ENERGY AND CLIMATE
PANORAMA

Energy Transition and Position of Intended Nationally Determined Contributions (**INDCs**) in Pakistan

About Us

Who we are

We are a dedicated team of researchers and experts who recognize the urgent need for action in addressing climate resilience and energy transition in Pakistan. Our mission is to develop and implement effective policies for cleaner, renewable energy sources like solar and wind, aligning with Pakistan's 2030 goal of 30% renewable energy in its electricity mix. As a multidisciplinary team, we leverage expertise in three key disciplines of study—Energy Systems Engineering, Thermal Energy Engineering, and Electrical Power Engineering—to drive our mission forward. We are united by a shared vision of creating a sustainable and resilient future for Pakistan, where cleaner energy sources play a pivotal role in reducing the nation's vulnerability to climate-related challenges.

What we do

We conduct in-depth, evidence-based research to analyze and improve energy policies in Pakistan. Our focus is on advancing renewable energy solutions and engaging stakeholders to ensure effective policy implementation. Our methodology involves a critical examination of current energy policies to pinpoint areas of improvement and formulate strategies for the widespread adoption of renewable energy sources across various levels.

In line with our commitment to fostering sustainable practices, we have established a fellowship program as part of our broader initiatives that aims to facilitate evidence-based research for promoting energy transition in Pakistan. Through research studies, surveys, and forecasting, we plan to assess various aspects of energy transition, including the adoption of renewable energy technologies and their impact on climate change. Our approach involves active engagement with stakeholders to address their concerns and facilitate the effective implementation of policies, fostering the growth of renewable energy manufacturing and marketing facilities.

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1. Introduction

The Sustainable Development Goals (SDGs) aims to provide a global blueprint that transforms our climate. To accelerate energy transition towards a sustainable, low carbon, and climate-resilient economy, Government of Pakistan intends to set a cumulative ambitious conditional target of overall 50% reduction of its projected GHGs emissions by shift to 60% renewable energy and 30% electric vehicles by 2030. This study is designed to achieve this sustainable target by strengthening the capacity to coordinate and promote climate change adaptation (CCA) at systemic, institutional and individual levels, and help poor and climate vulnerable communities to adapt towards energy transition. Achieving the United Nations SDG- 7 (Affordable and clean energy) and SDG-13 (Climate Action) by 2030 requires an understanding of the trade-offs and synergies between sustainable transitions and challenges to energy access. Findings of current study will help to highlight the importance of the climate concept in energy policies and regulations and share knowledge, experience, and lessons learned at national and sub-national levels to advance CCA and clean energy policies for Pakistan.

The aim of the project is mainly categorized into three main objectives:

1. Strengthening multicriteria analysis, reporting and monitoring mechanisms for national energy transition policies with respect to Pakistan INDC commitments (2021).

2. Gap analysis of national energy policy implementation to foster adaptation and mitigation strategies for climate action in Pakistan.

3. Recommendations for implementing and mainstreaming SDG (7&13) in national and local development plans and policies on Energy Transition in Pakistan.

2. Country Profile

2.1. Geographic Overview

Pakistan is located in South Asia, bordered by Iran to the west, Afghanistan to the northwest, China to the northeast, India to the east, and the Arabian Sea to the south. It has a total area of 881,913 square kilometers, making it the 33rd largest country by area. Pakistan is divided into five distinct geographic regions.

The Thar Desert and Lower Indus Valley: Located in the southernmost province of Sindh, this region consists largely of arid valleys and rocky hills that extend into neighboring India. Farming is successful only in the irrigated areas nearest to the Indus River.

Figure 1. Map of Pakistan

The Indus Basin: This region features the largest contiguous irrigation system in the world. The province of Punjab comprises the northeastern quarter of Pakistan and is located in this region. The name "Punjab" means "five waters" in Persian, referring to the five major rivers (Indus, Jhelum, Chenab Ravi, and Sutlej) in the basin.

The Northern Areas: This region is the most visually stunning of Pakistan and has five of the world's seventeen highest mountains. The world's second-highest mountain, K-2, is located in the Far North, as are a dozen other peaks of more than 25,000 feet elevation, including Nanga Parbat, Gasherbrum, and Akitoshi.

The Baluchistan Plateau: This region is located in the west and is largely arid and mountainous. It is the largest province in Pakistan by area.

The Himalayan and Karakoram Ranges: This region is located in the north and includes the world's highest mountain range, the Himalayas, and the Karakoram Range.

2.2. Economic Landscape

Pakistan's economy is classified as a developing economy and is the 24th largest in terms of GDP based on purchasing power parity (PPP) and 46th largest in terms of nominal GDP. The country has a population of 232 million people as of 2023. The growth poles of Pakistan's economy are situated along the Indus River, with the diversified economies of Karachi and major urban centers in Punjab co-existing with lesser developed areas in other parts of the country. Pakistan's economy has been classified as a semi-industrial economy since the late 1990s, with heavy dependence on agriculture and the textile industry being dependent on cotton production. Pakistan's economy has experimented with several economic

models during its existence. At first, Pakistan's economy was largely based on private enterprise, but significant sectors of it were nationalized beginning in the early 1970s, including financial services, manufacturing, and transportation. In terms of the structure of its economy, Pakistan resembles the middle-income countries of East and Southeast Asia more than the poorer countries of the Indian subcontinent. Pakistan's economic performance compares favorably with that of many other developing countries, and it has maintained a sustained and fairly steady annual growth rate since independence. However, there has been a relentless increase in population, so despite real growth in the economy, output per capita has risen only slowly. Nonetheless, a significant proportion of the population lives below the poverty line, and the relative prosperity of the industrialized regions around Karachi and Lahore contrasts sharply with the poverty of the Punjab's barani. Pakistan's economic freedom score is 49.4, making its economy the 152nd freest in the 2023 Index. Its score is 0.6 point higher than last year. Pakistan is ranked 33rd out of 39 countries in the Asia-Pacific region, and its overall score is below the world and regional averages. The government has demonstrated little commitment to much-needed economic reform, and efforts in key areas have been marginal at best. Pakistan's GDP grew just 0.3% in the last fiscal year (July 2022–June 2023). Activity was blunted by floods, government austerity, and a balance-of-payments crisis.

2.3. Environmental and Climate Context

Pakistan's environmental and climate conditions are challenging. Pakistan is ranked as the 8th most vulnerable country to the impacts of climate change according to the worldwide climate index. The variability in climate and weather patterns has increased the frequency of disasters, which undermines development in Pakistan. Pakistan is also ranked as the 5th most vulnerable country to climate change according to the Global Climate Risk Index. Floods and droughts have become regular occurrences, anticipated each year in Pakistan. Air pollution is on the rise in urban areas due to multiple factors, including environmental problems, inefficient energy use, a rapid increase in the number of vehicles, industrial activities without adequate air emission control, and the open burning of solid waste, including plastic. Pakistan's climate change vulnerability is driven particularly by the nation's exposure to earthquakes and the risks of internal conflict. However, Pakistan also has high exposure to flooding, including riverine, flash, and coastal, as well as some exposure to tropical cyclones and their associated hazards, and drought. The country's environmental and climate conditions are also affecting its economy and development. The variability in climate and weather patterns has increased the frequency of disasters, which undermines development in Pakistan.

2.4. Energy Sector Analysis

Pakistan possesses substantial reserves of natural gas and coal, both of which are

categorized as fossil fuels. These resources account for a small fraction of the global total, with natural gas comprising 0.30% and coal representing 0.29%. However, the country's oil reserves are notably lower, standing at a mere 0.03%. In comparison to other leading nations, Pakistan's gas and coal reserves fall significantly short. For instance, its gas reserves are approximately 37 times smaller than those of Qatar, while its coal reserves are a staggering 45 times less abundant than those in Australia.

Based on data from 2022, the distribution of conventional fossil fuels in Pakistan is as follows: coal dominates with a share of 77.9%, followed by natural gas at 19.4%, and oil at 2.7%. Furthermore, unconventional fossil fuels play a role, with shale gas representing 68.9%, followed by shale oil and coal mine methane at 30.8% and 0.2%, respectively.

In the realm of renewable energy capacity, hydropower prevails, accounting for over 77% of the total, while wind energy and solar photovoltaics contribute 10.3% and 8.4%, respectively. Hydropower plays a pivotal role in Pakistan's electricity generation, contributing 26% to the total electricity production in 2021. However, the nation has not fully harnessed its abundant hydropower potential, a situation that also applies to wind and solar power generation due to the favorable climate conditions. Pakistan experiences an average daily solar activity of 5.5-5.7 kWh/m2 and commonly witnesses wind speeds of 4.0-5.5 m/s. The Baluchistan province, situated in the southwestern part of the country near the Iranian border, boasts the most significant potential for renewable energy development in Pakistan. Here, the solar Global Horizontal Irradiance (GHI) can reach 6.2-6.3 kWh/m2 per day, while wind speeds exceed 7.5 m/s at a height of 50 meters.

Table 1. Share of Available Energy Sources in Pakistan

Resources	Availability (%)
Crude Oil	0.03%
Natural Gas	0.30%
Coal	0.29%
Tight Oil	30.8%
Shale Gas	68.9%
Coal mine methane	0.2%
Solar potential	5.5-5.7 kWh/m2/day (GHI)
Wind potential	4.0-5.5 m/s
Biopotential	47.6 (percentage of agricultural land area) and 4.8 (percentage of forest land area)
Municipal solid waste	0.43 (kg/per/capita/day)

3. Overview of Energy Transition, NDCs and GHGs Trends

3.1. Energy Infrastructure

The primary gas fields currently in development are situated in the southeastern regions of Pakistan, specifically in the provinces of Baluchistan and Sindh. Meanwhile, the principal oil fields are concentrated in the northern part of the country. Pakistan's conventional oil infrastructure encompasses a range of operational medium-sized refineries, along with several relatively large refineries in operation and some under construction. To illustrate, the accompanying map depicts six functioning refineries with a combined crude oil processing capacity of 425,400 barrels per day (bpd), and it also highlights four refineries that are currently under construction, with a projected capacity of 483,000 bpd. Additionally, the southern region of the country, near Karachi, hosts two substantial oil terminals and two liquefied natural gas (LNG) import terminals, namely PGPC Port Qasim and Engro Elengy. Coal mining activities are primarily concentrated in Sindh Province and Baluchistan Province.

Both the Pakistani government and various commercial organizations have demonstrated significant interest in the construction of the Turkmenistan-Afghanistan-Pakistan-India (TAPI) gas pipeline and the gas pipeline originating from Iran. While the latter was initially planned for completion in 2014, recent information indicates that Pakistan aims to finalize it by 2024. The TAPI project, however, carries substantial risks, primarily stemming from the complex situation in Afghanistan. Pakistan boasts an extensive network of hydroelectric power plants,

