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China-Pakistan economic corridor initiative and its impact on future energy consumption in Pakistan

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Abstract: The China-Pakistan Economic Corridor (CPEC) is a key strategic initiative designed to promote economic ties between Pakistan and China. We appraise the impact of CPEC-concerned economic development on electricity usage and the forecast indications for Pakistan by 2030. The Johansen cointegration technique helps to classify the long-run correlation between energy usage and its sources at the aggregation and sectoral levels and anticipated future power needs using scenario analysis. According to the predictions of the baseline scenario, energy usage in 2030 would be almost 41% higher than in 2013. Below the baseline scenario, power usage in the industrial and commercial sectors will rise by 136 and 414 percent appropriately, in 2030. The scenario interpretation results are confirmed by Monte Carlo simulations that account for future uncertainty. For each sector of the economy, the government should operate diligent accounting and correlated planning to account for the conceivable growth of energy consumption due to CPEC-linked economic projects.

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1. Introduction

In the 21st century, the concept of regional and international strategic movements across the world has evolved in geostrategic and evaluation outcomes in collaboration between countries. States have modified their strategies to define their goals. They've concluded that they won't be able to protect their interests with their resources. The importance of high-level meetings and diplomatic consultations cannot be overstated. Every country is doing everything possible to promote global cooperation in various disciplines, including infrastructure development, industrial ventures, trade, energy, and other related economic areas. One of the crowning achievements of such collaboration is the China-Pakistan Economic Corridor (CPEC),(Noor et al., 2008).

Pakistan would gain significant importance in this region and worldwide if these projects were to be implemented. China and Pakistan have been working hard to begin significant projects that would benefit both countries' economies. Pakistan's electricity, infrastructural, economic, and agricultural production would get about $46 billion from the CPEC (Rafiq, 2016). With the reduction of power outages resulting from increased power generation capacity and development in other industrial sectors, Pakistan's GDP is forecast to grow up to 7.5% by 2030, with approximately 2 million job opportunities. The 2025 vision of Pakistan anticipates an increase in urban development (50%-60%) and a good growth in GDP by 2025 (8%), (MOP, 2015). Fuel and energy usage will grow exponentially due to higher economic activity and rapid urbanization (Huang et al., 2008; Michieka, 2014). Any country, such as Pakistan, depends heavily on energy. Despite Pakistan's current energy problem, a significant rise in economic activity and electricity consumption is likely to have long-term implications for the country's power generation (Mirza & Fatima, 2016). Because Pakistan's current electricity generation relies on imported fuel, the total energy mix shows that thermal power accounts for 64% of the country's electricity. This is due to the lack of proper price of indigenous fuels and their predatory usage. The bulk of the oil used to create energy in the country comes from overseas. Due to its significantly skewed energy balance, Pakistan is sensitive to any adverse supply shock, such as a rise in global oil prices, increased energy usage, and reliance on imported coal to manufacture power as a result of CPEC projects are supposed to bring pressure on the payment account mix. In the longer term, they hurt numerous economic sectors. Because of its highly skewed energy mix, Pakistan is sensitive to any unexpected supply shock generated by a boost in global oil prices.

Further increases in energy consumption and dependence on imported coal to generate power through CPEC projects are expected to impact the payment account balance. It has a destructive impact on the power affordability and accessibility for a range of economic sectors. The CPEC projects are primarily designed to meet Pakistan's and China's growing energy demands. According to project planning, 21,000 megawatts of energy would be generated; in this framework, electricity projects in Pakistan will be completed rapidly (Today, 2014).

Pakistan is now suffering a 5,400 MW energy shortfall since it is an energy-consuming country that loses 2.5% of its yearly GDP attributable to this shortage. The industry, agricultural, and service sectors have been hurt badly by this enormous deficiency, resulting in a severe economic recession (Zahid & Rashid, 2018). The Chinese Exim Bank provided money for these energy projects at a rate of 5% to 6%. Some scholars (Aqeel & Butt, 2001; Kalar & Khilji, 2011) indicated that the inauguration of CPEC projects might result in poor financial and social outcomes because of a lack of apparent anticipation of the future power demand. As a response, to make appropriate policy decisions in advance, a comprehensive analysis of future energy demand and its variables is necessary. There seems to be little research on future energy predictions in Pakistan directly relevant to CPEC, both at the aggregate and sectoral levels (Ahmed & Mustafa, 2016).

