Wind energy PLF estimated based on installed wind energy capacity and annual energy generation published by the International Renewable Energy Agency (IRENA).

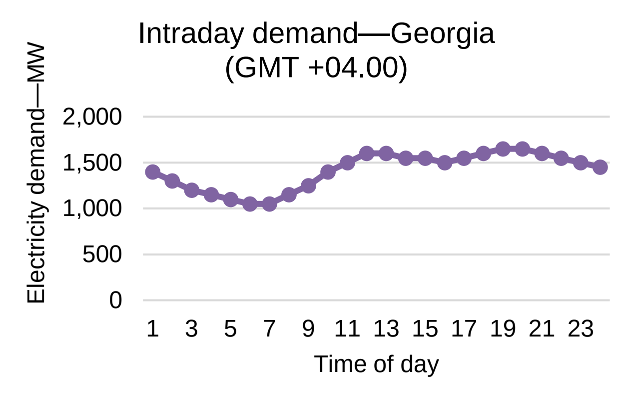
It is now widely believed that incremental change on offer by member nations would need to be replaced by 'extraordinary policy action' to encourage the transformation of the world's energy system to limit global warming to below 2 degrees Celsius by 2050, (relative to pre-industrial era temperatures), as set out in the Paris accord.[70] The recommendations of this study, if implemented accordingly, will help to more than achieve the most recent commitment to emissions reductions level for the CAREC region. **Table 3.4** demonstrates the various levels of emission reduction, the commitments made at Paris and Glasgow and also the emissions reductions for the region that can be brought about by implementing the recommendations relating to regionwide optimization made in this report.

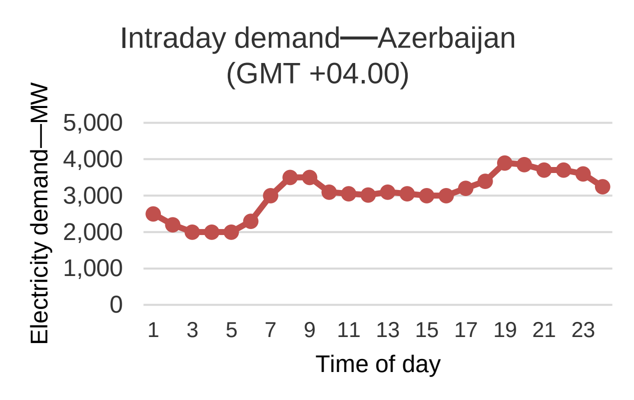
Table 3.4: Levels of emissions reductions in the 10 CAREC countries, the commitments made at Paris and Copenhagen and the emissions reductions potential based on recommendations of this report

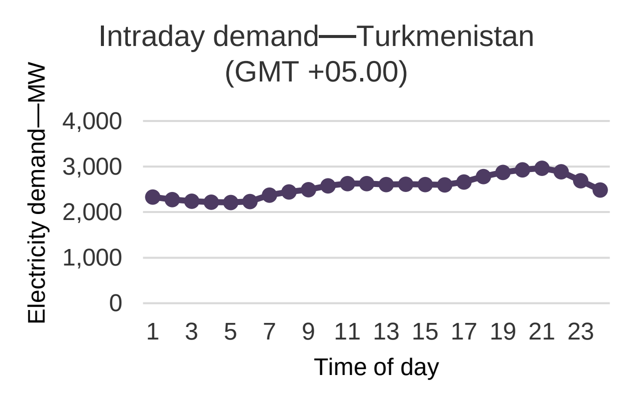
Country	2030 (BAU CO_2mt) total emissions	Paris commitment (reduction in CO_2mt)	Co commitment (reduction in CO_2mt)	Emission 2030 projected reduction (CO_2mt)
Azerbaijan	1,72,98,195	TBD	TBD	
Georgia	93,36,602	25,66,500	25,66,500	
Kazakhstan	25,04,21,664	TBD	TBD	
Kyrgyzstan	1,12,11,121	15,41,529	17,90,416	
Mongolia	2,68,45,110	37,58,315	60,93,840	**49,68,91,757**
Pakistan	20,77,06,868	3,11,56,030	7,26,97,404	
Tajikistan	1,42,36,625	25,42,006	36,31,436	
Turkmenistan	3,05,40,214	TBD	TBD	
Uzbekistan	1,97,88,164	16,02,213	56,07,744	
Total	**58,73,84,565**			**49,68,91,757**

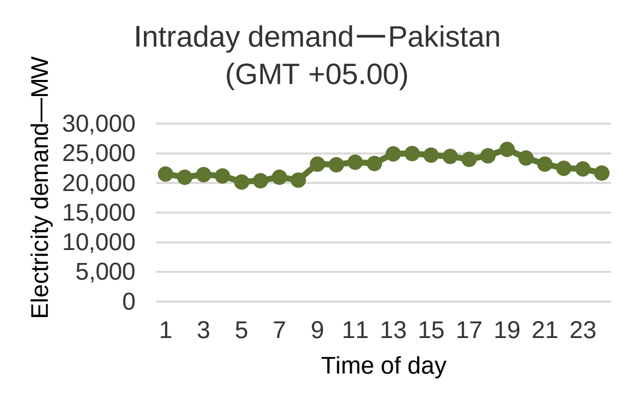
1. The 2030 BAU scenario is generated by extrapolating the total estimated CO_2 emissions from 2009 to 2018.
2. Emission reduction proposed in 2030 considers that all the fossil fuel plants are replaced with wind or solar PV as proposed in this report, with other RE options continuing to grow as projected by individual countries.
3. Given the enhanced efficiency of RE asset use, some countries produce more electricity than required merely to meet domestic demand; regionwide optimization and the consequent emission reduction are achieved through cross border trade in such surpluses.
Source for BAU: EIA Site (undated), retrieved on 24 October 2021 from https://www.eia.gov/electricity/data.php
Source for unit conversions: https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-.calculations-and-references
Source for Paris and COP26 commitments: UNFCC retrieved from https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments