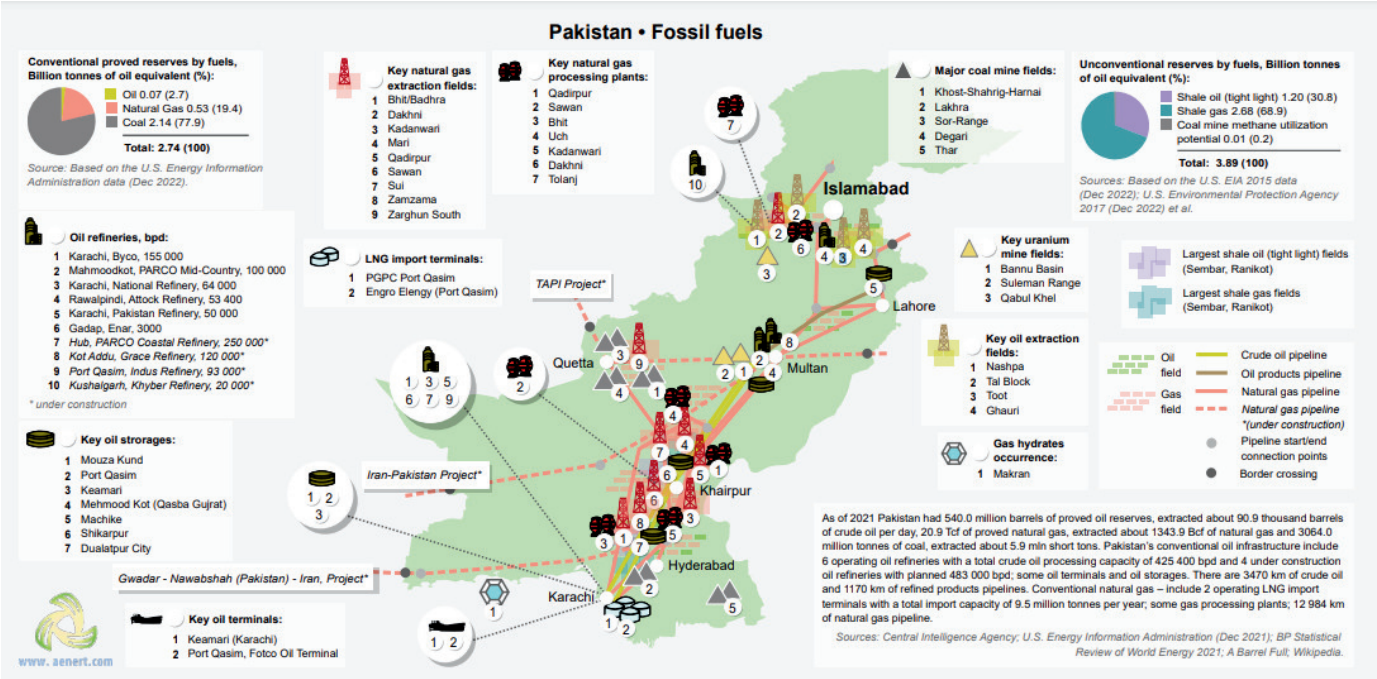

Figure 2. Basic Infrastructural Facilities of the Fossil Fuel Sector in Pakistan

primarily concentrated in the northern regions of the country, contributing over 26% of the nation's electricity production. Fossil-fuel power plants are predominantly located in the eastern part of Pakistan. In the southern region, particularly in the Karachi area, two of the three nuclear power plants are situated. The third and largest nuclear power plant in Pakistan, boasting a capacity of approximately 1,300 MW, is positioned in the northwest within the Punjab province.

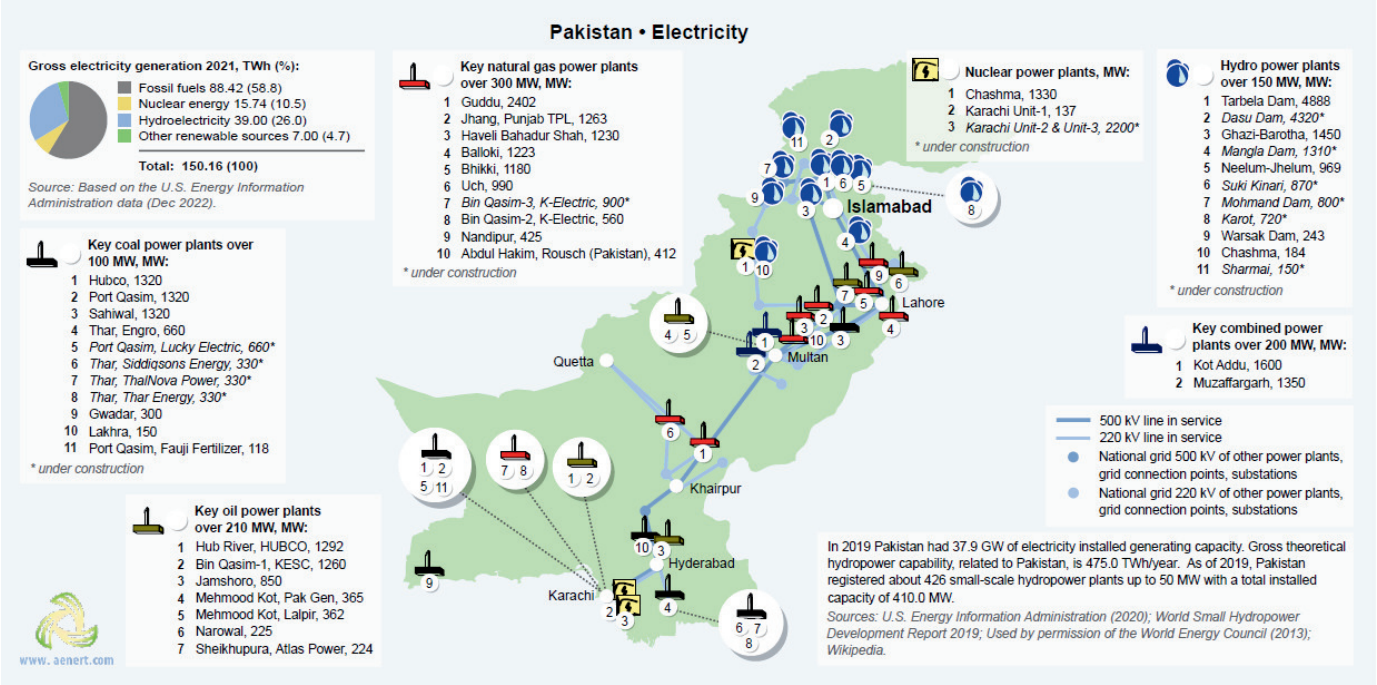

Figure 3. Electricity Production in Pakistan

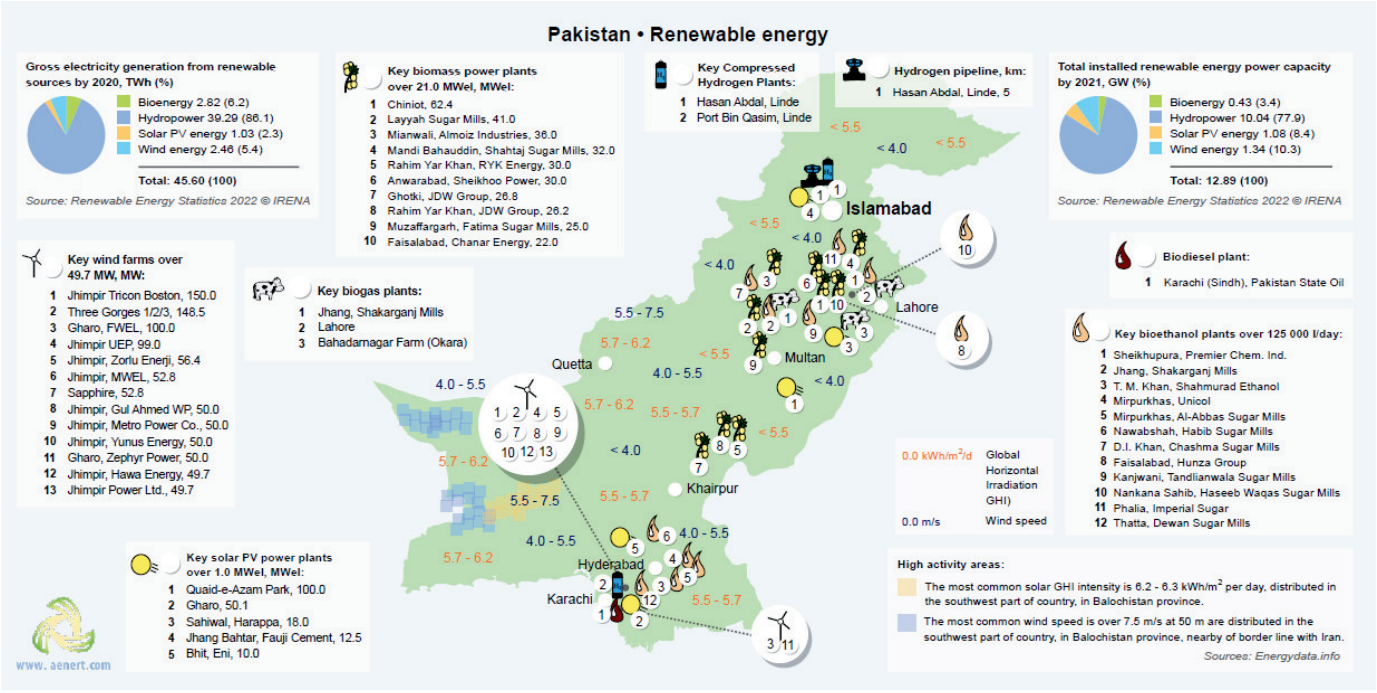

Figure 4. Renewable Energy Production in Pakistan

The dominant source of installed renewable energy capacity in Pakistan is hydropower, representing approximately 78%, with wind energy following closely at around 10%. Solar photovoltaics made up less than 9% in 2021, and bioenergy contributed approximately 3.5%. In 2020, hydroelectric power plants generated about 86% of the total electricity produced from all renewable sources. A significant concentration of wind power plants can be found in the southern regions of the country, with several of them boasting capacities exceeding 100 MW.

3.2. Energy Mix

Pakistan's energy profile is characterized by a significant reliance on fossil fuels. Around 5280MW of electricity is generated from coal, in which 1320MW is coming from Thar coal and 3960MW is contributed by the imported coal. These figures reveal that Pakistan is heavily dependent on the imported coal.

While Pakistan possesses a significant hydropower potential estimated at 60,000MW, the country is utilizing only 16% of this vast potential. Presently, the total hydro installed capacity is 10,251MW. Similar to hydropower, Pakistan holds substantial potential for electricity generations from solar and wind. Wind power contributes to 1985MW, while solar power contributes to 600MW. Additionally, Pakistan has a gross nuclear power plant capacity of 2530MW1.

The data below sketch picture of the country which is heavily dependent on the thermal resources. Thermal fuels have the largest share in the generation of electricity which is 61% followed by the Hydel 24%, Nuclear 12% and renewable energy 3% respectively.

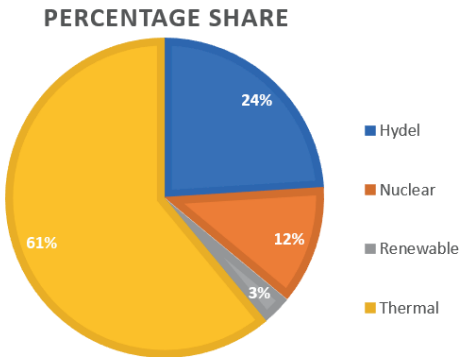

Figure 5. Energy Mix of Pakistan

3.2.1. Energy Mix Trends

From 1990 to 2020, Pakistan's Total Primary Energy Supply (TPES) increased from 43.1 million tonnes of oil equivalent (Mtoe) to 107.8 Mtoe, exhibiting an annual growth rate of 3.1% over this period. The share of coal in Pakistan's TPES also saw an increase, rising from 83,799 terajoules (4.6%) in 1990 to 584,876 terajoules (13%) in 2020, with an annual growth rate of 6.7%. Biofuels traditionally held the majority share in Pakistan's TPES mix, starting at 43.6% (785,890 terajoules) in 1990 and decreasing slightly to 34.9% (1,575,667 terajoules) in 2020. Other significant sources of energy include oil and natural gas. Natural gas supply increased annually by 3.6% from 422,032 terajoules (23.4% of TPES) in 1990 to 1,216,022 terajoules (26.9% of TPES) in 2020. The supply of oil grew at an annual rate of 2.3%, rising from 447,217 terajoules (24.8% of TPES) in 1990 to 875,619 terajoules (19.4% of TPES) by 2020.

Traditionally, fossil fuels, excluding biofuels,

accounted for nearly 90% of the primary energy mix, with an average contribution of 85.9% over the years. Among fossil fuels, oil had the greatest share, averaging 40.6% over the entire period, although it decreased from its peak of 56.4% in 1968. In contrast, coal played a substantial role in the energy mix in the late 1960s, experiencing a resurgence after 2015 with the introduction of coal-fired power projects under the China-Pakistan Economic Corridor (CPEC). The average share of coal in the energy mix from 1965 to 2021 was 8.1%, with a peak of 19.5% in 1965, followed by a decline to 4.9% by 2000. In 2021, coal contributed 17.4% of the primary energy supply.