In this respect, our research presents an empirical assessment of this problem by evaluating the relative significance of CPEC-related economic activity on Pakistan's future sectoral electricity consumption. Even though there are energy inadequacies in every sector of Pakistan, no energy efficiency measures or regulatory requirements for energy use have been adopted (ENERCON)1.

This research work contributes by predicting energy use by 2030 to country-specific empirical investigations. There is no empirical research that we know that indicates future energy consumption in Pakistan, particularly in CPEC. Merely price and income elasticity of demand has been used to forecast Pakistan's energy consumption, with structural factors being disregarded (M. A. Khan, 2015; Wahid et al., 2015). Based on scenario analysis and Monte Carlo simulations, we derived future energy consumption projections. Below is a list of the specific research goals. In the case of Pakistan, we examine the influence of macroeconomic variables on overall and sector-specific energy usage. The specific research objectives are listed below.

In the context of Pakistan, we examine the influence of macroeconomic variables on overall and sector-specific energy usage. Second, we use a scenario approach to assess the impact of CPEC-related economic activity on Pakistan's regional and aggregate energy consumption. Third, we employ Monte Carlo Simulation to evaluate the accuracy of our projections and estimate different scenarios for sector-specific power consumption by 2030 while dealing with uncertainty.

1.1 CPEC and Pakistan

The CPEC is an economic growth opportunity to improve regional connectivity for the growth in the economy of both China and Pakistan. From 2014 to 2030, an industrial corridor would connect Pakistan's Gwadar port with China's northwestern area. It is projected to support Pakistan, China, and other surrounding nations by strengthening Pakistan's geographical relation with landlocked Central Asian republics. CPEC is comprised of five major components as shown in Table 1. CPEC is more than just a network of roads, highways, and rail networks; it collects projects that will meet Pakistan's energy and other needs. China's entire investment is estimated to be over $ 46 billion.

[1] Fordetailsseehttp://www.enercon.gov.pk/.

Table 1. CPEC major components.

Components	Outputs
Gwadar	Including port. City development and Gwadar region socio-economic improvement
Energy	Hydel, Wind, Solar, Coal, LNG, and improve the transmission
Transportation infrastructure	The advanced infrastructure of Road, Rail, Aviation
Investment & Industrial Cooperation	Free Zone and other industrial parks to be finalized
Any other area of interest mutually agreed	The industrial and manufacturing sector

1.2 Chinese energy sector investments in Pakistan

As previously noted, Chinese investment in Pakistan is focused on the electric power system. The CPEC's early harvest projects, which target to add 10,400 megawatts (MG) to the electrical grid, include coal, wind turbines, Liquefied natural gas (LNG), solar-panel parks, and, most relevantly, hydropower projects. The total production in 2015 was 22,571MG (Rizvi, 2015). 7,097MG accounts for the hydro sources of full installed capacity, whereas the thermal sources contribute to 15,474MG. This 10,400MG will bring Pakistan's current electricity generating capacity to 32,971MG by the ending of the year. The electricity shortage problem can be solved in the short term if the government's plans are managed to carry out and all the prospective power plants are functioning by 2019. Table 2 summarizes the specific details of the Chinese energy industry projects.

Table 2. List of Chinese energy infrastructure investments in Pakistan.