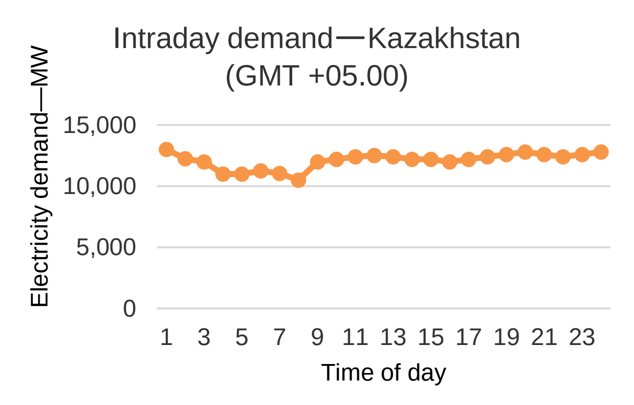
B. Analysis of demand patterns

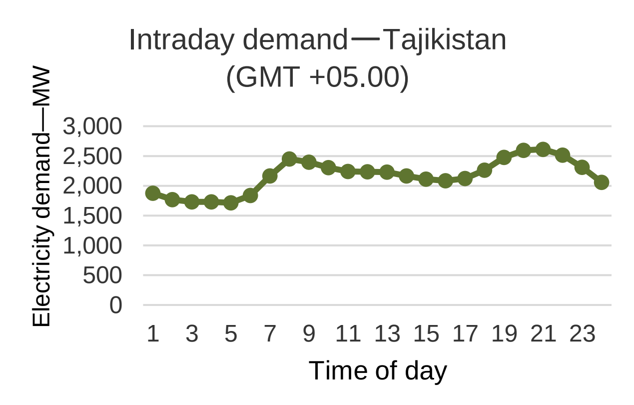


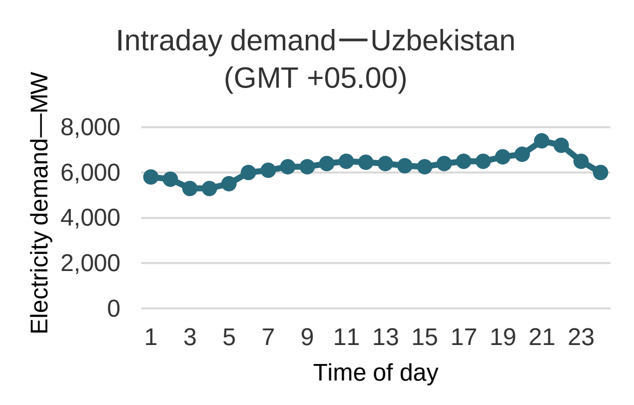


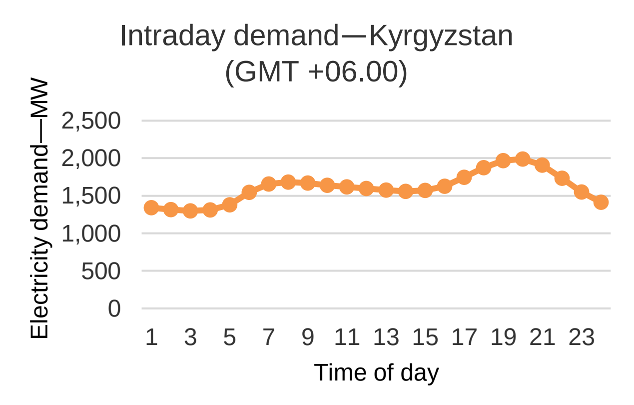












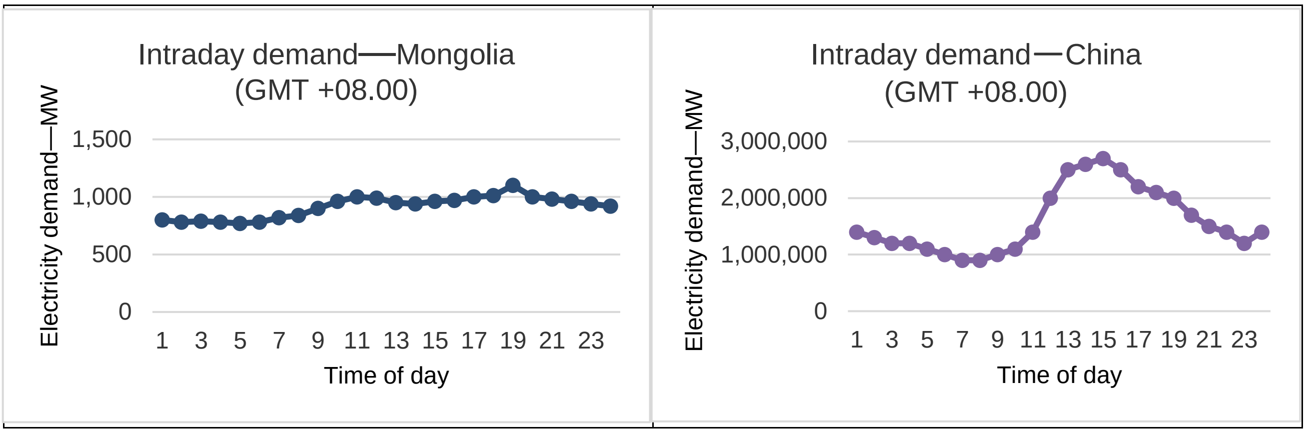


Figure 3.1: Representative intraday profiles for electricity demand in individual countries within the CAREC region (excluding Afghanistan)

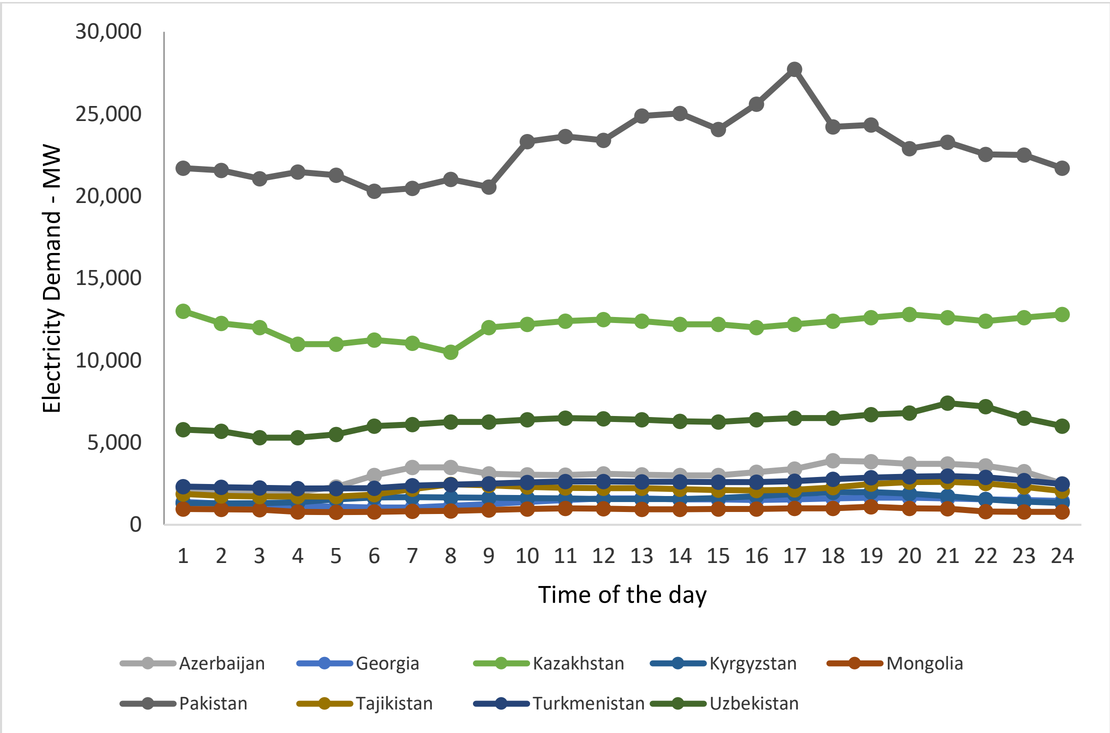


Figure 3.2: Intraday load profiles adjusted to GMT + 5.0 (non-China CAREC)

The typical standalone intraday demand profiles for individual countries are presented within **Figure 3.1**. As shown in **Figure 3.2**, the representative intraday load profiles are collated and the demand patterns are adjusted and viewed from the perspective of the time zone set at GMT + 5.0: evidently, the power demand in Pakistan and Kazakhstan over the course of the typical day is far greater than the other member countries of the region (excluding China) and such profiles present with higher intraday variability. The time zone adjusted standalone intraday demand profiles for the countries within the CAREC region (excluding China) are cumulated and presented within **Figure 3.3**. The differences between the peak and non-peak demand (the duck curve) observed for individual countries is largely eliminated owing to the complementarities of demand profiles. The typical aggregated regionwide intraday demand ranges from a little over 45,000MW to a little under 60,000MW over a 24 hour period.

The time zone adjusted standalone intraday load profile for the CAREC region countries **including China** is presented within **Figure 3.4**. The duck curve, in this scenario, peaks at about 280,000MW at about 15:00 hours on the representative day (GMT + 5.0). Given the vast difference in demand and given the possibility of internal demand hedging within China, the present study seeks to explore the possibility of China's serving as a **residual supplier to meet net shortfalls** in supply within the region. Likewise, the study seeks to explore the possibility of China's serving as a residual consumer to absorb the net surpluses generated within the countries of the region, after meeting the aggregate demand within the group of ten countries, and after providing for such internal balancing with Kazakhstan and Pakistan.

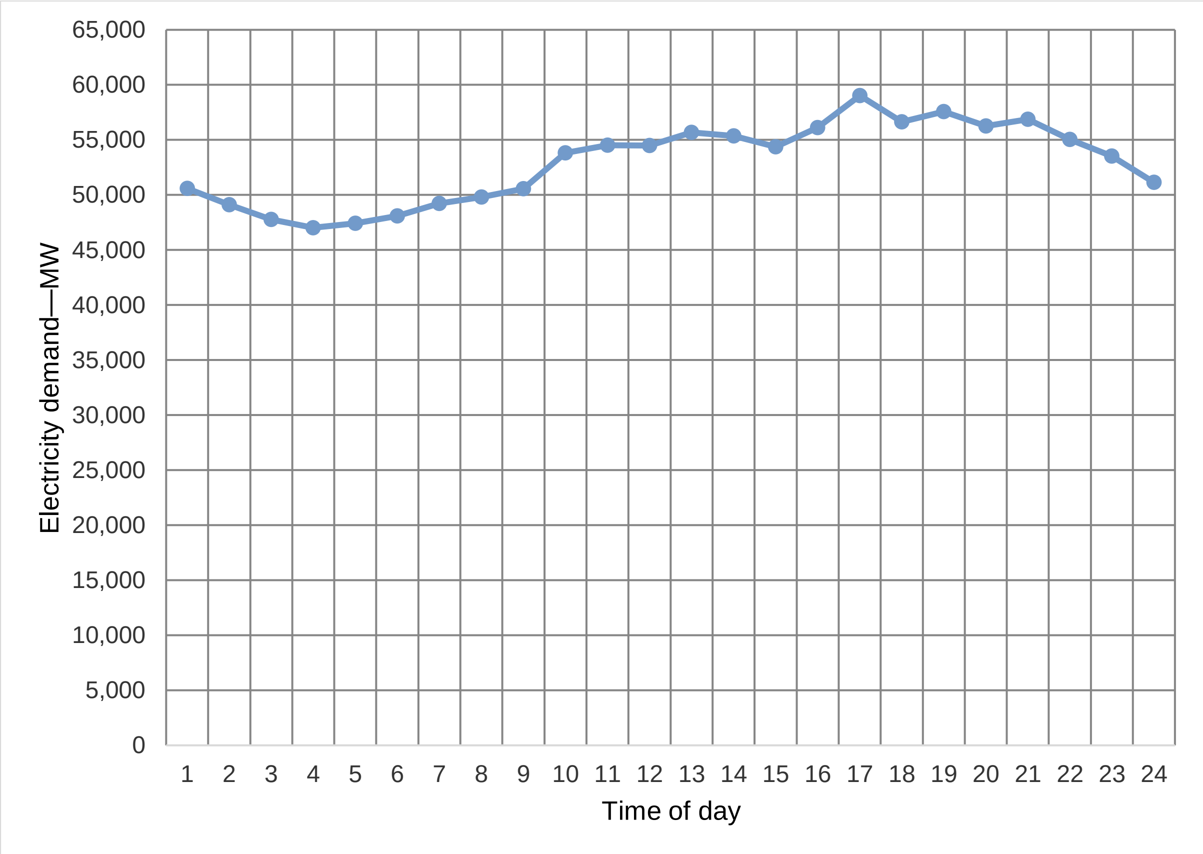


Figure 3.3: Cumulated time zone adjusted intraday demand profile for CAREC region (excluding China)