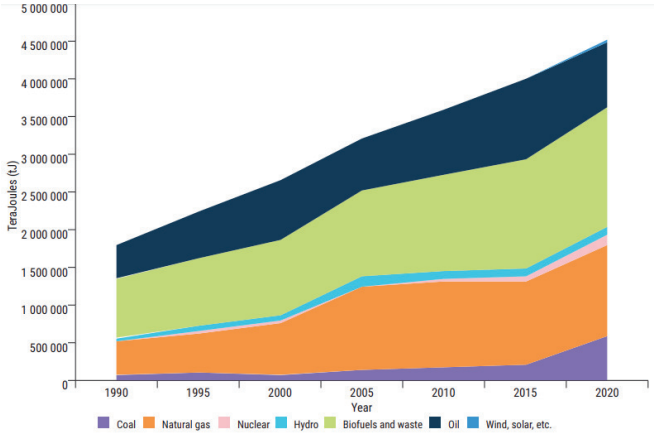

Figure 6. Share of Total Primary Energy Supply

3.3. Greenhouse Gas Emission Trends

From 1990 to 2020, Pakistan's total emissions surged from 56 million metric tons of CO2 equivalent to 166 million metric tons of CO2 equivalent, marking a nearly three-fold increase over the period. Initially, in 1990, the industrial sector was the leading contributor to emissions at 30.4% (17 million metric tons of CO2e), closely followed by the electricity sector at 26.8% (15 million metric tons of CO2e), with the transport sector representing 25% of the total emissions (14 million metric tons of CO2e). However, by 2020, as illustrated in Figure 3 and 4, there was a shift in sectoral emissions contributions, with electricity taking the lead at 31.3% (52 million metric tons of CO2e), followed by the industrial and transport sectors, both contributing 27.8% each (45 million metric tons of CO2e).

Regarding emissions by energy source, traditionally, oil had been the predominant contributor to Pakistan's fossil fuel mix and, consequently, the largest source of CO2 emissions. However, the role of coal in overall CO2 emissions had strengthened as its share in Total Primary Energy Supply (TPES) increased post-2015. On average, oil contributed 54.1 million metric tons of CO2 annually, natural gas added 41 million metric tons of CO2 annually, and coal contributed 18 million metric tons of CO2 annually to the total CO2 emissions during this period.

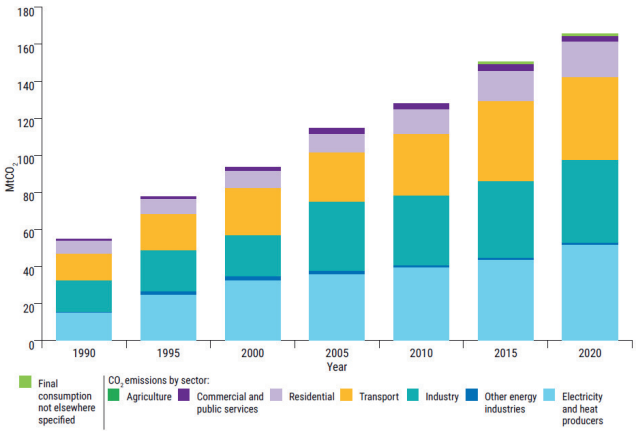

Figure 7. Carbon Dioxide Emissions by Sector

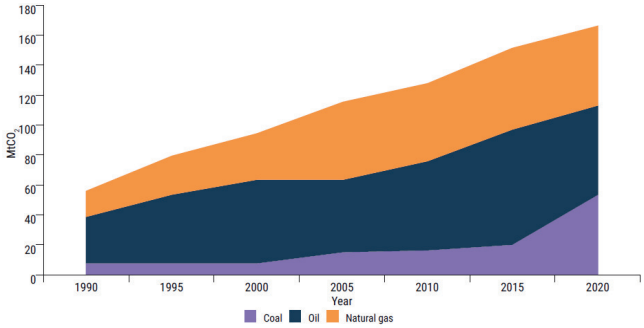

Figure 8. Carbon Dioxide Emissions by Source

3.4. NDCs and Climate Commitments

NDCs are the commitments made by each participating country under the Paris Agreement to outline their efforts to reduce greenhouse gas emissions, adapt to the impacts of climate change, and support sustainable development. The concept of Nationally Determined Contributions (NDCs) plays a crucial role in addressing climate change at the global level. NDCs are central to the Paris Agreement, a landmark international treaty adopted in 2015 with the goal of combating climate change and limiting global temperature rise to well below 1.5 degrees Celsius above pre-industrial levels. Here are the key aspects and roles of NDCs in addressing climate change:

The term "**Nationally Determined**" signifies that each country has the autonomy to determine its own contribution to addressing climate change based on its national circumstances, capabilities, and development priorities. This allows countries to tailor their commitments to their specific contexts, taking into account their economic, social, and environmental considerations.

NDCs encompass both mitigation and adaptation measures. Mitigation refers to efforts aimed at reducing greenhouse gas emissions to mitigate the causes of climate change. It includes targets and actions related to transitioning to renewable energy, energy efficiency, forest conservation, and other measures to reduce emissions. Adaptation refers to actions that help societies and ecosystems adapt to the impacts of climate change, such as implementing resilient infrastructure, enhancing water resource management, and improving disaster risk reduction.

Transparency and Accountability:
NDCs require countries to report on their progress towards their commitments, ensuring transparency and accountability. The Paris Agreement sets up a robust transparency framework to track and monitor the implementation of NDCs. This includes regular reporting of emissions inventories, mitigation efforts, adaptation actions, and support received or provided.

Long-Term Vision:
NDCs are expected to reflect each country's long-term climate goals and aspirations. Countries are encouraged to outline their long-term low-emission development strategies, demonstrating how they plan to achieve sustainable development and transition to a low-carbon, climate-resilient economy over time.

Enhanced Ambition:
The Paris Agreement includes a mechanism to regularly review and enhance the ambition of NDCs. Countries are urged to

regularly communicate updated or enhanced NDCs every five years, reflecting their increased efforts to address climate change. The aim is to collectively strengthen global climate action and ensure that emissions reduction targets are aligned with the overarching goal of limiting temperature rise to well below 1.5 degrees Celsius.

Overall, NDCs serve as a critical framework for countries to outline their climate action plans and contribute to global efforts to combat climate change.

High Priority Action

- Mitigation

Renewable Energy:
By 2030, 60 % of all energy produced in the country will be generated from renewable energy resources including hydropower.

Transportation:
By 2030, 30 % of all new vehicles sold in Pakistan in various categories will be Electric Vehicles (EVs).

Coal:
From 2020, new coal power plants are subject to a moratorium, and no generation of power through imported coal shall be allowed, shelving plans for two new coal fired power plants in favor of hydroelectric power and focusing on coal gasification and liquefaction for indigenous coal.

Land-Use Change & Forestry:
2016 onwards, continued investments in NbS through the largest ever afforestation program in the history of the country—the Ten Billion Tree Tsunami Programme (TBTTP)—will sequester 148.76 MtCO2e emissions over the next 10 years. The estimated project cost of about US$800 million is being met nationally from indigenous resources as an unconditional contribution.

- Adaptation

Recharge Pakistan:
By 2030, the project envisages the reduction of flood risk and enhanced water recharge at six sites in the Indus Basin, building resilience of 10 million people, as well as strengthening vulnerable ecosystems. The project is under review by Green Climate Fund (GCF) for funding. In the meantime, Pakistan has allocated PKR 6 billion from national resources to commence the activities in three sites, namely Manchar & Hamal wetland, Taunsa pond area, and Dera Ismail Khan.

Protected Areas:
By 2023, total protected areas in the country will be enhanced from 12% to 15% that will result in preserving rare fauna, flora, green job opportunities for 5,500 people, and promoting eco-tourism. In 2020, government of Pakistan launched Protected Area initiative which will support in the promotion and development of the habitats for the wildlife across the national parks of Pakistan.

Table 2. Mitigation and Adaption, High Priority Actions

High Priority Actions	
	Status/Activities/Projects
Mitigation	
Renewable Energy	• 26 private wind energy projects producing approximately 1335 MW. • 10 winds projects under construction. • 6 solar power projects with cumulative capacity of 430MW
Transportation	• Development of electric vehicle policy • Launching of first electric bus in Karachi by the Sindh Government
Land-Use Change & Forestry	• Ten Billion Tree Tsunami Programme (TBTTP)
Adaptation	
Recharge Pakistan	• "Recharge Pakistan: Building Pakistan's Resilience to Climate Change through Ecosystem-Based Adaptation for Integrated Flood Risk Management," • Scaling-up of glacial lake outburst flood (GLOF) risk reduction in northern Pakistan
Protected Areas:	• Protected Area Initiative (PAI)

3.5. Clean Energy Initiatives

Through the enactment of the Alternative & Renewable Energy Policy in 2019, Pakistan solidified its aspirations to elevate the contribution of renewable energy. The goal is to raise the renewable energy share from 5.3% in 2021 to 20% by 2025 and further to 30% by 2030. These objectives will be primarily realized through annual competitive bidding capacity auctions to accelerate the growth of substantial photovoltaic (PV) and wind projects. Additionally, the strategy involves fostering the domestic production of technology, developing manufacturing capabilities, and cultivating a skilled workforce in this sector.

The Government of Pakistan (GOP) has established a wind energy corridor in the southern coastal regions of Sindh and Baluchistan. Wind data, sourced from Pakistan's Meteorological Department, reveals that Pakistan's coastal stretch, spanning 60 kilometers (from Gharo to Keti Bandar) and extending 180 kilometers, offers an exploitable potential for generating 50,000 megawatts (MW) of electricity through wind turbines. Presently, there are 26 private wind projects in operation, collectively producing around 1335 MW of electricity. Additionally, 10 wind projects with a combined capacity of 510 MW have secured financial backing and are currently under construction.

The Government of Pakistan has also devised a Renewable Energy Policy aimed

at achieving the ambitious target of generating 60 percent of the country's energy from renewable resources by 2030. This forward-looking goal presents numerous opportunities for the wind energy market in Pakistan.

As per the Pakistan Economic Survey, within the last five years, six solar power projects with a combined capacity of 430 MW have commenced commercial operations, effectively contributing to the electricity supply. As electricity costs in Pakistan continue to rise, and grid reliability remains uncertain, an increasing number of industries and commercial organizations are turning to self-reliant solar solutions. Notably, there has been a significant upswing in the installation of rooftop photovoltaic panels in major cities. For projects under 1 MW, net metering regulations were put into effect in September 2015. This sector is poised for substantial growth in the near future, with the Government of Pakistan (GOP) targeting at least 1 million customers and the addition of around 3,000 MW of solar power through net metering.

To further bolster the presence of renewable energy in Pakistan's energy mix, the World Bank has extended $100 million in financing to the Sind Solar Energy Project. This initiative aims to support independent power producers in the development of 400 MW of new solar power projects and provide partial grants to private sector firms for the commercial deployment of Solar Home Systems to benefit 200,000 households.

In addition to large-scale hydroelectric projects, there are promising opportunities for the development of small, mini, and micro hydro power facilities, as outlined in the revised Renewable Energy (RE) Policy. The Government of Pakistan (GOP) views small hydropower projects as a clean and cost-effective source of energy. These smaller hydropower projects are primarily situated in remote areas of Pakistan, especially in the northern regions of the country.

More recently, the GOP has identified new requirements for power generation capacity, fuel technology, and the utilization of indigenous resources through the introduction of the Indicative Generation Capacity Expansion Plan (IGCEP). This plan envisions the development of hydropower projects, aiming to add an additional 13,000 MW of hydropower capacity by 2030. This substantial increase would augment the existing capacity of 9,000 MW, resulting in a 25 percent share of hydropower in the overall energy mix.