Project	Company
Prioritized/Early Harvest Projects, 10400 MW	
Port Qasim Coal-fired Power Plant (2×660 MW)	Power China Resources Ltd.
Sahiwal Coal-Fired Power Plant (2 × 660 MW)	Huaneng Shandong Ruyi (Pakistan) Energy (Private) Ltd.
Engro Thar Coal-fired Power Plant and Surfice Mine in Block II of Thar Coal Field (4×330 MW)	China Machinery Engineering Corporation (CMEC)
Dawood Wind Farm (50 MW)	Hydro china International Engineering (HIE) Co. Ltd.
Quaid-e-Azam Solar Park in Bahawalpur (900 MW)	Zonergy Company Ltd.
Jhimpir Wind Farm (100 MW)	UEP Wind Power (PVT) Ltd.
Sachal Wind Farm (50 MW)	HIE Co. Ltd
Karot Hydro-Power Project (720 MW)	China Three Gorges South Asia Investment Ltd.
Suki Kinari Hydropower Project (873 MW)	China Gezhouba Group Corporation International Ltd. (CGGC)
Sachal Wind Farm (50 MW)	China Sunec Company
Rahimyar Khan Coal Power Plant (2 × 660 MW)	To Be Decided (TBD)
Thar Coal Block I and Mine Mouth Power Plant (2 × 660 MW)	Shanghai Electric
Hubco Coal Power Plant (2 × 660 MW)	China Power International Holding Ltd.
Gwadar Power Plant (300 MW)	TBD
Matiari-Lahore Transmission Line	China State Grid
Matiari-Faisalabad Transmission Line	China State Grid
Gaddani Powerplant at District Lasbela, Balochistan (2 × 660 MW)	TBD
Kohala Hydro-Power Station (1100 MW)	China Three Gorges South Asia Investment (CTGSAI) Ltd
Wind Farm Phase II of Pakistan (2 × 50 MW)	(CTGSAI) Ltd.
HUBCO Coal Power Plant (660 MW)	China Power International Holding Ltd.
Salt Range Mine Mouth Power Plant including Mining (300 MW)	China Machinery Engineering Corporation
Thar Mine Mouth Coal Fired Power Plant by Oracle (2 × 660 MW)	TBD
Muza□argarh Coal-fired Power Plant (2 × 660 MW)	(CMEC)
Gas Fired Power Plant (525 MW)	TBD

Source: CPEC, 2019; (Iqbal et al., 2019)

1.3 Research question

As stated in the introduction section, the major problem for Pakistan's economic progress is the energy crisis. Consequentially, for the successful realization of CPEC, most investments will rebuild Pakistan's energy sector to make CPEC a success. Among the BRI's economic corridors, CPEC is also one of the most expensive. As a result, the question of what impact the CPEC investments would have on Pakistan's future energy demand becomes more important.

1.4 Objectives of the study

The research's main goals are as follows:

- To identify the role of CPEC in future energy consumption in Pakistan
- To develop a framework that emphasizes the need for CPEC to improve renewable energy consumption in Pakistan.
- To investigate the sectoral level of future energy consumption in Pakistan

The remaining structure of this research work is as follows: Section 2 contains the literature review and author's intentions about CPEC, while section 3 covers the methodology. Results and discussion are presenting in section 4. Finally, section 5 is the conclusion of the study.

2. Literature review

2.1. Impact of CPEC on Energy

Kazmi (2016a) evaluated the influence of sustainable energy investments in Pakistan as part of the CPEC by using time series data from 2000 to 2016. The early harvested CPEC projects would generate 2840 MW of renewable energy. The investment in wind energy, hydro and solar projects reflects Pakistan's determination to weak economic scenarios. China's Foreign Direct Investment (FDI) has the potential to increase expansion in the renewable energy industry. This relationship with China in the RE area can facilitate the transfer of information and know-how, provided the government has regulations in place to facilitate the flow of knowledge to a business location. Direct professional development must be created with China's involvement for this goal. It is possible to establish win-win scenarios in which a low environmental worker is provided with the required knowledge and talents to work on Chinese-managed projects in Pakistan. Furthermore, local manufacturing of renewable energy goods or products must be encouraged by resolving market failures and supporting local manufacturers.

Khurshid et al.,(2018) investigated the influence of CPEC energy projects on Pakistan's socio-economic development. Using Johansen-Juselius cointegration analysis. Pakistan's energy issues (i.e., 8000 MW) would be addressed by the end of 2019, adding 17000 MW to the national grid as part of CPEC. Pakistan has been suffering an energy problem for the previous two decades, and CPEC has made a significant contribution in the electricity sector by investing $35 billion. CPEC is significant in all sectors, including FDI, transportation, infrastructure development, trade agreements, job opportunities, industrial estates, cultural exchange, tourist, and so on. Despite all of these positives, there are certain problems, such as security, political culture, terrorists, equitable funding allocation, local corporate stabilization, and so on. The long-term impact of GDP, road conditions, and labor productivity conditions, which are the primary factors in generating and lowering oil consumption. Energy, as in other states, is an important factor in Pakistan's economy. Pakistan has been suffering from acute electricity shortages for the last year. The CPEC energy projects have significantly supported Pakistan in eliminating energy poverty.