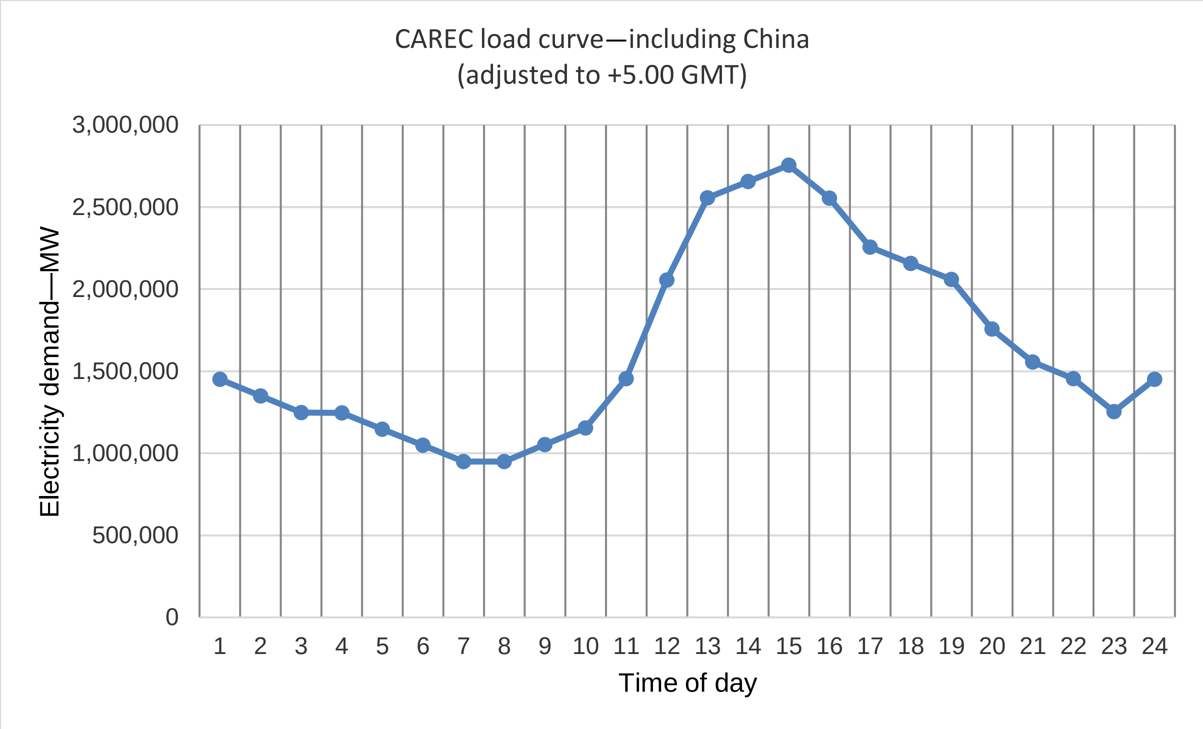


Figure 3.4 Cumulated time zone adjusted intraday demand profile for CAREC region, including China

C. Analysis of supply options

The following inputs have been considered in optimizing regionwide supply to meet regionwide demand:

1. Regionwide annual demand is projected to rise by 2.4 percent (CAGR) each year.
2. In 2030, generation plants across technology options are projected to operate at PLF levels comparable with 2018 efficiency levels; correspondingly the operational generation capacity required to meet such demand is computed.
3. Close to 100,000MWp of solar PV and an estimated 53,000MW of wind energy generation capacity are proposed as potential replacements for the existing fossil fuel driven capacity of about 80,000MW; hydropower capacity and other alternatives are projected to continue to be built, upgraded, and operated at planned growth rates through to 2030.
4. The choice of technology and the allocation of capacity for each country is based on ensuring the **most efficient use of the generation asset based on the assumptions made on the available data.**
5. To ensure consistency, annualized PLF for solar PV was estimated through computing the annual energy output from a typical (hypothetical), slope and azimuth optimized, 1.0MWp power plant installed at the major airport (to specify latitude and longitude of the site) in the capital city of each country. The EU PV-GIS portal was employed as a part of the estimation of such annual output for the given location.[71]
6. For the purposes of the illustration, the PLF for wind energy generation was estimated using the average production during a year using IRENA data for operating projects. For Kazakhstan, Turkmenistan, Tajikistan, and Uzbekistan, PLF for wind energy generation was assumed as the average PLF across projects operating within other countries in the CAREC region.

As presented in **Table 3.3**, the replacement of some 80,000MW of fossil fuel driven capacity is to be achieved by installing an estimated 100,000MW of solar PV and an estimated 53,000MW of wind energy generation capacity with a view to:

(i) Remaining within range of the existing proportion of generation capacities across countries;
(ii) Making the most efficient use of the available solar PV and wind energy capacities;
(iii) Meeting consolidated intraday [time zone adjusted] demand through consolidated [time zone adjusted] supply options including a mix of base load (predominantly hydropower capacity) and other RE options;
(iv) Designating one or more of the non-China CAREC region countries as the residual supplier–residual consumer to help balance supply and demand in the region;
(v) When regionwide links are established to transfer surpluses, designating China as the ultimate residual consumer or ultimate residual supplier to help balance supply and demand in the region: net of adjustments made within non-China CAREC.

The distribution of solar PV and wind energy capacity mentioned in **Table 3.3** is achieved based on the efficiency factors estimated and summarized in **Table 3.1**.

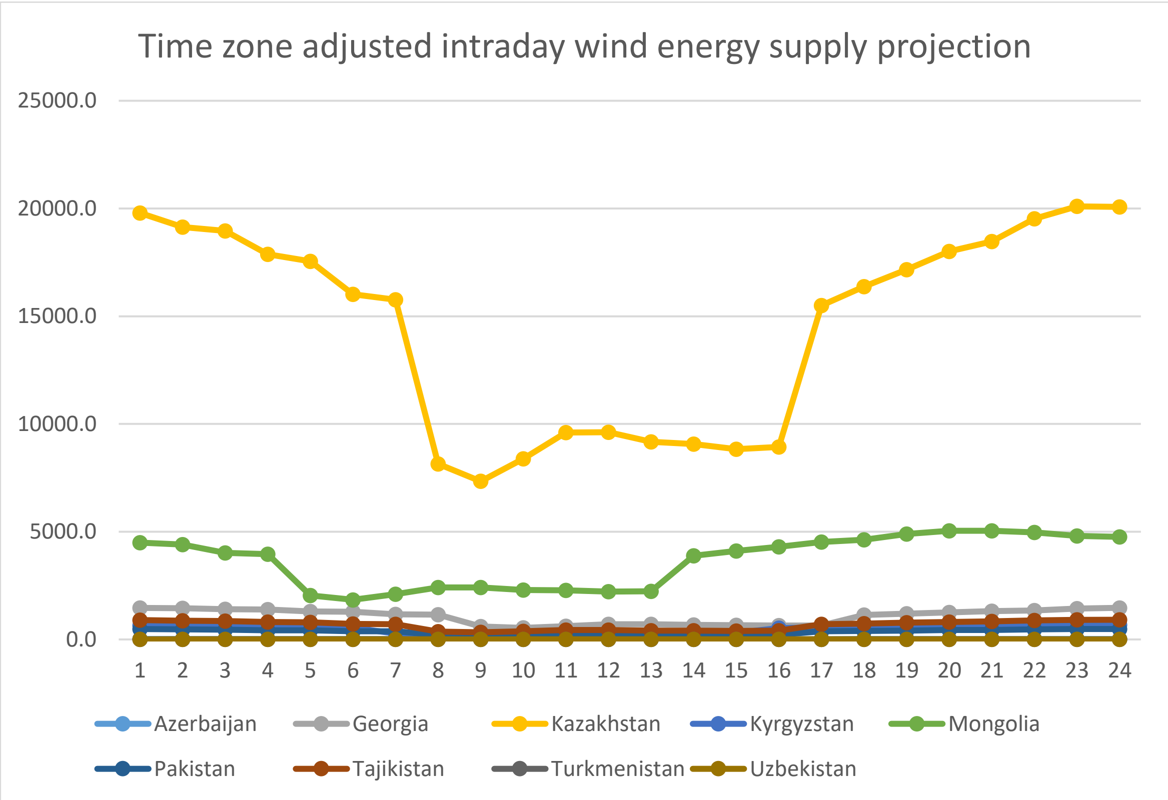


Figure 3.5*: Time zone adjusted intraday wind energy supply estimation;*
horizontal axis: hour of the day (0-24); vertical axis: power output in MW.