4. Climate financing and NDCs

4.1. Global Climate Financial Architecture

Climate finance refers to the funds allocated for addressing the impacts of climate change, encompassing actions related to both mitigation and adaptation. This financial support includes commitments by developed nations under the UNFCCC, although there is no universally agreed-upon definition for the term "climate finance". Historically, in the 2009 Copenhagen Accord, and later reaffirmed in the Cancun Decision and Durban Platform, developed countries pledged to provide financial assistance nearing USD 30 billion between 2010 and 2012. The Paris Agreement reinforced the obligation of developed nations to lead in mobilizing climate finance from diverse sources, instruments, and channels, transcending prior efforts. The accompanying COP decision set a new collective target, aiming to scale up from a

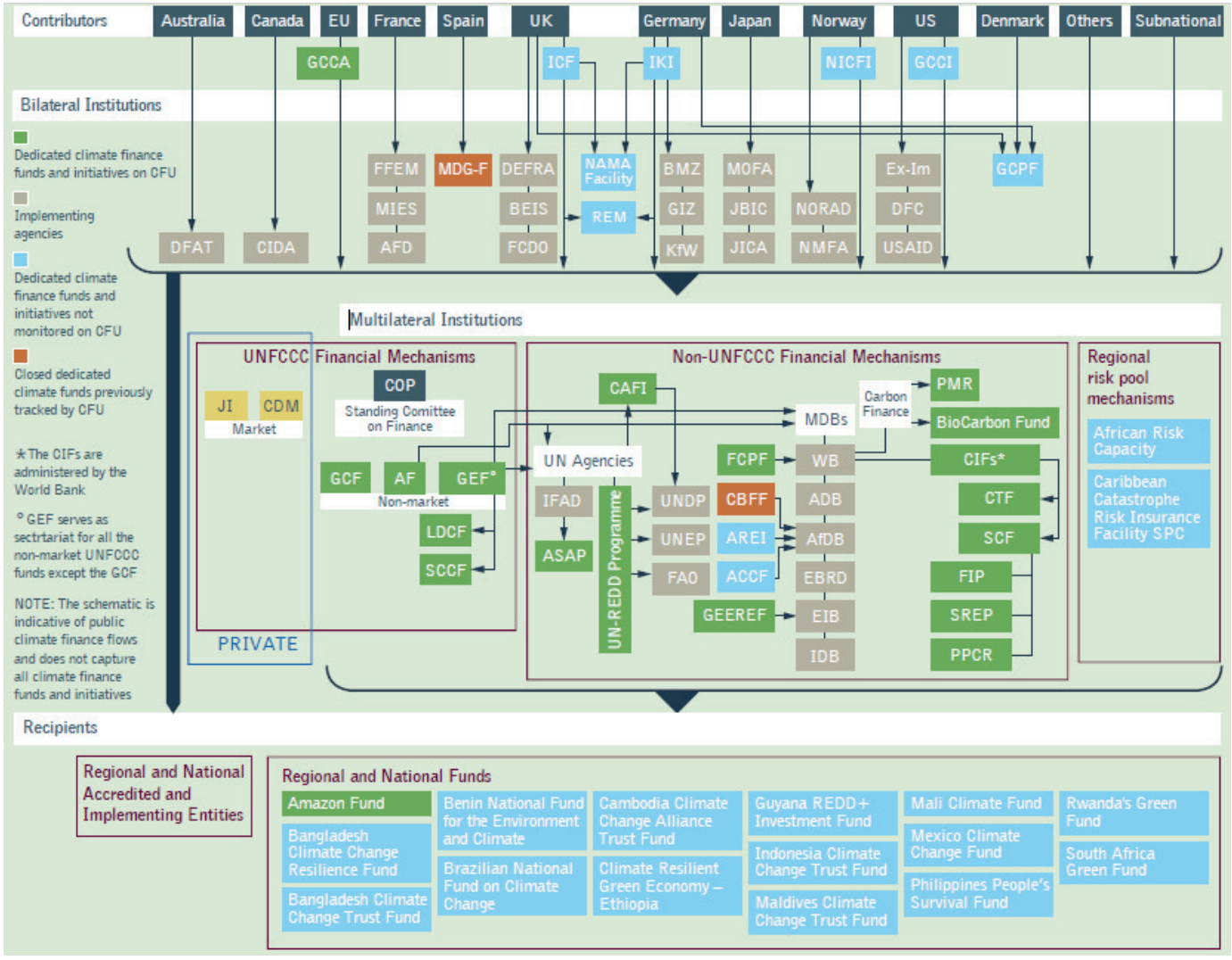

Figure 9. Climate Financing Infrastructure

minimum pledge of USD 100 billion annually by 2020, initiated in Copenhagen. Developing countries have highlighted the need for increased international support in implementing their National Adaptation Plans (NAPs) and enhancing the ambition of their Nationally Determined Contributions (NDCs). This necessitates ensuring that the necessary finance and investments are available, which presents a significant challenge. Furthermore, developing countries have emphasized the requirement for finance to address the loss and damage incurred due to ongoing climate change impacts. Various estimates indicate the levels of climate finance provided by developed countries to developing countries. These figures have shown growth over the years, reaching USD 80 billion in total climate finance in 2021. However, this figure falls short of the developed country target of USD 100 billion by 2020. It's important to note that a substantial portion of this funding comes from the private sector, and the extent of public finance's additionality is unclear, i.e., the degree to which it represents efforts beyond existing development finance commitments.

4.1.1. Climate Financing in Asia

Asia have varying economic and human development needs, climate mitigation, and adaptation requirements. While per capita emissions remain low in most Asian countries, the demand for cheap fossil fuel energy in major Asian economies contributes significantly to global greenhouse gas (GHG) emissions. For instance, China, the world's largest GHG emitter, is making strides in energy transition and low-carbon technology adoption.

Several countries in the region have committed to carbon neutrality by 2050 or 2060 as part of their updated nationally determined contributions (NDCs), reflecting increased climate ambition. Addressing deforestation and forest degradation is critical, particularly in Indonesia, to reduce global emissions. Moreover, many Asian countries are home to large populations of vulnerable individuals who face intensifying climate change impacts, such as food insecurity, undernourishment, and various health hazards. Climate finance is essential to support these initiatives. Major multilateral climate funds, including the Green Climate Fund (GCF), Clean Technology Fund (CTF), and the Global Environment Facility (GEF), play a significant role in providing funding for climate-related projects in Asia. Bilateral climate finance also complements multilateral funding, with contributions from countries like Germany, Australia, and the United Kingdom. Recently, the International Partners Group (IPG) committed substantial financial support for decarbonization projects in Indonesia and Vietnam under the Just Energy Transition Partnership (JETP) initiative. Furthermore, seven Least Developed Countries (LDCs) in Asia, which are highly vulnerable to climate change due to geographic, economic, and political factors, receive climate finance to enhance their resilience. Bangladesh, Nepal, and Cambodia have secured significant project approvals from multilateral climate funds, primarily focusing on adaptation efforts, including disaster risk reduction and agriculture.

Fund or initiative	Amount approved	Projects approved
Green Climate Fund (GCF-IRM, GCF-1)	2,587.1	42
Clean Technology Fund (CTF)	1,809.2	38
Global Environment Facility (GEF-4, 5, 6, 7)	1,005.2	208
Pilot Program for Climate Resilience (PPCR)	296.9	31
Least Developed Countries Fund (LDCF)	217.9	46
Scaling Up Renewable Energy Program in Low Income Countries (SREP)	178.4	22
Global Climate Change Alliance (GCCA)	168.5	19
Adaptation Fund (AF)	134.4	50
Forest Investment Program (FIP)	100.0	8
Forest Carbon Partnership Facility (FCPF)	63.0	8
Adaptation for Smallholder Agriculture Programme (ASAP)	62.4	6
Global Energy Efficiency and Renewable Energy Fund (GEEREF)	60.3	7
Special Climate Change Fund (SCCF)	47.2	13
Partnership for Market Readiness (PMR)	32.3	13
UN-REDD Programme	29.4	8
Millennium Development Goals Achievement Fund (MDG-F)[3]	25.0	3
BioCarbon Fund	15.0	1

Figure 10. Approved Funds in Asia

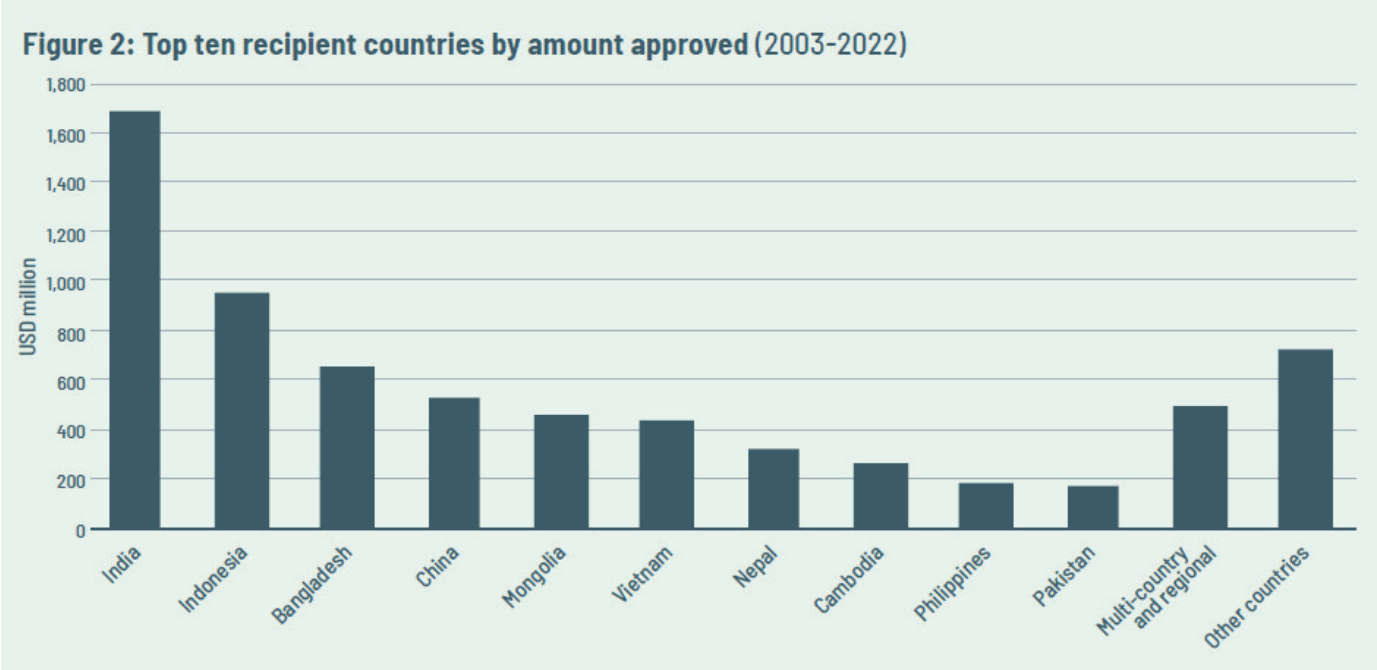

Figure 11. Top 10 Receipt Countries

4.2. Climate Financing in Pakistan

4.2.1. Pakistan International Public Finance Sources

Multilateral Funds:
These support projects, policy processes and technical support for international cooperation. Examples: Green Climate Fund and the Least Developed Countries Fund.

Multilateral Development Banks:
The banks foster economic and social progress in developing countries by financing projects including adaptation measures. Example: The World Bank, International Finance Corporation, Asian Development Bank, European Investment Bank and European Bank for Reconstruction and Development.

Bilateral Cooperation:
The bilateral cooperation mechanism supports technical and financial exchange between two governments for implementation of policies, projects or specific measures, usually financed through bilateral development banks and national development organizations.
Example: The Nordic Development Fund and the European Union's Global Climate Change Alliance Programme.

4.2.2 Private Finance Sources

Non-profit Organizations:
National and international foundations and NGOs may operate on a regional, national, or international scale and may not be limited to a domestic context.

Market Debt:
The largest source of potential private finance for climate change adaptation measures stems from investment and financial lending operations. Example: Green Bonds.

4.2.3. Domestic Public Sources

National Adaptation Funds: Established by national or sub-national governments to financially or technically support adaptation actions. They are often part of a country strategy or development plan to drive policy implementation. Many national funds receive their resources from national (taxes, levies and fees, bonds, subsidies and ecological fiscal transfers) and international sources. Examples: Peoples Survival Fund in the Philippines.