Lin & Xie,(2013) utilized time-series data from 1980 to 2010 to assess the demand for oil in China's transport industry and the potential savings. They investigated the impact of causal variables such as GDP, oil prices, total roadway, and automotive industry technological level on the dependent variable of energy consumption. The long-term impacts of GDP, road conditions, and labor productivity conditions, which are the primary factors in generating and lowering oil consumption, were predicted using Johansen-Juselius cointegration analysis. According to Monte Carlo risk analysis, improving internal oil-saving strategies can increase productivity.

H. Raza et al.,(2018) Twenty-one new energy projects being built as part of CPEC are intended to minimize energy poverty in Pakistan. According to the research, energy sufficiency will stimulate the economy by revitalizing industries and companies and providing hundreds of direct and indirect job opportunities.

Mirza et al.,(2019) using secondary data on energy consumption (Dependent variable), GDP, energy prices (P), energy intensity (EI), trade openness (TO) and foreign direct investment (FDI) (Independent variable), and qualitatively evaluated the effect of the CPEC on job creation in Pakistan. According to the sources mentioned above, the CPEC project is expected to promote private investment by establishing free economic zones, energy supply security, a stable economy, and efficient infrastructure. All of these enhancements will result in a 1.5 percent increase in annual GDP growth.

Iqbal et al.,(2019) investigated 17 works of literature on the CPEC and Pakistan's power sector. They used factors like planning, energy mix, and the electricity supply system. They demonstrated that CPEC is very helpful in resolving Pakistan's energy crisis 82.30%. The studies also showed concerns, including poor planning 47%, an unsustainable energy mix of 64.7%, and dilapidated electricity distribution systems causing losses of 64.7%. China's investment in energy infrastructure will reduce Pakistan's dependency on furnace oil for power generation, reduce the import of oil, alleviate Pakistan's balance of payment restrictions, and make Pakistan's power generation mix quite sustainable. The system of decrepit power, such as electrical power stations, distribution systems, and smart meters of energy, must be upgraded. Additionally, Long-term policy, energy scheduling tools, and foreign direct investment are other key factors for Pakistan.

CPEC allows Pakistan to manage its energy crises and rebuild its outdated infrastructure. However, suppose proper corrective actions to mitigate environmental risks are not adopted (Kouser & Subhan, 2020). In that case, Pakistan would be one of the top emitters of CO2, and its position in the global climate risk index will deteriorate after the project is done. As a result, assessing the potential environmental consequences of CPEC projects in terms of energy, infrastructure, and transportation is critical. In addition, scientists from both countries should work together to manage the environmental consequences of CPEC projects.

Ali et al.,(2018) developed a method based to assist the Pakistani government in determining which CPEC energy priority projects should be performed in the first wave of development. The second section of the study advises small/medium-sized industry and company owners on how to choose the best available solution for addressing the energy shortage while CPEC projects are being completed. the data demonstrate a gradual decline in the gap, which will reach zero in the year 2019. Agriculture, manufacturing, and service sector losses have been steadily declining over the years but will not approach zero in the next four years. This is evident from the tertiary analysis, which indicates a high dependency on energy shortages for key economic indicators including the industrial, agricultural, and service sectors. In addition, Pakistan's biggest industry, textiles, is examined, and it is concluded that the huge damage to this sector, estimated in billions of PKR, might be significantly reduced by lowering power losses.

Pakistan has had major energy crises as a result of population increase and industrial demand (Abid & Ashfaq, 2015). To develop proposals for policymakers in Pakistan to take dramatic actions to effectively address the country's energy crisis, it's necessary first to identify all of the most critical characteristics that affect the economy and residents' lives. The main reason for Pakistan's poor energy generation is an exponentially growing demand for power, political instability, and a lack of efficiency.

Asif, (2012) concluded that no meaningful solution to the problem has yet been developed. It continues to torture citizens because power is one of the most necessities in this age of contemporary technology. Power outages and load shedding (planned blackouts) are widespread in Pakistan, particularly in its main cities. WAPDA and KESC have been unable to solve the issue, which reveals the state's system's failure(Awan & Khan, 2014).

Several studies have indicated that with rising industrial expansion and household demand owing to rising per capita income, the essential criteria to consider include capacity, cost, installation time, environmental, health, and safety concerns (Farooqui et al., 2008).