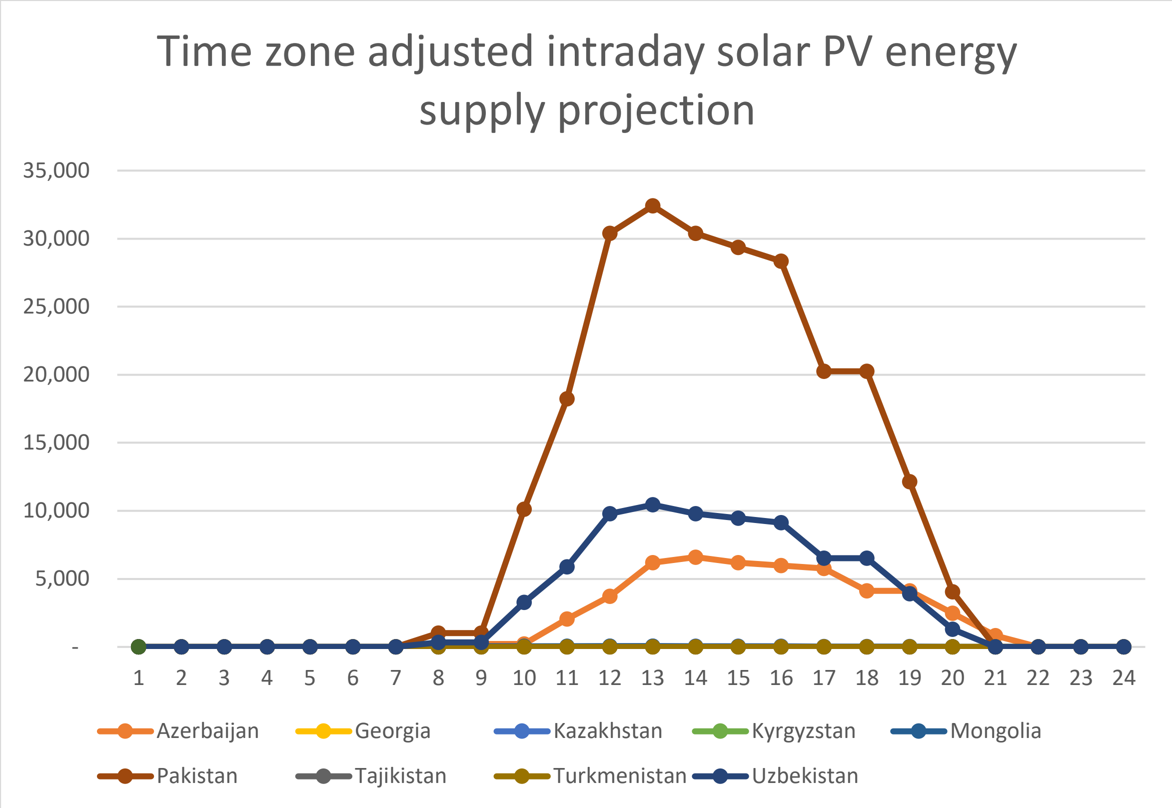


Figure 3.6: Time zone adjusted intraday solar PV based energy supply estimation; Horizontal axis: hour of the day (0-24); vertical axis: power output in MW.

Estimated, time zone adjusted, regionwide, solar PV and wind energy supply to meet projected regionwide 2030 aggregated demand:

1. For the purpose of this illustration, the intraday supply profile data for solar PV was adopted from the annual average generation of 2.0MW plant located in Kazakhstan.[72]
2. Intraday hourly generation/supply profile for wind energy was adopted for 1 June from a 500MW wind farm located in Uzbekistan.
3. These production profiles were then mapped onto the time zones of the other CAREC region countries excluding Afghanistan and China. For avoidance of doubt, the projected demand from Afghanistan is included within regionwide demand computations.
4. The intraday wind and solar PV output for 2030 for each country was estimated based on proposed total capacities for wind energy generation and solar PV deployment proposed for each country for 2030.
5. Total intraday supply was computed by adding individual country supply values for solar PV and wind energy generation for their respective time zones. Such supply was then consolidated to adjust for differences in time zones (**Figures 3.5 and 3.6**).
6. Such total supply by the hour of the day (representative day in 2030) was mapped on to the estimated consolidated intraday demand for the same time zone (representative day in 2030) as shown in **Figure 3.7**.
7. The shortfall in supply from solar PV and wind capacities (0 to 12 noon and 18 to 24hr, GMT + 5.0) is to be met by other generation options including hydropower.
8. The net shortfall in supply from base load, solar PV and wind capacities (0 to 12 noon and 18 to 24hr, GMT + 5.0) is to be met by imports from residual and ultimate residual supplier countries.

9. Likewise, the net surplus during the period 12 noon to 16:00 hrs (GMT + 5.0) might be available for export to designated residual consumer countries.

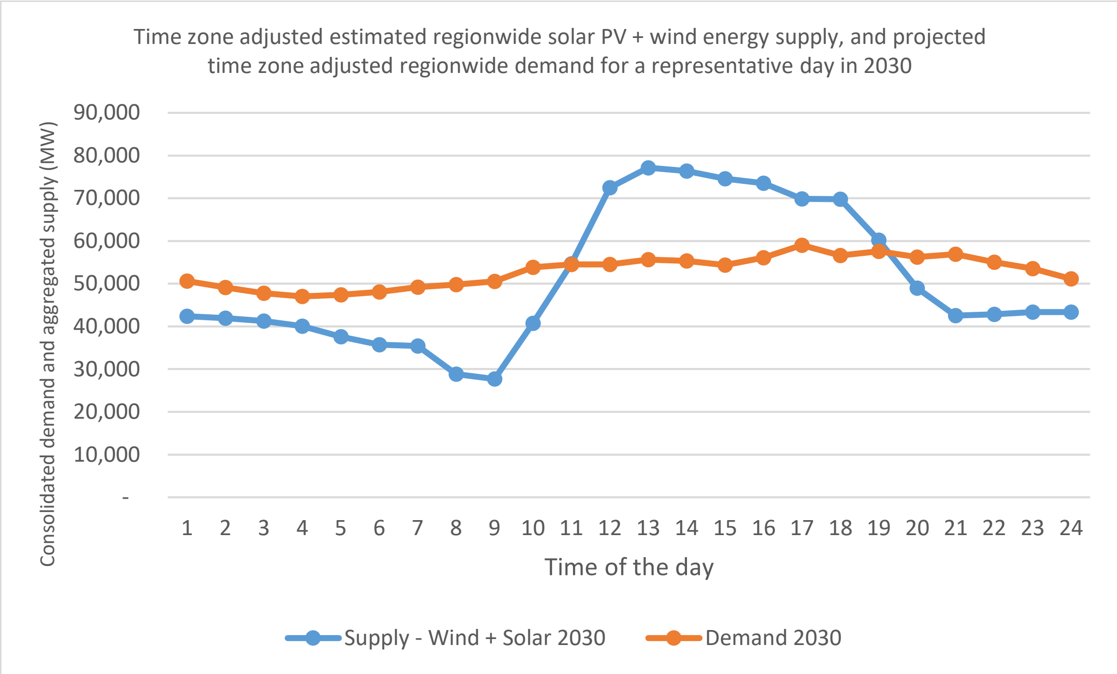


Figure 3.7: Time zone adjusted (GMT + 5.0) intraday regionwide wind energy and solar PV based energy supply estimation mapped onto time zone adjusted (GMT + 5.0) intraday regionwide aggregated demand Horizontal axis: hour of the day (0-24); vertical axis: power output in MW.

4. CHAPTER 4: GOVERNANCE PATHWAYS TO ACCELERATE ENERGY TRANSITION

Cross border integration of electricity networks as proposed here offers various benefits while posing several challenges, as indicated in Figure 4.1.

Figure 4.1: Benefits and challenges of cross border integration

Benefits of cross border integration
▪ Allowing project developers and investors to take advantage of the economies of scale on both the supply (larger projects) and demand (larger number of consumers), enabling the efficient use of resources and consequently positioned to supply energy at least cost to the end users. ▪ Making more diverse and larger power systems—in terms of generation as well as of consumption—in terms of both supply and demand providing better energy security through internal hedging. ▪ Integrating[73] higher shares of variable RE through natural complementarity of the underlying resource.
Challenges for cross border integration
▪ Effective regionwide operation requires detailed planning: allocating costs and benefits across market participants could be an economic and regulatory challenge. ▪ To begin with, each individual country might want to prioritize self sufficiency: this could prevent individual countries from cooperating and implementing necessary arrangements for cross border integration. The regionwide optimization plans proposed herein therefore provide for the growth in generation capacity as planned by individual countries with substitution of fossil fuel capacities with non-fossil fuel generation capacities in keeping with RE resources available. ▪ Flexibility required to isolate parts of the network are to be designed into the regionwide network to potentially lower the risk of a major regionwide blackout. ▪ Likewise, requisite forecasting of demand and supply are to be built into operating the regionwide network: such interconnected and synchronised systems could then avoid unexpected cross border power (surge) flows. CAREC countries are involved in various interstate initiatives and already have obligations under them: EAEU, CIS, CASAREM, and so on, which may create barriers to electricity exports and imports within CAREC (such as, high customs duties).