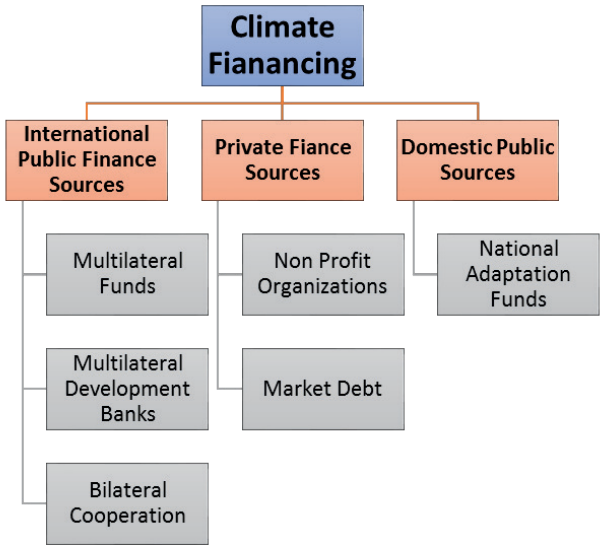

Figure 12. Climate Funding Sources

4.2.4 Financial Instruments

Financial Instruments for Climate Change Mitigation and Adaptation

- Market - Based Finance

Debt for Climate Swap provides predictable

and additional finance for environmental projects, including projects leading to a reduction in GHG emissions in countries burdened by huge amounts of debt.

Nature Performance Bonds (NBP):
Building on an earlier experience with the Government of Italy, Pakistan is engaged with several bilateral and other development partners to channel outstanding payments into conservation and climate-related investments via NPB. If successful in implementing the first pilot project, Pakistan will capitalize from country's performance shown in the last few years through various flagship projects.

Nature performance bond is a sustainability-linked financing instrument that links debt payments to predetermined nature-based targets. This 'pay-for-performance' instrument incentivizes the issuer to achieve positive outcomes through an improvement in debt terms via a reduction in coupon and the potential for a principal adjustment on full delivery of the targeted nature/climate outcomes. Nature performance bonds do not impose any restriction on the use of proceeds, thereby extending spending autonomy to the Government of Pakistan to utilize the funds for any economic purpose, but tied to delivering the outcomes.

Green Banking:
Pakistan is currently in the earlier stages to adopt green banking initiatives for low carbon emissions. According to Rehman et al, (2021), the banking sector is one of the major stakeholders in the achievement of Sustainable Development Goals in Pakistan, by providing green financing to industries at lower interest rates to combat environmental issues. Recently, in June 2020, the SBP revised its green banking guidelines to support renewable energy projects (SBP, 2021).

As per the revised guidelines, an effort has been made to facilitate the Renewable Energy Investment Entity (RE-IE), certified under the Alternative Energy Development Board (AEDB), for financing their renewable energy projects at lower electricity costs.

Under this scheme, financial concessions will be provided to both small- and large-scale renewable projects. Till June 2021, funding of around PKR 53 billion, was granted for renewable energy projects under concessional financing schemes.
Moreover, SBP signed an agreement with IFC, in 2018, to support environmental-risk management practices and also assure ethical lending practices – hence promoting green banking in the country.

Moreover, SBP is enroute to enhancing the share of Islamic banking to one-third of the share of the total banking sector by 2025. It plans to do so by increasing assets and deposits of Islamic banking to 30% of the total banking sector (Bukhari, 2021).

In this purview, issuing green bonds and engaging commercial banks make it efficient to achieve the target. Banks can offer low-interest loans to companies that make efforts to reduce the adverse impact on the environment. Generating green financing through green banking may not only generate domestic green funding but

also reduce the foreign dependency on funding.

Debt Swap:
Another efficient tool used to raise capital, address environmental issues and challenges to encourage green economic growth is debt swap. The management of public debts has always remained one of the grave concerns for Pakistan. Debt swap could be a useful option.

Instead of repaying the debt payment to the creditor organization, Pakistan can utilize the payment to support the renewable energy sector. It could be easy as Pakistan has already been part of the Debt Service Suspension Initiative (DSSI) - debt concession initiative.

Moreover, it is not the first time when Pakistan is engaged in any debt swap agreements. For example, in 2006, Pakistan signed a debt swap agreement with Italy in exchange for the Afghan refugees' project and the development of infrastructure for environmental protection. Besides, Pakistan continues to stay in touch with four countries and two international donor agencies for debt relief, through debt-swaps deals and adheres to commit to the conservation targets (The NEWS, 2021).

Debt-for-nature swap is essentially a bespoke deal, limiting its scalability. Furthermore, the funds for conservation are held in the trust which monitors the use of proceeds. Consequently, such an arrangement may not be very beneficial in case of Pakistan where the use of proceeds is restricted to conservation targets.

Guarantee Mechanisms:
Governments across the World, have numerous financial tools at their disposal to promote development. Government guarantees are another useful tool to mobilize private investment in infrastructure. The government authorities in several countries give guarantees for various projects, which minimizes the investors' risk, emboldens their confidence, and makes it easier to raise funds for such projects with the active engagement of both investors and lenders.

In 2021, the government of Pakistan gave $9 million (PKR 2,055 billion) worth of guarantees to the power sector (GOP, 2021). Similarly, a sovereign guarantee worth $2 billion was offered by Pakistan in 2015, to the thar coal mine and power generation project (Hasan, 2015).
The Loan Guarantee Instrument for Trans-European Transport Network Projects (LGTT), which is a joint effort of the European Investment Bank and the European Commission. Another example was the guarantee refinanced by the Flemish government in 2009, to address liquidity issues (Lu et al, 2019).

However, even in the absence of government guarantees, multilateral banks like the African Development Bank, the European Bank for reconstruction and development, and the World Bank can also issue such guarantees in countries where guarantee mechanisms are not available (Majid, 2020).

Green Bonds:
Green bonds have the potential to

significantly contribute to the creation of climate funds to help Pakistan's energy transformation. According to (Dina Azhgaliyeva, 2020), the market share of green bonds for energy efficacy grew from $16 billion in 2016 to $47 billion in 2017 globally. They were usually established to support programmes that have a positive environmental impact or that helps to reduce the consequences of climate change.

The Securities and Exchange Commission of Pakistan (SECP) has already approved the rules for green bonds, which would encourage innovative financing for various sectors in both mitigation and adaptation as shown in BOX 1 below (Daily Times, 2021).

In Pakistan, Water and Power Development Authority (WAPDA) has issued green euro bonds worth $500 million for the construction of the Diamer-Bhasha dams (Karandaz, 2022). Therefore, Pakistan has the potential to issue such bonds for other renewable energy projects, including solar or wind energy.

Sukuk Bonds:

Green finance tools like Sukuk bonds may play a critical role in mitigating climate change and to overcome the financing gap. A Sukuk is an Islamic bond that can provide returns to investors while adhering to Islamic Shariah law, which prohibits interest payments.

Sustainable Sukuk bonds may offer green investment for renewable projects. In the recent past, the global Sukuk market has grown rapidly from an estimated US$85 billion of Sukuk issuances, in 2016, to an estimated US$ 172 billion in 2020.

In January 2022, Pakistan had released Islamic sukuk bond of $1 billion in the international market at 7.95% with a maturity period of seven years (Business Recorder, 2022).

Carbon Pricing:

Carbon pricing is considered an efficient, significant, and straightforward approach for reducing GHG emissions and generating green financing at the domestic level. Globally, around $53 billion revenue was generated and 21.5% of carbon emissions were covered under this initiative in 2021- higher in comparison than previous years - that was around 15.1% in 2020 (WB, 2021). Similarly, around $40-80 is required per ton of carbon emission for achieving the 2o C goal (World Bank, 2021).

Pakistan is exploring ways for carbon pricing to generate green funding and discover the impact carbon markets have on achieving the country's NDC. In December 2019, Pakistan established a National Committee on the Establishment of Carbon Markets (NCEC) to understand the role of carbon market in delivering the country's NDC and identify the potential challenges for improving on carbon emissions data (WB, 2021). Moreover, Pakistan has also acquired funding from Collaborative Instruments for Ambitious Climate Action (CIACA) to design Carbon Pricing Instrument (CPI) (NDC, 2021).

- Non Market - Based Finance

Sustainable Finance Framework:
The creation of a Sustainable Finance Framework (SFF) would allow the GoP to issue green, social and sustainability bonds, as well as loans, through the Ministry of Finance (MoF). SFF will provide guidance on identifying eligible expenditures, share best practices on setting up required systems to implement the framework and organize a Second Party Opinion (SPO) on the SFF.

a. Sustainability Bonds:
are the bonds wherein the proceeds will be exclusively applied to finance or refinance a combination of green and social projects. Sustainability bonds are usually aligned with the ICMA's Sustainable Bond Guidelines or the Sustainability Bond Principles.

b. Social Bonds:
Bonds which raise funds for new and existing projects with positive social outcomes. Social project categories include affordable basic infrastructure, access to essential services, affordable housing, employment generation, food security, and socioeconomic advancement.

Public-Private Partnerships:
Pakistan encourages the involvement of the private sector in implementing its climate ambition across sectors and the development of nature-based solutions (NbS) that address Pakistan's mitigation and adaptation potential. Private investors may participate in transactions involving the transfer of mitigation outcomes through the instruments of Article 6 of the Paris Agreement or using voluntary market where in the recent development, 26 private sector entities have pledged significant emission reduction targets. Pakistan plans to promote bottom-up actions by the private sector, and develop plans for emission reductions form major sectors, particularly cement and textile.

The State Bank of Pakistan (SBP) in 2017 approved green banking guidelines to promote environmental risk management within the commercial banks and encourage climate finance that to reduce vulnerabilities. SBP has also determined to develop a framework for risk management systems. A steering committee comprising of the SBP, International Finance Corporation (IFC), and the Pakistan Banks' Association was constituted to oversee the progress.

The PPPA can facilitate the flow of financing for implementation of the NDC and adaptation and mitigation priorities from the GCF, as the Ministry of Climate Change has already pursued direct access modalities for climate finance through accreditation of JS Bank and National Rural Support Programme (NRSP) as the National Implementing Entity.

Blue Carbon:
Using the terrestrial forest price of carbon credits of US$ 3 and aspirational blue carbon prices of US$12-15; revenue generated would be US$75 million and US$300-500 million, respectively. Carbon removals would continue beyond 2050 sustaining ongoing revenue. While this preliminary assessment requires further research, a combination of market and

non-market-based approaches like blue bonds can help meet Pakistan mitigation and adaptation objectives in mangrove forests, and also reap co-benefits of livelihood and biodiversity protection.

- Other Instruments/Mechanisms

Carbon Offsets In its ambitious efforts toward afforestation through the Ten Billion Tree Tsunami Programme, Pakistan expects significant carbon sequestration which can potentially be sold to third parties as carbon credits, earning substantial income for the country. Moreover, in Pakistan, alternative and renewable energy projects have the prospects for development as carbon offsetting initiatives. The summary of climate financing is presented in the figure 12 along with the detailed table ahead.

Table 3. Comprehensive Matrix Table Representing Climate Financing Mechanisms in Pakistan

Sr. No	Indicators	Executing Body	Programs	Projects	Criteria Yes = ✓ No = x Information not found= ©
			MARKET BASED FINANCE		
1.	Nature Based Performance Bonds	• Finance for Biodiversity Initiative (F4B) • Government of Pakistan Ministry of Climate Change • IUCN • WWF	• Ecosystem Restoration Initiative (ESRI) • 10 billion Tree Tsunami project (10 BTTP) NBP bond in collaboration with UNDP • Protected Areas Initiative • Green Pakistan Programme (GPP)	• Recharge Pakistan Project • NBP Projects Targeting US$1 billion in nature-based bonds	✓
2.	Green Banking	• State bank of Pakistan • Muslim Commercial Bank(MCB) • Soneri Bank • JS bank • UN Green Climate Fund (GCF)	• Renewable Energy Investment Entity (RE-IE) ➢ Green Banking Office ➢ Environmental Due Diligence (EnvDD) ➢ Green Awareness campaign • Pakistan distributed solar Project SAPO24	• Financial concessions costing PKR 53 billion for renewable energy projects • SBP launches: 1. SDGs and 2. Sustainability Report – Pakistan Banking Sector Perspective 3. Mapping the progress of Pakistan's banks towards Sustainable Development Goals (SDGs) and identifying specific gaps • Requested GCF funding Total Amount: 10,000,000 ($) Guarantee facility provided by GCF will be deployed to finance 43 MW solar PV installations for households, agribusinesses and small and medium enterprises (SMEs)	✓
3.	Debt Swap	• United Nations • Ministry of Economic Affairs, Government of Pakistan • Technical Support Unit (TSU)	• Substantial debt relief • PAK ITALIAN DEBT SWAP AGREEMENT (PIDSA)	• Rs.8.27 billion of Pakistan's debt owed to Italy was swapped for expenditure on development projects	✓