According to Shaalan,(2003), the power plant's location is the most important factor because it determines how far energy must be transported in bulk and whether transmission lines are accessible. Similarly, Akber,(2015) revealed that the initial phase of China's generated funds would support around 22 energy projects as part of CPEC. Since the power projects are of diverse capacity and type, policymakers resolve to decide where to launch these plants.

Haq,(2016) investigates the effects of CPEC on social welfare in Pakistan at the local level. A district-level analysis is done using data from the tenth round of the Pakistan Social and Living Standards Measurement (PSLM) Survey 2014-15 to investigate the socio-economic welfare impact of CPEC projects in different regions of Pakistan(Haq & Farooq, 2016). There are 5428 sample blocks in the survey (Primary Sampling Units) as well as 81992 families (Secondary Sampling Units), which is required to generate trustworthy district-level findings. In this study, 78,635 families across the country were surveyed, and data on a variety of social problems was obtained from them. The primary focus of the study was on the major areas of education, health (including a child), maternal health, and housing problems. The majority of plant locations are being constructed in specific regions, including a region with the largest population size. It is proposed that such facilities will lead to an unequal distribution of opportunities for other country regions. Afzal,(2008) established that the increasing demand for electrical energy caused by the extraordinary energy crisis in Pakistan is explicitly represented in the research.

Avais et al.,(2016) on the other side, CPEC is expected to have the ability to help solve the energy crisis if energy projects are developed promptly with sufficiently short-term solutions. For the socio-economic improvement of the population in all Pakistan provinces, the best location of power and industrial projects is crucial.

2.2 FDI as a Source of Technology

More research has specifically highlighted FDI as a cause of technology transfer. (Lall, 1993) indicates that FDI is the most common method of transferring resources and technology from developed to underdeveloped countries. 'It's the most comprehensive type of technology transfer, combining cash with technical expertise, equipment management, marketing, and other capabilities.'(Lall, 1993). Therefore, technology transfer encompasses not just the transfer of equipment, but also the transfer of vital know-how and other intangible skills required to successfully manage and utilize technology.

There is a considerable field of research that investigates the influence of Foreign Direct Investment (FDI) and multinational companies (MNCs) on the capacities of domestic enterprises. However, given the large theoretical support for positive spillover and information transfer from overseas to local companies, empirical research has produced conflicting findings. Some studies indicate that FDI has a beneficial influence on domestic company productivity and performance, indicating that firms are learning and implementing improved production methods. Some studies indicate that FDI has a beneficial influence on domestic company productivity and performance, indicating that firms are learning and implementing improved production methods. (Kazmi, 2016b).

Many studies, on the other hand, have thrown into doubt the transfer of technology and know-how between foreign businesses and their subsidiary(Giuliani, 2008). They have emphasized the need of governments concentrating on increasing the local knowledge base rather than depending on horizontal and backward connections to upgrade local companies. (Kazmi, 2016b) evaluated panel data on Venezuelan plants and observed that overseas investment in manufacturing had an adverse impact on the local productivity of the company. Haddad and Harrison (1991 and 1993) According to the findings of Moroccan manufacturing research, spillovers do not take place in all industrial sectors. Finds that foreign presence does not result in technological spillovers (Blomström & Kokko, 2003).

2.3 Impact of GDP growth on Energy Consumption

O. Khan et al, (2019) investigated the link between energy usage economic development in Pakistan from 1985 to 2017. They used the ARDL-bounds testing technique and predicted that trade openness has an attractive impact on electricity while population and generating income have a negative impact. In concepts of sectoral analysis, agriculture and manufacturing have a beneficial impact on energy, but the services sector has a negative impact. Overall, the study found that increased energy consumption strengthens economic growth in Pakistan.

Aqeel & Butt (2001) examine the relationship between energy use and economic growth and employment in Pakistan. Co-integration and Hsiao's Granger causality were utilized as methodologies. The studies show that overall energy consumption, as well as petroleum use, is driven by economic development.

In a summary, following a detailed examination of a multitude of CPEC literature. Much farther, not single research has been conducted to investigate experimentally future energy use in Pakistan, particularly under the direction and supervision of CPEC. In this study, we think about the impact of electricity prices, GDP, FDI, and trade openness on aggregates energy consumption as well as sectors consumption, i.e., industrial, and commercial usage, in Pakistan.