A. Cross border integration models

Experience from across regions suggests that cross border power system integration involves the connection of two or more power systems together and can occur in many forms from limited integration to complete integration. Several models of such integration are operated contemporaneously, and the model also varies subject to time periods of operation, ranging from short term exchange to long term integration. The degree of integration is known to affect the extent of benefits delivered and the complexity of the organization to manage such integration. The hierarchy of integration can be divided into three broad groups: (i) bilateral, (ii) multilateral, and (iii) unified.

i. **Bilateral integration:** Under bilateral integration, the energy trading occurs between only two jurisdictions and trade of power could in theory be unidirectional. Thailand, for instance, imports power from hydroelectric plants located within the Lao People's Democratic Republic (Lao PDR) although Thailand does not export its own power to Lao PDR. Bilateral integration, on the other hand, may also involve an intermediary country. For instance, Lao PDR also exports power to Malaysia, with Thailand involved merely as a transit territory. However, in reality trade generally tends to be bidirectional when there is bilateral trade, as in the case of the North American countries.

ii. **Multilateral integration:** Under the multilateral mode of integration three or more countries may be involved, all trading among one another: an example of this model would be the *Southern African Power Pool*. The countries constituting the pool might have different market structures or could have a harmonized market structure and regulations. In both the scenarios, integration is facilitated by the development of regional institutions that coordinate and help in management of the integration even though such regional bodies do not displace local institutions.

iii. **Unified integration:** Under the unified model of integration, regional institutions are responsible for all or some of the management of the power systems across multiple jurisdictions.

The hierarchy is not meant to signify a direction of travel for power market integration, from unidirectional to complete integration for instance. In cases such as *Nord Pool*, the level of integration has increased significantly over the years while in others, the Association of Southeast Asian Nations (ASEAN), the bilateral model has remained in place for decades. The primary reason for the latter structure is the challenge associated with harmonization of grid network parameters, and arriving at an agreement on trade regulations, increased cross border collaboration, and, most importantly, the need for the willingness to surrender some control to a regional institution or a group of institutions. As the level of integration increases, these issues could prove to be acute and could limit the degree of integration.[74]

Cross border integration can also involve collaboration that occurs over different timescales, including among others long term system planning, or short time windows and realtime dispatch, driven by information relating to day ahead schedules. Evidently, the shorter the time horizon available to the dispatch center, the greater the urgency and therefore the need for more rapid and robust communication protocols. Many cross border integration efforts start with increased collaboration on matters of long term system planning, and these plans may lead to closer collaboration on the development of regional day ahead markets and related forecasts.

In reality, the integration of governance frameworks in most cases falls somewhere in between extremes. For instance, although the ASEAN Power Grid (APG) has been under development for more than two decades, it continues to remain a group of interconnectors developed and operated on a bilateral basis by each pair of countries. There are no overarching governance frameworks or institutions, and so each interconnector is developed under a separate set of agreements—ones that, to varying degrees, enable trade, so that the autonomy of the national power systems is not sacrificed. To begin with, **the CAREC member countries could emulate this model of long term bilateral trade**. Various changes that need to be made to the governance structures under the model are discussed in this section.

B. Technical governance

As illustrated in Chapter 3, electricity demand and supply across the region can be met by matching the peak demands with the ability to supply from across time zones—when demand might be low in the vicinity of the generation node itself. However, the integration of governance structures is a prime requisite for this model of interconnection to succeed. As summarized within **Table 4.1** the ten countries of the CAREC region have already engaged in cross border power trade over the years and such arrangements would need to be upgraded to provide for substitution of generation sources and to accommodate potential intermittency in supplies from wind, solar PV, and other RE sources.

Table 4.1: Import and export of electricity in the CAREC region (billion kWh)

Country	Billion kWh	Year				
		2015	**2016**	**2017**	**2018**	**2019**
Azerbaijan	Export	0.265	1.096	1.283	1.445	1.491
	Import	0.108	0.114	0.108	0.1312	0.137
China	Export	18.654	18.907	19.470	20.906	21.655
	Import	6.210	6.185	6.423	5.688	4.858
Georgia	Export	0.660	1.409	0.940	0.602	0.380
	Import	0.699	1.329	1.751	1.522	1.763
Kazakhstan	Export	1.614	2.572	5.692	5.042	2.419
	Import	1.618	1.318	1.327	1.561	1.935
Kyrgyzstan	Export	0.184	0.199	1.215	0.755	0.271
	Import	0.729	0.331	0	0	0.269
Mongolia	Export	0.051	0.036	0.026	0.027	0.024
	Import	1.427	1.446	1.574	1.666	1.723
Pakistan	Export	0	0	0	0	0
	Import	0.463	0.496	0.556	0.487	0.487
Tajikistan	Export	1.4	1.428	1.421	2.945	3.175
	Import	0.063	0.103	0.11	0.559	0.281
Turkmenistan	Export	3.201	3.2	3.2	3.2	3.2
	Import	0	0	0	0	0
Uzbekistan	Export	6.81	6.774	7.585	2.627	2.067
	Import	5.52	5.278	6.945	2.233	3.379

Source: EIA retrieved on 20 November 2021, from https://www.eia.gov/international/data/world

The scope for enhancing demand side efficiency in electricity use is discussed alongside the analysis of the countrywise electricity sector profiles in **Annexure 1** of this report. On the supply side, however, T&D loss data aggregated and disseminated by the US-EIA **(Table 4.2)** illustrates the scope for reduction in losses in Kyrgyzstan, Mongolia, Pakistan, Tajikistan, Turkmenistan, and Uzbekistan.

Table 4.2: Transmission and distribution losses across CAREC region countries (US-EIA data)

	2014	2015	2016	2017	2018
Azerbaijan					
Generation (billion kWh)	23.320	23.300	23.567	22.961	23.819
Distribution losses (billion kWh)	3.363	2.869	2.350	2.251	2.220
	14%	12%	10%	10%	9%
China					
Generation (billion kWh)	5387.911	5562.476	5883.822	6283.525	6801.859
Distribution losses (billion kWh)	309.988	298.786	306.293	319.583	334.596
	6%	5%	5%	5%	5%
Georgia					
Generation (billion kWh)	10.166	10.605	11.347	11.305	11.922
Distribution losses (billion kWh)	0.600	0.711	0.784	0.904	0.886
	6%	7%	7%	8%	7%
Kazakhstan					
Generation (billion kWh)	90.011	86.696	89.619	97.596	101.718
Distribution losses (billion kWh)	7.082	5.174	5.342	6.411	6.569
	8%	6%	6%	7%	6%
Kyrgyzstan					
Generation (billion kWh)	14.363	12.803	13.041	15.293	15.309
Distribution losses (billion kWh)	3.458	2.668	2.655	2.844	2.814
	24%	21%	20%	19%	**18%**
Mongolia					
Generation (billion kWh)	5.062	5.195	5.342	5.690	6.169
Distribution losses (billion kWh)	0.793	0.783	0.817	0.811	0.875
	16%	15%	15%	14%	**14%**
Pakistan					
Generation (billion kWh)	103.251	108.082	119.020	126.300	143.986
Distribution losses (billion kWh)	17.627	17.209	23.582	21.110	23.978
	17%	16%	20%	17%	**17%**
Tajikistan					
Generation (billion kWh)	15.990	16.982	17.030	17.884	19.477
Distribution losses (billion kWh)	2.804	2.670	2.746	2.884	2.878
	18%	16%	16%	16%	**15%**
Turkmenistan					
Generation (billion kWh)	19.179	21.185	21.185	21.185	21.185
Distribution losses (billion kWh)	2.547	2.895	2.895	2.895	2.895
	13%	14%	14%	14%	**14%**
Uzbekistan					
Generation (billion kWh)	52.723	54.552	56.004	58.066	59.424
Distribution losses (billion kWh)	9.195	9.018	9.102	9.831	9.826
	17%	17%	16%	17%	**17%**

Source: EIA retrieved on 20 October 2021, from https://www.eia.gov/international/data/world

Electricity sector policy frameworks, regulatory mechanisms and institutional structures in individual countries should therefore be oriented to achieving regionwide objectives as discussed in **Figure 4.2**.