				• Out of 35 proposed projects 10 projects are completed	
4.	Guarantee Mechanisms	• Government of Pakistan • ASIAN Development Bank • World • Bank Group (WBG) • European Investment Bank European Commission	• $9 million worth of guarantees to power sector • $2 billion worth of guarantees to thar coal mine and power generation project	Loan Guarantee Instrument	✓
5.	Green Bonds	• Pakistan Water and Power Development Authority (WAPDA) • Securities and Exchange Commission of Pakistan (SECP)	• Green Bond Framework • Green Bonds Guidelines	• $500 million green bond to fund hydroelectric project • Construction of the Diamer-Bhasha dams • Protective Area Initiative	✓
6.	Sukok Bonds	• Government of Pakistan • Mezan Bank	• Islamic sukuk bond • Sustainable Sukuk	• $1 billion in the international market at 7.95% with a maturity period of seven years	✓
7.	Carbon Pricing	• UNFCCC • European Union (EU) • Pakistan's Ministry of Climate Change	• National Committee on the Establishment of Carbon Markets (NCEC) • Ambitious Climate Action (CI-ACA) project	Carbon Pricing Instrument (CPI)	✓
NON-MARKET BASED FINANCE					
1.	Sustainable Finance Framework	• State Bank of Pakistan (SBP) • Ministry of Finance (MoF) • UNDP • Climate Finance Unit (CFU • Government Of Pakistan • Ministry of Climate Change	Climate Change Financing Framework (CCFF)	• SBP enhances the scope of Refinancing Facility for Modernization of Small and Medium Enterprises (SMEs) by including new zig-zag technology brick kilns for financing under the scheme	✓
2.	Sustainable Bonds	• SDPI • SECP • U.S Embassy and Consulates in Pakistan	Climate Finance Accelerator program Environmentally Conscious Design	Climate Smart agriculture Project	✓

3.	Social Bonds	• PIDE • MoCC • World Bank • U.S Embassy and Consulates in Pakistan		• Green Jobs - Green Stimulus • Ecosystem Restoration Fund • Electric Vehicle Policy • Clean Green Pakistan Movement • Pakistan Clean Air Program • Natural Capital Accounting	
4.	Public Private Partnerships	• WWF • Private Investors • GCF • SDPI • MoCC • International Finance Corporation (IFC)	National Rural Support Programme (NRSP)	Building Pakistan's Resilience to Climate Change through Ecosystem Based Adaptation for Integrated Flood Risk Management	✓
5.	Blue Carbon	• Government of Sindh • Delta Blue Carbon • ATPI ASIA PORTFOLIO • Pollination • Blue Carbon Lab • MoCC • Prudence Consultancy • World Bank • GoP • ICIMOD	• First Pass of Blue Carbon Assessment in Pakistan • Blue Carbon Policy • Blue Carbon Initiative	THE DELTA BLUE CARBON PROJECT The project protects the existing 102,000 hectares of mangrove forests and is rehabilitating and restoring another 226,000 hectares of degraded and de-vegetated mangrove lands.	✓
OTHER INSTRUMENTS					
1.	Carbon Offsets	• GOP • SBP • Alternate Energy Development Board (AEDB) • Pakistan Environment trust • IUCN	• Ten Billion Tree Tsunami Programme • Clean Development Mechanism (CDM)	• ARE projects • Net Zero Pakistan	✓

4.2.5. Funding Secured by Pakistan

In 2021 NDC, Pakistan intends to set a cumulative ambitious conditional target of overall 50% reduction of its projected emissions by 2030, with 15% from the country's own resources and 35% subject to provision of international grant finance that would require USD 101 billion just for energy transition and additional US $65 billion by 2050 considering the ongoing renewable energy projects. Similarly, according to Asian Development Report 2017, Pakistan's climate adaption required $7 billion to $14 billion per year.

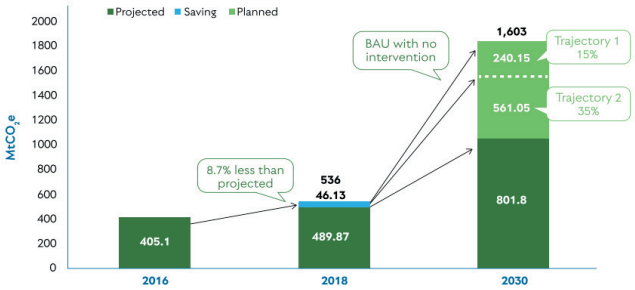

Figure 13. Voluntary and Conditional Reduction of 50% Below its Projected BAU

Following table provides an overview of the initiative/proposed actions along with the investment needed.

Table 4. Major Proposed Actions

Sector	CO_2 – e 2018 (Mt)	Major Proposed Actions	Projected Investment by 2040 (USD Billions)
Energy	219	• Complete more than 12 GW of hydro (and coal) projects under construction • Expand RE (including hydro) to at least 30% of capacity by 2030 and 2050 • Upgrade of transmission by 2040; higher if a higher proportion of variable solar/wind power • Buy out 2 relatively new coal thermal plants and the Thar coal mines • Replace coal power plants with solar	• 20.0 • 50 and 80 • 20.0 • 18.0 • 13.0
Agriculture	199	• Complete ban on open burning of rice stubble, etc. • Improve disposal of crop residue	
Transport	51	• Increase electric vehicle sales to 30% and 90% of passenger vehicles and heavy-duty truck, respectively, by 2030 and 2040 • Adhere to Euro emission standards, including Euro 5	
Industry	26	• Incentivize carbon trading between industrial firms • Promote/ develop plans for emission reductions from major sectors, especially cement and textiles	• 0.8
Land-use, Land use Change and Forestry	25	• Complete Ten Billion Tree Tsunami Program (TTBTP) • Conserve existing forests and increase tree cover through community participation • Identify policy priorities for protecting soil quality	
Waste	19	• Encourage conversion of animal waste into methane for household/ urban transport fuel • Promote source reduction and re-use of waste	
Total	539		151.8+

According to the Pakistan Economic Survey for 2020, Forest carbon partner facility of the World Bank has granted $3.8 million since 2015 through a competitive process to support efforts aimed at reducing emissions from deforestation and forest degradation. Furthermore, an additional grant of $4.01 million to support preparedness activities in Pakistan until June 2020 was granted by FCPF. Moreover, the Parliamentary Research Digest for 2019 indicates that by June 2019, total financing of $234.42 million along with $626.68 million co-financing was provided by Global Environment Facility. As of August 2023, the Green Climate Fund (GCF) dashboards reveals that its total funding allocated to Pakistan has reached $197 million, marking an increase from $121 million as of August 2020.

Moreover, at United Nation event in New York 2023, the Government of Pakistan (GoP) announced a plan to invest $2.84 billion in projects aimed at making the country more resilient to climate change. Alongside this, they introduced a special tool called the "SDG Investor Map 2023" to show potential investors where they can put their money to support sustainable projects in Pakistan. Pakistan has enjoyed limited access to international finance. It has secured 2 projects from the adaption fund, 5 projects totaling $197 million from Green Climate Fund, 25 projects from the Global Environment Fund have been completed, and 13 more projects has been approved. However, 1 project from the Climate Investment Funds. Additionally, around more than 50 projects have been approved by Clean Development Fund. In May 2021, Water and power development authority raised USD 500 million through a Green Bond issuance in Pakistan, with an 7.5% interest rate. Following graphs reveals projects awarded by multilateral and bilateral funding organizations. The data unmistakably indicates that Pakistan is falling short in securing the necessary climate financing for a just energy transition. However, by formulating an effective strategy, Pakistan has the potential to secure the required funding.

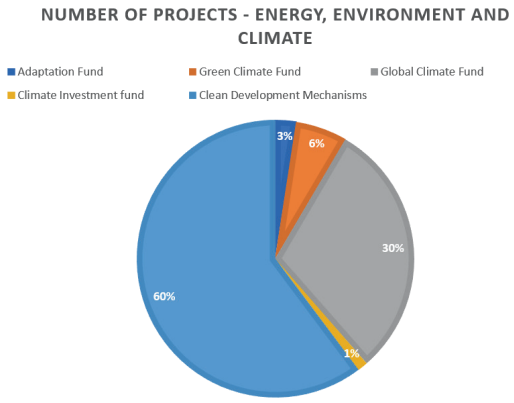

Figure 14. Multilateral and Bilateral Funded Projects

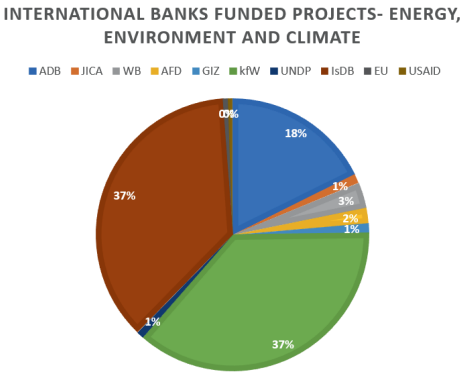

Figure 15. International Banks Funded Projects

5. Energy Transition Pathway

5.1. Industrial Sector

The industrial sector of Pakistan shows great saving opportunities. Over $4 billion dollar of investment opportunities exist only in energy efficiency improvements with a payback of 5 years The key areas of intervention include energy management systems, energy audits, energy saving certificate schemes and energy efficiency mechanisms. The textile industry is one of Pakistan's largest industrial sectors which accounts for 27.6% of total electricity consumption and 40% of natural gas. Followed by the textile sector, cement industry is responsible for 68.9% of total coal consumption by industries.

In Pakistan, there are approximately 73 operational sugar mills, many of which employ outdated structures and technologies. A majority of these sugar mills exhibit a notably high specific energy consumption of 1,250 megajoules per ton, significantly exceeding the regional sugar sector's average of 935 megajoules per ton. This elevated energy consumption in Pakistan can be attributed to the utilization of antiquated sugar manufacturing systems, resulting in a high steam-on-cane ratio of approximately 52% and substantial electricity usage, amounting to 24 kilowatt-hours per ton of cane crushed. Additionally, the industry relies on inefficient low-pressure boilers, which typically exhibit efficiencies ranging from 65% to 75%. It's worth noting that boilers and steam distribution systems are the primary energy consumers across nearly 22 industrial sectors in the country.

The sugar industry alone has the potential to save approximately 138,350 megawatt-hours per year through energy optimization measures.

Table 5. Potential Energy Saving Opportunities in Industrial Sector

Industry	National Sector-Wide Energy Savings %	Energy Saving Estimates per year (MWh)	Associated Cost Saving per year (Million PKR)
Textile Spinning	3.50	247990	2075
Textile Processing	188.40	2155043	4262
Sugar	3.60	1149901	1698
Leather	6.90	9776	14
Pulp and Paper	6.30	167176	142
Total		3729886	8191

Some of the technological alternative results in energy and emission savings can be achieved through improvements in heat transfer and recovery systems, motor efficiency enhancements, general process optimizations, and steam system upgrades. Some of the are given below:

Waterless Dyeing Technologies:
Traditional dyeing processes consume large amounts of water and generate wastewater. Waterless dyeing technologies, such as air dyeing or digital printing, are being used to minimize water consumption and reduce pollution.

Energy-efficient Machinery:
Manufacturers are investing in energy-efficient machinery, such as high-speed looms and energy-saving dyeing machines, to reduce electricity consumption and improve energy efficiency.

Electric-Motor Driven Systems:
These systems power various equipment

such as pumps, fans, compressed air systems, material handling, and processing systems, consuming approximately 75 terawatt-hours (TWh) of electricity each year. There is a potential to reduce nearly 9 TWh of annual electricity consumption by 2030, resulting in an emissions reduction of 18.5 million metric tons of CO2 by that same year.

Boilers:
Boilers are employed to generate steam for various industrial processes, including drying, dyeing, and printing. The typical boiler operates with an efficiency ranging from 75% to 90%. Depending on the type of fuel used, there is a potential for fuel savings of 15% to 20%, although the actual savings depend on the specific fuel source employed.

Alternative Fuels:
Cement manufacturers are exploring the use of alternative fuels, such as biomass, industrial waste, and agricultural residues, to replace conventional fossil fuels in kilns. This helps reduce greenhouse gas emissions and dependence on fossil fuels.