3. Methodology

In this research work we implemented a modified version of the Impact Population Affluence Technology (IPAT) model to evaluate the underlying causes of Pakistan's overall and sector-specific energy consumption. Biologists, conservationists, and ecologists developed the IPAT model in 1970 (Dietz & Rosa, 1994). It's a widely used framework for analyzing and forecasting the interactions among humans and the environment. The IPAT method may not only complete a quantitative analysis of the environmental implications of population, economics, and technology, but it may also replicate economic, social, and other elements of development.

3.1 Data and data sources

The major goal of this research is to forecast Pakistan's future power usage at the national and departmental levels from the perspective of the

CPEC scenario. Due to data availability and the fact that these two sectors would be closely connected to CPEC growth, we targeted our research on the industrial and commercial sectors. Time series data from 1981 to 2019 were used in the research. Data on sector-specific and aggregate energy usage was gathered from multiple publications of Pakistan's energy yearbooks and is measured in tons of oil equivalents (TOE). We developed fractional power prices as a measure for power bills, so we used Ref. (NTDC, 2020) to get the sector individual and aggregate electricity prices. Electricity bills are calculated as a Paisa/kWh weighted aggregate of WAPDA and KESC. World Bank Development Indicators provided information on GDP, industry revenue generation, and aggregate trade openness. Data on net inflows of foreign direct investment in US dollars has also been gathered and translated to the country's currency units by World Development Indicators (WDI). The statistical results of the variables are given in Table 3.

3.2 Proposed Model

IPAT is a multiplicative approximation of the impact (I) of the population (P), affluence (A), and technology (T) on the environment; Where affluence indicates economic growth per capita, and technology signifies the impact per unit of economic activity as represented in Eq (1). The values of I, P, and A can be used to determine technology (Ehrlich & Holdren, 1972; Raskin, 1995) because affluence is characterized as per capita GDP. P×A =GDP. As a consequence, technology is evaluated as I/PA or I/GDP.

$$I = P \times A^{*}T \ldots(1)$$

Dietz & Rosa,(1994) denoted the modified version of the IPAT model by adding stochastic terms in and can be presented as in Eq. (02)

$$I = a \times P^{k*} A^{.L.} \times T^{.M.} \; {}^{*}e \ldots (2)$$

The letter e represents the residuals. The parameters to be estimated using advanced econometric procedures are a, k, L, and M. The STIRPAT model provided in Eq. (02) may be represented as in Eq. (03) by logarithmic transformation:

$$\ln I = a + k(\ln P) + L(\ln A) + M(\ln T) + \varepsilon \ldots \quad (3)$$

In the basic STIRPAT model, technology is regarded as an element of the standard error. This model is not measured independently to comply with the IPAT model. As a result, in the STIRPAT model, technology represents any parameters other than population and economic growth that might influence the impacts. According to (Fischer-Kowalski & Amann, 2001) the IPAT equation must integrate the socio-economic systems of different economies and the implications of globalization to better understand their influence on various outcome variables. The IPAT model is a mathematical identity that may be modified to comprise the dynamics influencing effects on the environment. In our example, the modified IPAT model for overall and sectoral energy consumption is described in equations (04) and (05), respectively:

$$\ln EC_t = \beta_0 + \beta_1 \ln Pr_t + \beta_2 \ln GDP_t + \beta_3 \ln EI_t + \beta_4 \ln TO_t + \beta_5 \ln FDI_t + \mu_t \quad (4)$$

$$\ln EC_t = \beta_0 + \beta_1 \ln Pr_t + \beta_2 \ln GDP_t + \beta_3 \ln EI_t + \beta_5 \ln FDI_t + \mu_t \quad (5)$$

In Eq. (04), EC_t means standing for energy consumption, GDP_t means standing for gross domestic product, P_t is for aggregate energy prices, and EI_t needs to stand for energy intensity, which is a measure of technical advancements and energy efficiency in the economy. TO_t measures trade openness, whereas FDI_t measures net inflows of foreign direct investment. We utilize EC_t, Pr_t, EI_t, and FDI_t for the commercial and industrial sectors, respectively, in Eq. (05).

Few preliminary studies have quantified economic activity as GDP per capita by using IPAT model estimation (Bargaoui et al., 2014; Fisher & Freudenburg, 2004; S. Lin et al., 2009; Zheng et al., 2016).