Figure 4.2: Discussion and recommendations for technical governance

Discussion and recommendations for technical governance
1. For the purposes of this illustration, through to 2030, the growth in installed hydropower capacity (or improvement in plant capacity utilization, or both),[75] biomass/biogas, wind energy, solar PV, [nuclear power, geothermal] and other non-fossil fuel based sources is assumed to continue in the **same proportion of the energy mix as observed in 2018**. 2. Regionwide policy structures would then need to be oriented towards the installation and commissioning of an aggregate of about 153,000MW of solar PV and wind energy capacity supported with planned hydro projects to meet the regionwide demand. 3. Such policy structures should provide for requisite transmission capacity to convey such RE based power from the production nodes to the demand centers, while reducing T&D losses. 4. Institutional structures and policy frameworks would need to be oriented towards regional cooperation to facilitate China's functioning as the *ultimate* residual supplier and the residual consumer for the region. 5. Sufficient training would need to be provided to the national workforce to facilitate integration of solar and wind energy into power systems.

C. Legal governance

While countries of the region have formulated policy frameworks and have promulgated specific laws to help formalize and implement specific aspects of energy generation and supply, and while some of the countries already trade in electricity with neighbouring member countries, there is an evident need for the region as a whole to come together to coordinate electricity generation and supply policy frameworks, governance structures, pricing schemes and attendant technical infrastructure.

1. Investors seek assurances of **non-curtailment of RE plant** and prompt payments against supply of power:

   As with most bilateral transactions, prospective investors seek greater assurance relating to the sustained off-take by the buyer of the power generated, and a binding assurance relating to the RE plants not being taken off the grid ('curtailment') as witnessed with the Salkhit wind farm case discussed or with the small hydropower plants in Kyrgyzstan—although in each case, such curtailment was attributed to different reasons. Such an assurance would have to be backed by appropriately structured guarantees incorporating a 'take or pay' assurance—indemnifying investors and lenders against defaults in off-take, or defaults in payment by the utilities concerned, or both ('counterparty risks').

   The utilities, for their part, could insist on day ahead forecasts of power to be generated from each plant with 15 minute intervals and a 95 percent level of confidence. This might help the utilities, or regional level dispatch center/s, prioritize low marginal cost RE supplies and improve the matching of such regionwide supply with the demand expected over the course of a 24 hour day in each member country.

2. Investors seek policy stability for the tenure of the PPA:
   Given the weak financial situation of the utilities in most CAREC region countries, The power purchase agreement (PPA) issued for RE projects—small hydropower, solar PV, wind energy, biomass energy, and solid waste-to-energy options—might often not be considered bankable by overseas investors, especially when non-recourse finance is sought to be mobilized. This inhibits the inflow of expertise and potentially cheaper cross border capital to the region's RE sector. Across markets, investors have often called for a well defined risk allocation mechanism in such contracts, consistent with international best practice.

3. Overseas investors seek assurances relating to currency conversion and repatriation:
   Overseas investors need to move their earnings out of the country as individual projects mature and start offering dividends, in the face of few reinvestment opportunities within a given country, or even within the region on occasion, and in the event that suitable investment opportunity is found elsewhere. Investors seek assurances from the authorities concerned relating to making it convenient for the local currency earnings to be converted to foreign currency, and for the foreign currency amounts to be repatriated without administrative challenges. In countries where the domestic currency has suffered sudden and unexpected depreciation in the past, the risk of exchange rate fluctuations would have to be borne by agencies best equipped to bear such risks.

4. Investors require provisions relating to overseas arbitration:
   Experience suggests that investors would need firm assurances relating to organizing arbitration proceedings at neutral locations, perhaps in places like Singapore or London. The arbitration proceedings might be held in a language agreed upon within the PPA and at a venue convenient for all parties concerned.

Case Study

Kyrgyzstan: Kok-Sai and Konur-Olon small hydropower plants

In 2017, two small hydropower plants (SHPs) 'Kok-Sai' and 'Konur-Olon' were built in the Kok-Sai and Konur-Olon villages of the Ton district of the Issyk-Kul region of Kyrgyzstan (KGZ). The Issyk-Kul region is an energy deficient region with a developed tourist infrastructure.

> 'We supported the project from the very beginning and started cooperating. If the company was up and running, additional income would flow into the budget. In addition, the investor had to fulfil obligations under the social package. We believed that if the HPPs started working, people would get jobs.'
>
> Ilyich Kookorov,
>
> Head of Bolot Mambetov
>
> Rural Administration
>
> Issyk-Kul region, 2018

The total capacity of the HPPs is 6.9MW, and the projects were projected to generate 45.5 million kWh of electricity each year.[76] The stations were built by a local investor with a loan of 515 million KGS (including a 434 million KGS soft loan from the Kyrgyz–Russian Development Fund).

The small HPPs are equipped by the Austrian company, *Andritz Hydro* (https://www.andritz.com/hydro-en) with Pelton type turbines and components from the Czech Republic, Switzerland, Germany, and Turkey. The *Andritz* turbine has a degree of efficiency of more than 92 percent and is almost insusceptible to cavitation.[77] The HPPs are fully automated.

According to the Law 'On Renewable Energy Sources' of the KGZ, all electricity generated from RES that is not consumed by the owner of the installation for the owner's captive needs and not sold to other (third party) contracted consumers must be purchased by the largest electricity distribution company in the administrative territorial unit where the RES installation is located, regardless of the identity of the electricity company whose grid evacuates the power from the RES installation—in this case the power is to be procured by *Vostokelectro* OJSC ('Vostokelectro').

According to the investor, before construction of the plants began, the State Agency for Regulation of the Fuel and Energy Complex (Regulator) issued a decision, according to which Vostokelectro was to buy electricity generated at 4.7 KGS.[78,2] The HPP owner complied with the technical specifications issued by *Vostokelectro* and a contract was concluded with *Vostokelectro* in January 2017 for the annual purchase of 19 million kWh of energy.

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[2] The Law of the Kyrgyz Republic 'On RES' established an increasing coefficient of 2.1 to the maximum tariff for small HPPs. As of 24 July 2019, this coefficient is 1.3 to the maximum tariff for the payback period of the project (not exceeding ten years).

Case Study

After receiving all the documents and starting construction of the HPPs, a government decree of 24 March 2017 approved the 'Regulation on the tender for the right to build small hydropower plants in the KGZ,' providing that electricity will be purchased by power companies from SHPs built after the tender held by the authorized bodies.

> 'According to the law 'On RES,' we have to buy energy from small HPPs at 4.7 KGS, and sell it to the population at 0.77 KGS. Thus, the state companies incur losses of almost 4 som per kWh. Vostokelectro will simply lose the funds intended for annual repairs. We cannot take this step. The said law was adopted ten years ago, it is not in line with current realities.'
>
> Aibek Kaliev
> Former Chairman
> National Energy Holding, 2018

Owing to the enactment of this decree, and given that the land on which the HPPs were built was allocated by a decision of the Ton District Administration, with no government permission to convert the intended use of land allotted for the project, the investor was not given the permission to commission of the small HPPs. On 23 November 2017, *Vostokelectro* unilaterally terminated the power purchase agreement (PPA); but the Prosecutor General's Office considered this decision illegal and issued an injunction.[79]

The analysis showed the existence of contradictions between the 'Regulations on the tender for the right to build small HPPs in the KGZ' and paragraphs 10 and 23 of Article 3 of the Law of the KGZ 'On Public Procurement.' On this basis, the conclusion of the Ministry of Justice of the KGZ and the Decision of the Committee on Fuel and Energy Complex and Subsoil Use of the Jogorku Kenesh (the country's Parliament) on the need to put into operation small HPPs Konur-Olon and Kok-Sai were issued. The Regulator was instructed to resolve the issue of purchase of electricity generated by the small HPPs by *Vostokelectro*by on 18 April 2018.

> 'Since 15 March 2018, the 3.6MW Konur-Olon HPP and the 3.4MW Kok-Sai HPP have been idle, with a daily interest charge on the loan of 100,000 KGS.'
>
> Rahatbek Irsaliev
> HPP Owner

In addition, Article 2-1 of the Law 'On Protection of Entrepreneurs' Rights' of KGZ states that one of the basic principles ensuring the conditions for entrepreneurial activity is that contradictions, gaps, and ambiguities in legislation establishing mandatory requirements cannot be used by state and local authorities against business entities, which must be guided by state authorities in making decisions on the matter. Regulation on the tender for the right to build small HPPs in the KGZ has been repealed by the KGZ government decree dated 30 October 2020 No. 525 'On Approval of the Regulations on the conditions and procedures of production and supply of electricity using RES,' which provides for the establishment of power capacity of power installations using RES by regions and by types of RES for a certain period of time, paid at the maximum tariff. As of 2019, the entrepreneur started to sell electricity to block chain companies. As of October 2021, the PPA had been executed between *Vostokelectro* and the project. The purchase tariff was set at 2.13 KGS.It should be noted that a socially oriented tariff policy is in place in the KGZ. At the end of 2020, the average tariff was 1.31 KGS/kWh, and the tariff deficit was 0.18 KGS per kWh.