Energy-Efficient Kilns:
The adoption of energy-efficient kiln designs, such as preheater and precalciner systems, helps improve thermal efficiency and reduce energy consumption during the cement production process.

Food Processing Industry:
The food processing industry in Pakistan is incorporating technological alternatives to improve efficiency and reduce waste.

Cold Storage and Refrigeration Technologies:
Advanced cold storage facilities and refrigeration systems are being adopted to enhance food preservation and reduce post-harvest losses. This helps minimize food waste and extend the shelf life of perishable products.

Solar Drying Systems:
Solar drying technologies are being utilized in the food processing industry to dehydrate agricultural products, such as fruits and vegetables. Solar dryers reduce energy consumption and provide a sustainable method for food preservation.

5.2. Building Sector

In Asia, Pakistan is considered as one of the most rapidly urbanizing country. It is estimated that around 40 million people will be living in urban centers and towns. In order to ensure reduction in emissions and energy savings, NEECA has introduced buildings codes and several energy efficiency measures. Some of the energy saving opportunities in the building sector are provided in the table below:

Table 6. Energy Saving Opportunities in Building Sector

	Recommendations	Energy Savings
Building Envelop and Design	Walls and Roof should be Properly insulated with the optimum thickness	22% to 79% depending on thickness
	increase the reflectivity of Walls and Roofs using Cool Roof technique, light paint color, green roof etc.	5-30% savings on cooling Cost
	Isolation element such as shutters, roller blind, sunshade, cellular shade etc.	Heat loss reduction 40% Energy Saving 10%
	Positioning of windows & large areas wall should be towards the South	Up to 10 to 20%
	cracks, holes, leakages must be properly sealed gasketed, caulked and weather stripped	Over 18% in your energy bills
Heating, ventilation and Air Conditioning (HVAC) system	Electricity driven heat pump (Electricity generated from the PV & Geothermal Heat Pumps	Fossil fuel primary energy savings up to 96% 25% energy bills saving (Geothermal)
	Proper maintenance of HVAC system that include cleaning, cooling, heating coils, burners, radiators, cooling towers and most importantly Filters	Energy usage lowers up to 20%
	Demand control ventilation that adjusts the ventilation rate according to occupancy rate	10 to 20%
Lightning	Replace the incandescent lights with the LED Bulbs	90%
	if the main light is ON, then avoid turning on lamps in your room	Depends on the electric cost
	install photosensors and dimming ballasts to dim lights when day lightning is sufficient	50% power reduction
	Choose light colors when painting your walls to reduce the light load	Reduces the light load
Renewable Energy	Use roof top solar panels for lighning and other loads	

5.3. Transport Sector

In 2019, the total final energy consumption accounted by the transport sector was 33.93%. Oil is the major and dominant fuel in the transport energy mix with the contribution of 13% to the GDP of Pakistan while the share of natural gas is 10%. In NEECA strategic Plan, NEECA highlighted requirements to adopt the labeling programs to target the vehicle fuel efficiency standards and emissions to phase out inefficient fuels.

Several automobile manufacturers are introducing electric vehicles to the Pakistani market, promoting cleaner and more sustainable transportation options. This includes the production of electric cars, electric buses, and electric two-wheelers. To support the growing adoption of electric vehicles, charging infrastructure is being established across major cities in Pakistan. Public charging stations and home charging solutions are being implemented to facilitate EV charging. Moreover, the development of electric vehicle policy and establishment of model motor vehicle examination center will subsequently facilitate the energy transition. The sustainable projects such as “Pakistan

Sustainable Transport" funded by the UNDP along with the GEF with the aim to reduce the energy consumption growth and related GHGs from the transport sector. Such initiatives will support the Pakistani government to reduce the targeted emissions and to facilitates the adoption of cleaner fuels and efficient vehicle technologies.

6. Barriers

6.1. Barriers in Renewable Energy Adoption

Several barriers impede the rapid adoption of renewables, including:

Dispatchability:
A key obstacle is the perception that renewable energy technologies cannot consistently meet the dispatchability requirements of electricity systems. As the penetration of renewables such as solar and wind increases, they necessitate more flexible generation from other power sources to meet grid demands. Distinguishing between variable (e.g., solar and wind) and dispatchable (e.g., hydro and biomass) renewables is crucial for a more accurate assessment of integration challenges.

Up-front Costs:
The substantial initial capital investment needed for building and installing wind and solar farms poses a significant financial hurdle compared to coal-fired power plants. Renewables require more significant financing and are sensitive to financing costs, unlike fossil fuels, where costs are spread over fuel and capital expenses. These up-front costs hinder the widespread adoption of renewable energy sources in Pakistan.

Lack of Holistic Policy Framework for Indigenization:
The absence of an effective policy framework for indigenizing renewable energy technologies limits their availability

and affordability, hindering broader implementation. Shifting the policy focus towards fostering the indigenization of renewable technologies is essential for long-term sustainability.

Political Uncertainty and Policy Inconsistency:
The most crucial factor hindering the uptake of renewables is the prevalent political uncertainty and policy inconsistency in Pakistan. The absence of a clear and stable policy framework for renewable energy discourages significant investments and hampers the transition to renewables.

Land-Use Concerns:
Another obstacle to renewable energy expansion is the need for suitable land for wind and solar farm construction. Managing land resources and addressing competing land uses can slow down renewable energy projects, leading to delays.

6.2. Coal Expansion Plans

CPEC, a flagship project of the Belt and Road Initiative (BRI), aims to enhance economic cooperation between China and Pakistan. Since its inception, Pakistan has received approximately USD 23.1 billion in energy investments, encompassing transmission lines, coal, wind, solar, and hydro power plants, along with USD 17.1 billion in transport investments under CPEC. The overall cumulative investment commitment for CPEC stands at USD 62 billion (CPEC Authority 2023), which includes both long-term planned projects and those in progress.

One of the central elements of CPEC involves the development of coal-fired power plants in Pakistan. The investment in coal-fired power plants, covering completed and ongoing projects, amounts to around USD 12.1 billion (ibid). As of 2023, there are nine coal-fired power plants, either operational or under construction as part of CPEC, with a combined capacity of 8,220 megawatts (MW) (ibid). All these plants are expected to be operational by 2025 at the latest, including the 300 MW Gwadar coal-fired plant and the 1,320 MW Thar Mine Mouth Oracle Power Plant and surface mine, scheduled to be online by 2025 (ibid).

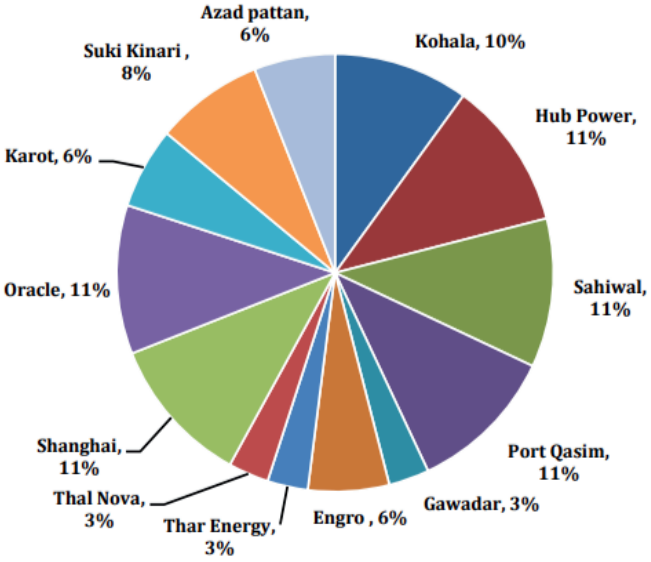

Figure 16. CPEC Energy Projects

Several factors drive the development of coal-fired power plants under CPEC. Firstly, coal is a readily available and cost-effective energy source in Pakistan. Furthermore, coal-fired power plants can meet the base-load requirements and generate a substantial amount of electricity. The government believes that these plants will address the growing demand for electricity in Pakistan and contribute to economic

6.3. Others

One of the major barriers to clean energy adoption in the industrial sector of Pakistan is the lack of adequate infrastructure and technology. Here are some specific factors contributing to this barrier:

Outdated Industrial Infrastructure:
Many industrial facilities in Pakistan lack modern infrastructure and rely on outdated machinery and equipment. These outdated systems are often inefficient and consume more energy than necessary, making it difficult to integrate clean energy solutions effectively.

Limited Access to Financing:
The upfront costs of adopting clean energy technologies can be substantial. However, many industrial enterprises in Pakistan face challenges in accessing affordable financing options for clean energy projects. The lack of financial resources and the high perceived risks associated with clean energy investments hinder the adoption of cleaner technologies.

Reliance on Fossil Fuels:
Pakistan's industrial sector is heavily dependent on fossil fuels, particularly natural gas and oil. The availability and relatively low cost of these fossil fuels have made them the primary energy sources for many industries. Shifting to clean energy alternatives requires significant investment in renewable energy infrastructure and the development of alternative fuel sources.

Inadequate Policy Framework:
The absence of a comprehensive and supportive policy framework specific to the industrial sector is another barrier. Clear policies and regulations that incentivize and promote the adoption of clean energy technologies are essential for creating a conducive environment for industrial enterprises to invest in renewable energy.

Limited Awareness and Capacity:
There is often a lack of awareness and understanding among industrial stakeholders about the potential benefits and cost savings associated with clean energy solutions. This lack of awareness extends to the technical expertise required for the integration and operation of renewable energy systems.

Insufficient Grid Integration:
The intermittent nature of renewable energy sources such as solar and wind can pose challenges for grid integration, particularly in areas with weak or unstable electricity grids. Inadequate grid infrastructure and limited capacity for integrating clean energy sources can discourage industrial enterprises from adopting renewable energy technologies. Addressing these barriers will require a multi-faceted approach involving government support, policy reforms, financial incentives, and capacity-building initiatives. Encouraging industrial enterprises to invest in clean energy solutions will not only contribute to environmental sustainability but also enhance energy security and create opportunities for economic growth and job creation in Pakistan.

7. Recommendations

7.1. Strategic Funding Mechanism

To facilitate the alignment of energy projects with Pakistan's Nationally Determined Contributions (NDCs) and ensure a focused approach towards emissions reduction, the proposition of a "Strategic Funding Mechanism" stands as an effective strategy.

It would exclusively channel financial support to energy projects that are in direct alignment with the goals set forth in Pakistan's NDCs. By directing resources solely to projects that demonstrate a clear commitment to emissions reduction and sustainability, this funding mechanism ensures that investments are optimized for the highest environmental impact. Incentivizing the development and execution of projects that adhere to NDC criteria would reinforce Pakistan's commitment to climate action while cultivating a robust portfolio of energy initiatives that collectively drive the nation towards its emissions reduction targets.

Energy projects seeking funding through this mechanism must undergo thorough assessment against the criteria, ensuring that only those projects demonstrating a clear commitment to emissions reduction, sustainability, and direct alignment with NDC targets are considered eligible.

7.2. Research-Led Funding Initiative

The distinct and dedicated funding mechanism would be tailored specifically for research institutes, aiming to facilitate in-depth research and innovation focused on enhancing the efficiency, effectiveness, and overall performance of energy projects.

The Research-Led Funding Initiative centers on the concept of collaborative research endeavors undertaken by esteemed research institutes. These institutes would receive targeted financial support to conduct comprehensive studies, experiments, and analyses that address key challenges and opportunities in the domain of renewable energy.

7.3. Development of National Energy Monitoring Software / Platform for Energy Projects

The development of a dedicated National Energy Project Monitoring Software or Platform serves as a centralized hub for tracking the progress, performance, and alignment of different energy-related initiatives with national development goals and commitments. This platform can aggregate real-time data from diverse energy projects, offering valuable insights into the emissions, efficiency, and overall impact on the environment.

By making comprehensive energy project data accessible to stakeholders, policymakers, and the public, the platform promotes transparency and accountability. This transparency can ensure that energy projects are accurately reported, monitored, and adhering to established

standards and targets.

The platform would aid in the efficient allocation of resources by identifying which energy projects are delivering the most favorable outcomes in terms of emissions reduction, energy savings, and sustainability. This information can guide future investments toward projects with the greatest potential for positive environmental impact.