Table 3: Present Descriptive Statistics

Series	Measurement	Mean	Std. Dev	Min	Max
Aggregate					
Energy	Million TOE	24.614	8.918	9.034	41.275
Prices	Paisa/kWh	491.36	96.768	272.736	611.372
GDP	Rs trillion	5.403	3.507	2.045	11.254
Energy Intenst	E*/GDP	2.15E-05	6.34E-07	9.65E-06	1.17E-05
FDI	Rs. Million	58074.13	95168.87	151.72	372969
TO	Rs Billion	1688.968	726.564	662.876	3024.765
Industrial Sector					
Energy	Million TOE	8.783	5.042	4.265	17.709
Prices	Paisa/kWh	528.673	88.789	317.297	672.181
GDP	Rs trillion	5.567	2.567	1.756	11.456
Energy Intenst	E/VA	8.25E-06	8.48E-05	7.25E-07	1.26E-03
FDI	Rs. Million	25679.76	44251.07	174.8	168076
Commercial Sector					
Energy	Thousand TOE	773.653	643.705	193.573	1675.346
Prices	Paisa/kWh	833.768	160.654	417.902	
GDP	Rs trillion	5.632	3.051	1.843	9.653
Energy Intenst	E/VA	0.000327	2.74E-06	0.000220	0.000321
FDI	Rs. Million	32721.54	64386.37	11.6	235865

Note: E shows primary energy consumption*

3.3 Unit root test

Before conducting the empirical studies, we evaluated the unit root features of the data purpose of the study using the Augmented Dickey-Fuller test (Dickey & Fuller, 1979). The Dickey-Fuller test's estimable equation is given by Eq. (06).

$$\Delta y_t = \beta_0 + \eta_1 y_{t-1} + \sum_{i=0}^{m} \gamma_i \Delta y_t - i + \mu_t \quad \ldots (6)$$

Where y denotes the interesting series, yt-specifies the lagged value of the y series, Δ shows the difference operator and m is indeed the maximum number of lags to be inserted, represents the difference operator. μ_t denotes the error term, which has a zero mean and a constant variance. If $\eta 1 \angle 0$ statistically, the null hypothesis of the presence of a unit root is rejected.

3.4 Johansen-Juselius Co-integration test

The next step would be that if all the project's variables are co-integrated or tied in a long-term connection. To approve the survival of a long-run relationship among all valued variables, Johansen,(1990) technique based on the "Maximum Likelihood method" and "eigenvalue statistics" is a broadly exploited method. Cointegration is considered to exist when the values of determined statistics deviate considerably from zero. If variables are determined to be co-integrated, it indicates they have a linear, stable, and long-run relationship, with disequilibrium errors that tend to fluctuate around zero. This indicates that in the long period, variables tend to migrate together to their steady-state path. By considering two variables Y_t and X_t , first-order VAR is presented in Eqs. (7) and (8).

$$Y_t = \gamma_1 \beta_{11} Y_{t-1} + \beta_{12} X_{t-1} + \mu_{yt} \quad \ldots (7)$$

$$X_t = \gamma_2 + \beta_{11} Y_{t-1} + \beta_{22} X_{t-1} + \mu_{xt} \quad \ldots (8)$$

Where μ_{yt} and μ_{xt} represent white noise error terms that may or may not be linked. In the context of matrices, these equations can be expressed as:

$$\overline{Y}_t = \gamma + \hat{A}_1 \overline{Y}_{t-1} + \varepsilon_t \quad \ldots (9)$$

Where, $\overline{Y}_t$ represents Y_t and X_t ,and ε_t represents ε_{yt} and ε_{xt} . Equation (09) indicates the VAR (1) model, whereas Eq. (10) reveals the VAR of pth order:

$$\overline{Y}_t = \gamma + \hat{A}_1 \overline{Y}_{t-1} + \ldots\ldots\ldots + \hat{A}_1 \hat{Y}_{t-1} + \varepsilon_t \quad \ldots (10)$$

Where $\overline{Y}_t$ is the $(k \times 1)$ vector of the whole time series. Each A is a $(k \times k)$ coefficient matrix, and

ε_t is a $(k \times 1)$ vector of white noise error terms with two attributes. The mean is 0, and the variance is constant. The Johansen-Juselius cointegration test is used in VAR to evaluate whether there is a long-term connection between our variables of interest Eq.11:

$$\Delta\overline{Y}_t = \gamma + \delta_1 \Delta\overline{Y}_{t-1} + ... + \delta_{p-1}\Delta\overline{Y}_{t-p+1}\delta\overline{Y}_{t-1} + \varepsilon_t \ldots (11)$$