Figure 4.3: Discussion and recommendations for legal governance

Discussion and recommendations for legal governance
1. Laws in individual countries must provide assurances of **non-curtailment of RE plant** and prompt payments against supply of power. 2. Among other things, policy frameworks need to provide stability and assurances of compensation through appropriate remedial measures and suitable payments to ward off adverse consequences emanating from premature and unilateral termination of the power purchase agreement (PPA) (by counterparties executing such PPA), against changes in the regulatory framework implemented subsequent to the execution of the PPA and against other such factors over which the investors have little control. 3. Laws must specifically document and provide firm assurances relating to currency conversion and repatriation. 4. Regulations must cover provisions for organizing arbitration proceedings at neutral locations. 5. Legislative measures must be developed to support integration of variable RE into power systems (grid codes).

D. Institutional governance

The CAREC region currently does not have a strategic regional cooperation mechanism that could govern the regional electricity sector across the ten countries under consideration for this study. There is a need for an institution that could oversee new cross border projects, and ensure security of supply for the region as a whole. More recently, an organization referred to as the Central Asia Transmission Cooperation Association (CATCA) has been proposed and supported by the ADB, to try and fill this gap.[80] CATCA proposes to develop a transmission network expansion plan, regulatory framework for the electricity sector in the region, and to manage regional transmission projects.

Figure 4.4: Recommendations for structural governance

Recommendations for structural governance
1. The technical obligations made under the power purchase agreements (PPAs) could be fulfilled by the utilities concerned, while the realtime matching of regionwide demand and supply could be brought under the purview of the regional load dispatch center. 2. Given that the present analysis has recommended regionwide optimization of supply to meet time zone adjusted aggregate demand, such consolidation might lead to equilibrating supply tariffs across the region. A distinct legal entity could be created to serve as the counterparty to implement the procurement and contracting process and to meet the legal and commercial obligations within the PPA, including ensuring periodic payments against the power supplied by the IPP. Such an entity would need to work in close coordination with the proposed CATCA. This entity would form the legal, technical, and commercial basis for building a future efficient and sustainable integrated energy system of the CAREC countries to meet SDG7 targets for 2030. 3. As a corollary to this, emission reduction contracts and revenues would also have to be channelled[81] to this legal entity serving as the counterparty to the PPA and such revenues generated from emission reduction might help subsidize the vulnerable sections of populations across the region.

E. Commercial governance

The assumption relating to investing time and effort into pilot projects to demonstrate underlying concepts, and for the private sector to then enter and serve the market on commercial terms has frequently been left unsubstantiated. Across sectors, viable projects—offering returns compatible with the risks associated with working in emerging markets—are few and far between: availability of grant funding has been limited and is generally insufficient to design and develop 'investment ready' projects. This has partly been attributed to the diverging incentives of the donors and the private investors: donor organizations have wanted to demonstrate the largest social impact, while private investors have sought competitive returns on their investments. Consequently, despite the supposed promise, such potential for 'blending' of public and private resources has not lived up to early stage projections.[82] RE and projects employing proven technologies would, therefore, have to be funded largely from mainstream sources of equity and debt and offer risk compatible returns to attract such investments. The present report presents preliminary recommendations on such a pecking order for RE investments that is based on resource availability and power output and on efficiency of asset use.

The present study has computed the capacities required to optimize regionwide supply to meet regionwide demand. Efforts have been invested into enhancing the efficiency of RE asset use, to minimize the deployment of storage capacity and to minimize the need for additional 'peaker plant capacity.' In addition to the technical advantages relating to asset utilization and efficient energy supply, the integrated approach is slated to reduce market risks for prospective investors concerned and to enhance returns on RE and transmission projects.

Given the projected economic and population growth and the strong and positive correlation between such growth and electricity consumption in the CAREC region, the sector clearly presents a collection of short and long term opportunities for investors. It is evident that while investors continually work towards analyzing the characteristics of specific projects, and towards identifying opportunities that offer risk compatible returns, in reality, the macroeconomic and sector specific policy environment and governance structures attract or deter investors. The RE PPA to be executed with the utilities or other counterparties in individual countries, for instance, would need to meet international standards, and need to be considered 'bankable' as generally understood by development partners, investment funds, and mainstream commercial lenders.

In the medium term, CAREC member countries should aspire to migrate to a sector governance regime where RE projects are funded with exclusive recourse to cashflows generated by the underlying project alone (referred to as 'non-recourse finance' or simply 'project finance'). While the feed in tariff (FiT) offered for the RE projects in some jurisdictions might have been attractive, relative to prices discovered in other markets—as, for instance, in the case of the *Salkhit* wind farm in Mongolia—the prospect of curtailment of power off-take by the grid network operator/utility, is known to reduce the attractiveness of such projects to prospective investors. This adverse situation could be remedied by offering potential investors deemed generation benefits (a 'take or pay' contract), mechanisms to compensate investors in the event of premature and unilateral suspension or termination of the PPA by the counterparty concerned, and offering recourse to international arbitration, conducted in a mutually accepted language of communication.

Case Study

Case study: Mongolia—Salkhit Wind Farm

The 50MW/USD122 million Salkhit ('windy mountain') Wind Farm located some 75km from the capital city of Ulaanbaatar in Mongolia was the country's first independently developed power project (the Newcom Group), and the first project in the country to be financed through international non-recourse funding ('project finance'). The Salkhit project was also the first RE project to connect to the Mongolian grid. The project presented technical challenges as well including the need to cope with an extraordinarily wide range in ambient temperatures over a 12 month period.[83]

'The Salkhit Wind Farm is a flagship project for Mongolia's renewable energy sector and energy sector as a whole. The project has introduced new and advanced technology and knowhow to the industry. We are proud to have completed the project to international best quality and safety standards.'

Enkh-Amgalan Sengee

CEO of Clean Energy and Chief Investment Officer of Newcom

Mongolian private business group, Newcom (www.newcom.mn), was awarded the license to build, own, and operate the wind farm for a period of 26 years. *Newcom* invested USD27.0 million of the total equity investment of USD36.0 million, representing 75 percent private ownership of the project. Of the USD84 million mobilized as debt (70 percent of the total project cost), the EBRD and the Dutch Investment Bank, FMO, each infused USD42 million. The EBRD is reported to have provided USD5.0 million in equity as well, while the Mongolian Government is reported to have provided the project with a payment guarantee ('indirect government support').[84] The project achieved financial closure in 2012. The Salkhit farm comprises 31 units of the GE manufactured 1,600kW name plate capacity (82.50 meter rotor diameter). The turbines for the project were manufactured in China and transported by road across the border. The Salkhit project was commissioned in June 2013 and, once operations had stabilized, the farm was operating at an estimated 35 percent PLF according to data published by the International Renewable Energy Agency (IRENA).

The special purpose vehicle ('project company') Clean Energy LLC (www.cleanenergy.mn) was 51 percent owned by *Newcom*, a Mongolian investor group that had founded the first mobile telephone service operations company, and at the time of implementing the Salkhit wind energy project, had also owned the largest domestic airline in Mongolia.[85] The minority stakes in Clean Energy LLC were held by the EBRD (14 percent), by the FMO (14 percent), and by *General Electric* (21 percent). By investing common equity into the project company, while also supplying equipment to the project, *GE* had made a demonstrable commitment to assure the performance of the equipment produced and supplied by the company.

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Case Study	The baseline emission factor for the Mongolian grid was estimated at 1.061 tCO2e/MWh, while project related emissions are ignored. According to the monitoring report submitted to the Executive Board of the Clean Development Mechanism (CDM) under the UNFCCC, the electricity supplied to the grid by the project between 1 July 2019 and 31 December 2019 was metered at 62,947,774kWh, representing a reduction of 66,787 tCO_2e during the period. The projected emissions reduction was 82,744 tCO_2e for the same period.[86] The Swedish Energy Agency, the designated national authority for the CDM, was directly involved as a project participant to procure the emission reduction credits generated by the project. ➢ Grid Company (energy buyer) and Clean Energy (project company) had been reading meter data remotely since February 2016. ➢ Invoices are sent to the Grid Company based on the signed joint report (buyer and seller personnel), and payments are made in accordance with the signed joint report and invoice. ➢ Signed monthly reports are compiled and archived. ➢ Actual average wind speed records were lower than the estimated average wind speed considered during project design. Such estimated were based on historic wind speed records. ➢ The project was facing curtailment from the National Dispatch Center, limiting production by about 4,419,160kWh during this particular reporting period. Estimates suggest that despite the 9.5 US cents per kWh guaranteed tariff paid by the Grid Company and despite the additional revenues from the sale of emission reduction credits, given the weighted average cost of capital (WACC) estimated at 9.54 percent, the project—with the lower than projected generation and higher than anticipated curtailment—might not be in a position to provide positive returns to the investors.[87]

Apart from the PPAs, the CAREC region countries should also focus on reducing dependence on coal and enhancing efficiency of energy use.

i. Reducing dependence on coal

In all, as of September 2020, some 138 financial institutions—commercial banks, aid agencies, insurance companies, and asset managers—had confirmed a formal commitment to shifting funding *away from* thermal coal mining projects and coal fired thermal power plants, owing partly to the environmental consequences, but largely owing to the compelling and adverse economics of, and the significant risks associated with, continuing their own exposure to the coal based thermal power sector.[88] In the manner of illustrating a self fulfilling prophesy, these announcements have raised the prospect of leaving 'stranded assets' in the coal/thermal power sector sooner than predicted. The long term benefits from curtailing the use of coal for power generation clearly come associated with short term political and economic costs.[89] Gas is viewed as a bridge fuel between coal and cleaner non-fossil alternatives. As indicated in the case study, many countries like Germany have already taken the lead to phase out coal plants in the near future. Within the CAREC region, Kazakhstan and

Azerbaijan have also signed declarations indicating an intention to move away from thermal power plants.