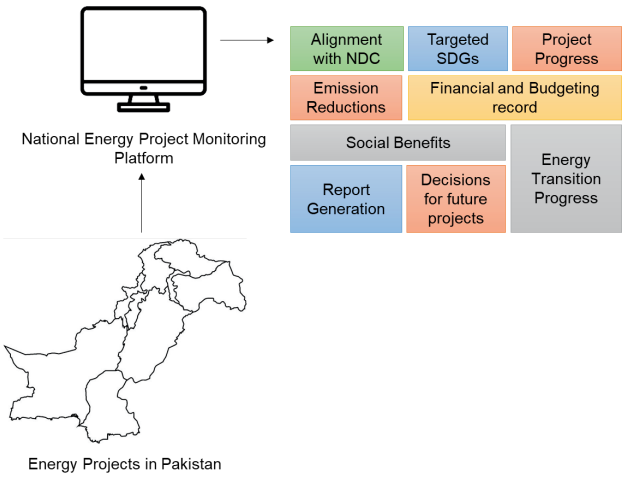

Figure 17. National Energy Project Monitoring Platform

7.4. Promote Root-Cause Emission Mitigation Projects

The prevailing practice of addressing emissions through secondary initiatives, such as implementing green building codes, often fails to address the primary sources of emissions. Taking the example of cement production – a significant emitter – projects focused solely on building efficiency overlook the larger emissions produced during cement manufacturing. This recommendation advocates for a holistic approach that scrutinizes the root sources of emissions and devises projects that directly target and transform these sources.

7.5. Introduction of Circular Economy – Waste to Energy Strategy

The approach involves a systematic process that begins by identifying regions where substantial waste generation occurs, particularly in urban centers and industrial zones. Research institutes would take a pivotal role in evaluating the feasibility and effectiveness of converting waste into valuable energy resources. This assessment would encompass an analysis of waste composition, available conversion technologies, and the potential energy output that can be derived from the waste.

To ensure the successful implementation of this strategy, a dedicated budget would be allocated, initiating the efforts at the local level. Pilot waste-to-energy facilities would be established in identified regions, serving as exemplars for effective waste management and energy generation practices. These pilot projects would offer valuable insights into the viability of the approach and help streamline processes before scaling up.

7.6. Fostering Industry-Education Collaboration

It aims to advocates for students to spend a year actively engaged in industry settings, gaining hands-on experience that sensitizes them to the intricacies of sustainable energy practices. This collaborative effort would enable students to work alongside industry professionals, contributing to real-world projects and initiatives related to sustainable energy. By participating in

industry activities, students would acquire practical insights into renewable energy technologies, emissions reduction strategies, and the multifaceted nature of achieving sustainability. This approach not only equips students with practical skills but also empowers them to be advocates for sustainable energy practices. As students reintegrate into their academic studies, they carry with them valuable industry experience and a steadfast commitment to supporting Pakistan's transition to cleaner and more sustainable energy alternatives.

7.7. Establishing a Cross-Sector National Expert Team

By uniting expertise from academia, research institutions, industries, and government, this initiative ensures a holistic and informed approach to monitoring energy projects' alignment with NDC commitments. Meetings would facilitate strategic collaboration, problem-solving, and course corrections, expediting progress toward sustainable energy goals. The team's role in reviewing project alignment, identifying challenges, suggesting solutions, and fostering innovation can lead to more efficient decision-making, transparent accountability, and accelerated energy transition. Ultimately, the collaborative efforts of this expert team could play a pivotal role in driving Pakistan's transition to a more sustainable energy landscape.

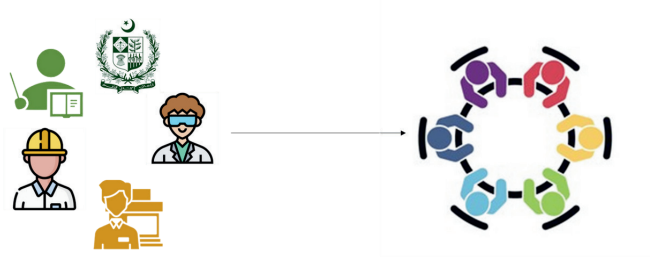

Figure 18. Cross-Sector National Expert Team

7.8. Decentralized Energy Solutions

Encourage the development of decentralized renewable energy systems, such as community-based solar microgrids and small-scale wind projects. These systems can improve energy access in remote areas and contribute to local economic development.

7.9. Industry-Specific Efficiency Programs

Tailor energy efficiency programs to address the unique needs of different industries, such as manufacturing, agriculture, and transportation, to maximize energy savings.

7.10. Advance Metering Infrastructure (AMIs) and Smart Grid Infrastructure

The integration of digital solutions along with the renewable energy within electrical grids and transformers is considered as one of the most important ways to improve the communication, reliability, safety, efficiency, and emission reduction. In Pakistan, a staggering $6 billion worth of electricity theft was reported in 2012-2013. Additionally, in 2013, it was estimated that Pakistan incurred losses of RS 90 billion due to electricity theft and line losses. These issues result in increased electricity

generation requirements and fossil fuel imports for power generation results in circular dept.

Depending on the carbon content and heating value, coal consumption for electricity generation averages 209 pounds of CO2 per million British thermal units (MMBtu), compared to 117 pounds of CO2/MMBtu for natural gas. Implementing solutions such as advanced metering system which represents the first step in smart grid technology, can deliver significant benefits.

7.11. Prospects of Hydrogen as an Energy Producing Mechanism

Considering Pakistan's significant renewable energy potential, the production of green hydrogen presents numerous promising opportunities. Pakistan currently relies heavily on fossil fuels for electricity generation and faces challenges related to energy storage.

Green hydrogen offers a solution to reduce dependence on fossil fuels for electricity generation. It can also serve as a valuable feedstock in energy-intensive industrial processes and address energy storage limitations. This versatile energy carrier can store excess energy generated from renewables during low-demand periods and release it when demand is high. Furthermore, the adoption of green hydrogen aligns with national goals to reduce CO2 emissions.

With strategic financial planning and policy development, green hydrogen holds the potential to become a key fuel for the future of Pakistan's energy landscape.

7.12. Coal Power Phase-Down

One of the primary challenges associated with coal phase-out in Pakistan is the presence of existing coal capacity and long-term agreements linked to coal projects, including those under CPEC. The government encounters difficulties in immediate plant closures due to capacity payments and circular debt issues. Moreover, global economic factors like the Russia-Ukraine conflict and Covid-related logistics problems have resulted in high natural gas prices, increasing reliance on coal for power generation.

To put the country on a path to sustainability, substantial increases in investments in greener energy are required by 2030 compared to 2021 levels. This entails scaling up and reallocating capital toward low-carbon fuels and energy efficiency while reducing investments in fossil fuels. Identifying cost-effective financing mechanisms, including grants, concessional finance, and innovative financial instruments, is essential to mobilize the necessary capital for the transition.

Just Energy Transition Partnerships (JETPs), which aim to align national climate goals with net-zero emissions targets and promote investments in renewable energy while managing the transition away from fossil fuels, represent one potential source of financing the coal phase-out. Countries like Indonesia, Vietnam, and South Africa,

which have been major coal energy users, are increasingly engaging in JETPs to phase out coal power and prioritize renewable energy sources. JETP funds are designed to be targeted and catalytic, mobilizing financing from multiple sources.

In conclusion, Pakistan, like many other countries, faces significant challenges in transitioning away from coal. While coal has played a significant role in electricity generation, the negative environmental and health impacts of coal combustion, coupled with the need to address climate change, necessitate a shift toward cleaner energy sources. This transition is complex and multifaceted, requiring a comprehensive approach that encompasses various sectors and stakeholders beyond power generation, including the fossil-fuel dominated industrial sector. Addressing the challenges associated with the energy transition, including communication, stakeholder engagement, and workforce transition, is crucial for the successful phase-out of coal.

Table 7. Recommendations Along with Targeted Areas, Outcome and Best Practices

Recommendations	Targeted Areas	Outcomes	Best Practices
Development of national energy monitoring platform	• Energy sector projects • Alignment of energy projects with NDCs • Tracking of Emissions • Real time consumption • Reporting progress	• Informed decision making • Strategic resource allocation • Performance evaluation and sustainability • Long term planning • Transparency and accountability • progress, performance, and alignment of various energy-related initiatives	
Strategic Funding Mechanism	• Identification of potential areas where maximum benefits can be achieved. • Projects with clear commitment and aligned with NDCS	• Accelerated transition to clean energy • Increased private sector investment • Job creation • Reduced emissions	India national clean energy fund
Research-Led Funding Initiative	Targeted funding for research institutes through a proper eligibility criteria or competition to ask universities to submit their proposal on how their project is aligned with the goals	• Enhanced research and innovation • Emerging of new concepts and ideas • Job opportunities for youth	Germany's Fraunhofer Society
Promote Root-Cause Emission Mitigation Projects	Industries with significant emissions, Cement, steel, and other heavy industries	• Emissions reduction at the source • Positive impact on air quality • Transition to cleaner production processes	
Introduction of Circular Economy – Waste to Energy Strategy	• Waste management • Waste-to-energy facilities	Reduced waste landfilling Energy generation from waste Circular economy principles	Denmark's waste-to-energy initiatives
Fostering Industry-Education Collaboration	• Educational institutions • Industries and businesses	• Skilled workforce in sustainable energy • Industry-ready graduates • Innovation and industry partnerships	Germany's dual vocational training programs
Establishing a Cross-Sector National Expert Team:	Energy professionals from academia, research, industries, government	• Informed decision-making • Accelerated energy transition • Innovation and collaboration	
Decentralized Energy Solutions:	• Rural and remote areas • Distributed energy generation	• Enhanced energy access Reduced transmission losses • Increased energy resilience	• India's Decentralized Renewable Energy Program • Kenya's Off-Grid Solar Access Project
Industry-Specific Efficiency Programs:	• Industrial sectors • Energy-intensive industries	• Improved energy efficiency • Reduced operational costs • Emissions reduction	

8. Knowledge Dissemination

Building the Academic Network on Climate Change and Energy Transition for knowledge sharing by systematic coordination with sectoral ministries, concerned departments and the provinces.

Team USPCAS-E in coordination with Pakistan Renewable Energy Coalition arranged a webinar in order to discuss the current state of solar energy in Pakistan, exploring its tremendous potential and identifying the key challenges faced by the industry. The event took place on 22nd February 2023. Dr. Noor-ul-Huda Khan, Professor and Chairman of the Department of Physics at Baluchistan University of Information and Technology, Engineering and Management Sciences, Quetta, Pakistan, Mr. Haseeb Chaudry, CEO of Solar Track Services Pvt. Limited, Dr. Irfan Yousuf, Consultant at World Bank on Carbon Pricing Instruments, Mr. Faiz Bhutta, CEO Master Trainer of Energy Training and Research Centre (ETRC) were invited as speakers

The webinar offered valuable insights into the conventional method of manufacturing solar panels in the industry and the specific challenges faced by the solar PV manufacturing industry in Pakistan. The experts highlighted the need for increasing access to reliable information on solar energy and building capacity through training and education programs. They

Figure 19. Webinar on Solar Energy Potential Poster

emphasized the importance of government support in creating an enabling environment for the industry to grow, including the implementation of favorable policies and regulations.

Another webinar was organizing a webinar on the topic of “Electrifying the Road Ahead: Exploring the Potential and Addressing Barriers for Electric Vehicles in Pakistan” on 7th June, 2023. This webinar explored the potential of electric vehicles in Pakistan and identify the key barriers hindering the growth of the EV industry. Dialogue titled "Resolving Energy Sector Crisis Through Digitalization & Innovation" on the energy sector crisis in Pakistan was organized on 6th March 2023. The event brought together experts from the energy sector, policymakers, and representatives from various industries to discuss the challenges faced by the sector and the potential solutions through digitalization and innovation. Ms. Sadia Dada, Chief Marketing & Communications Officer K - Electric, who presented KE's operational turnaround through innovation and digitalization. The event featured a panel discussion with representatives from multiple industries, including Mr. Amer Zia, Chief Distribution Officer at K-Electric; Mr. Noorul Arfeen Zuberi, Senior Advisor at China Three Gorges South Asia Investment Limited; Mr. Naveed Qaiser, Senior Finance Manager at CPPA.

Figure 20. Webinar on Electrifying the Road Ahead

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