Transition from coal: Germany to phase out coal by 2038

In early 2019, Germany, the world's fourth largest economy and the fifth largest consumer of coal at the time, announced a decision to completely stop using coal for power generation by 2038. The 28 member *Commission on Growth, Structural Change and Employment*, set up by the Government and comprising stakeholders from industry, civil society, and from environmental activist groups ('the coal commission'), had published the final report after six months of active deliberation.[90] The decision was clearly significant given that over a third of the country's power[91] amounting to almost 44,000MW came from coal. The commission recommended the phaseout of 12,500MW of coal capacity by 2022, the phaseout of 25,600MW of coal capacity by 2030, and the phaseout of the remainder by 2038. The report also provided a comprehensive overview on the impact of such exit on emission reductions, energy prices, prospects for ensuring supply security, the impact on the economic development in coal impact regions, and the future course of the country's energy transition.

The agreement based on the recommendations of the commission, ensured that each worker employed in the coal sector would have the opportunity to find alternative and equivalent quality employment.[92] Also, compensation packages for workers with payments estimated at 5.0 billion euros through to 2048 and support packages for affected regions worth 40 billion euros spread over 20 years were designed to develop alternative economic activities built on existing initiatives. Germany has since commenced implementation of the phaseout plan—without waiting for the European Commission's State Aid Approval, with the assumption that the plan would eventually be approved. *A key lesson from Germany's agreement is that the transition from fossil fuels cannot succeed unless it is based on a high degree of stakeholder consensus and offers a desirable, post coal future to the most vulnerable in society.*

ii. Enhancing efficiency of energy use

In most of the CAREC member countries, end user electricity prices are believed to be set at levels that are lower than the levels compatible with encouraging investments into energy efficiency and conservation (EEC) measures across consumer segments. When end user tariffs are set too low, industrial units across sectors and households do not demonstrate the commitment to investing into EEC measures. Building owners and transportation service providers might lack a focus on EEC implementation partly owing to the 'split incentive' problem—where the cost is borne by the asset owner and the benefit might accrue to the end user or occupant. In addition to the frequently cited uncertainty relating to establishing and benchmarking against a business as usual (BAU) baseline ('the hypothetical counterfactual') that has challenged EE projects globally, third party energy service companies (ESCos) face transaction costs associated with ESCo contracts could be large relative to investment sizes and the potential for saving. Likewise, the costs of capital might reflect the high levels of risk perceived by investors and lenders. All of these factors are known to have limited the growth of the EE sector across countries.

In several other markets, standalone EE programs, such as those purporting to replace aging refrigerators and space heaters with quieter and more efficient modern designs, have not always managed to help reduce aggregate electricity consumption owing to a phenomenon referred to in industry circles as 'rebound' (or 'takeback'): increased use of an appliance or service owing to lower unit costs of operation. Consequently, countries around the world have been working on combinations of price and non-price measures to incentivize EEC measures. This includes imposing minimum performance standards for equipment such as lamps, fans, refrigerators, space heaters, air conditioners, and water heaters to eliminate the least efficient models from the market. Additionally, energy labelling to inform potential consumers of the energy performance of the underlying appliance has also been implemented across markets, albeit with varying degrees of success. More recently, such measures are combined with providing information relating to electricity consumption by peers within the neighborhood, postcode, or district to help individual consumers benchmark against such measures.

Figure 4.5: Recommendations for commercial governance

Recommendations for commercial governance
1. The RE power purchase agreement (PPA) to be executed with the utilities or other counterparties would need to meet international standards and be considered 'bankable' as generally understood by development partners, investment funds, and mainstream commercial lenders. 2. In the medium term, CAREC member countries should aspire to migrate to a sector governance regime where RE projects are funded with exclusive recourse to cashflows generated by the underlying project alone (referred to as 'non-recourse finance' or simply 'project finance'). 3. End user electricity prices need to be set at levels that would encourage investments into energy efficiency and conservation (EEC) measures across consumer segments. 4. The CAREC countries could work with international financial institutions in assisting governments to formulate energy transition policies and launch RE auctions.

A summary of recommendations by the current study is reiterated in **Figure 4.6,** which could help overcome the barriers to the implementation of clean energy in the region.

Figure 4.6: Summary of all recommendations

Recommendations for governance
1. The study recommends that regionwide governance structures enhance coordination in generation and transmission, and that distribution be oriented towards the installation and commissioning of an aggregate of about 153,000MW of solar PV and wind energy capacity to meet the regionwide demand, in addition to the BAU growth of capacity in hydropower and other cleaner technology options. Institutional structures and policy frameworks would need to be oriented towards facilitating China's functioning as the *ultimate* residual supplier and the residual consumer for the region, absorbing surpluses and making up for deficits in the other countries of the region. 2. In pursuit of such technical objectives, the applicable statutes in individual countries and the framework contracts within the region as a whole must provide stability and consistency, and bankability of individual projects, including (but not limited to) assurances of **non-curtailment of RE plants** and prompt payments against the supply of power from RE sources; assurances against premature and unilateral termination of PPAs and other relevant contracts; assurances relating to currency availability and repatriation, and of appropriate and efficient judicial remedies. 3. Further, in the spirit of regionwide optimization of supply and demand of electricity among the CAREC member countries, realtime matching of regionwide demand and

supply could be brought under the purview of **the regional load dispatch center**. The load dispatch center would need to work in close coordination with the proposed CATCA.

4. A distinct legal entity could be created to serve as the counterparty to undertake and implement the procurement and contracting processes on behalf of the member countries, to meet the legal and commercial obligations within the PPA executed with generating projects, to enter into emission reduction contracts as appropriate, and to manage the revenues accruing from such emission reduction actions.

F. Discussion and conclusions

Within the span of one decade, the world plans to move to a system of energy generation and distribution that is very different from the current configuration that is considered 'mainstream.' Such a transition is a source of risk for investors, largely owing to the likelihood of the premature termination of supply agreements leading to the premature closure of units, as cleaner and more efficient alternatives offer new business opportunities for present day investors and sets the trend for improved environmental outcomes for the generations to come.

In addition to the large scale deployment of RE (storage) options for power generation, the transition would necessitate ultra high voltage transmission lines and the deployment of flexible and 'smarter grids'—improving responses to changes in demand and more efficient use of installed capacities—to balance among variable sources of generation and demand patterns. Yet, thus far, the projected transition has not materialized rapidly enough to help achieve the climate objectives set out in the UNFCCC Conference of Parties (COP) held in Paris in November 2015; commitments made in Glasgow at the 26th Conference of Parties are yet to be fully analyzed to make an informed projection.

In general, the economic cost of moving from fossil fuels to RE options in electricity generation is evidently 'very low' in many parts of the world, notwithstanding the additional investments required into T&D networks and into managing mismatches in supply and demand. The economic benefits from this transition are most certainly higher than the costs, and significantly higher when the projected environmental benefits are internalized. Facilitating such transition would require appropriate fiscal instruments, backed by regulatory measures and governance structures, standards on limiting emissions, and new pricing models for investors to recover the fixed and marginal costs of electricity generation and supply.[93] The present study explores the possibility of regionwide cooperation to optimize supply from a fleet of power plants covering a range of variable and base load technology options to meet projected demand from across countries and time zones.

The study has analyzed the possibility of aggregating demand across the CAREC region countries and to benefit from the staggering of peak demand hours. The study has then attempted to model variable supply through the addition of solar PV and wind energy capacity installed at sites that are best suited to maximizing yields and to making the most efficient use of the RE assets. The computations lead to the conclusion that regional cooperation and trading in surpluses is significantly more efficient than replacing fossil fuel based generation at individual country levels and replacing such displaced capacity with solar PV and wind energy generators to try to meet supply from within each country.

Electricity generation, transmission, and distribution systems need to be more flexible, capable of accommodating multiple generation sources, while simultaneously responding more closely to demand by aggregating and conveying small localized surpluses to demand nodes. Across countries in the region, T&D systems built during the Soviet era might need to be upgraded to provide for such flexibility. Given the rapid drop in costs from RE options, and simultaneously given the escalation in construction and operation costs of large hydro projects and thermal power plants, energy sector planning might need to be more dynamic, with such plans revisited frequently and revised periodically.

While EE and RE targets and other such medium and long term plans might be a necessary starting point, additional policy measures and institutional upgrades would be necessary to help exploit RE resources available within the region and to supply cleaner energy to support and accelerate the projected modernization of the countries in the CAREC region. The crucial barriers might be more administrative and regulatory than technical.

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