In this case, $\delta = \alpha\beta.\beta$ the matrix of co-integrating vectors and is also the co-integrating matrix's weight. The first element in the Johansen cointegration technique is to test for the hypothesis associated with matrix rank (r). The rank of a model shows the representation of co-integrating vectors. The number of co-integrating vectors may be evaluated using the trace and maximal eigenvalue tests. Trace test checks the null hypothesis of $r = 0$ near the alternative hypothesis of $r \geq 1$ but and Max test investigates the alternative hypothesis if $r = 1$. The bigger the values of Trace and max statistics, and therefore the more common the appearance of co-integrating vectors, the closer the characteristic roots are to one (Asteriou & Hall, 2015). Equations of Trace and Eigenvalue tests (12) and (13):

$$\lambda \text{trace}(r) = -T\sum_{i=r+1}^{n} \ln(1-\lambda r) \ldots (12)$$

$$\lambda \max(r, r+1) = -T \ln(1-\lambda_{r+1} \ldots (13)$$

3.5 Scenario analysis

As delineated in section 2, The CPEC will improve economic activity, commerce, and foreign direct investment (FDI) inflows that are all tied to energy demand. We developed a scenario research design based on cointegration to forecast the future energy consumption under CPEC in 2030. We present three scenarios for assessing future energy use: baseline (business as usual), moderate, and advanced. Each scenario has different exogenous variable growth rates for the future, which are briefly acknowledged in section 4. Based on scenario research, we've also predicted energy-saving possibilities.

3.6 Monte Carlo simulation

Monte Carlo simulation is a mathematical technique that accumulates the risk or uncertainty in our daily decision-making and helps carry out quantitative analysis for the future. It has been widely adopted to account for uncertainty in electricity generation planning and model uncertainties in energy prices (Feretic & Tomsic, 2005; Spinney & Watkins, 1996). But the tension in the issues relating to electricity consumption has been ignored (Vithayasrichareon & MacGill, 2012). And then B. Lin & Xie (2013) & B. Lin et al., (2012) from the standpoint of probability theory, we use Monte Carlo simulations to evaluate predictions based on cointegration results and quantify alternative future energy consumption scenarios in Pakistan by 2030.

4. Discussion and results

4.1 Results of unit root tests

Before performing the cointegration research, we conducted the Augmented Dickey-Fuller (ADF) technique to evaluate the order of integration of the series. The results of the ADF and P.P. tests are shown in Table 4. Except for GDP, which shows no trend, Table 4 shows clearly that the outcomes of the ADF and P.P. tests are complying. Furthermore, all the series are stochastic and stationary on the initial difference. These results fulfill the criteria for using the Johansen cointegration methodology. The SIBC criteria were used to determine the optimal lag length for each series.

4.2 Johansen-Juselius for co-integration test

We proceeded with an unconstrained VAR model to see whether there was any cointegration between the variables. We selected one lag in the unrestrained VAR based on the SBIC criteria. Table 5 shows statistics regarding lag selection. Table 6 illustrates the Johansen Trace and Max-eigenvalue test results for all the models. The max-eigenvalue test rejects the null hypothesis of one or zero co-integrating vectors for aggregate and industrial sector models, favoring the alternative hypothesis of r = 2. However, in the commercial sector model, the null hypothesis of no cointegration must be rejected in favor of the alternative hypothesis of r = 1. The Johansen Trace test accepted the alternative hypothesis ($r \geq 3$) for the aggregate model, the presence of a high concentration of three or more co-integrating vectors among the variables. Moreover, the industrial sector model has four or more co-integrating vectors, whereas the commercial sector model contains two or more. These results demonstrate that the variables in all models have a long-term relationship.

Table 4: Present Unit root tests Results

Series	Augmented Dickey-Fuller Test (ADF)					
	Aggregate Model		Industrial Sector		Commercial Sector	
	Level	1st Difference	Level	1st Difference	Level	1st Difference
LnE	1.421	-5.219***	-3.0101	-4.812***	-1.8342	-3.978***
LnP	-1.753	-3.782***	-2.023	-6.234***	-0.276	4.765***
LnGDP	2.213	-2.987***	1.754	-4.182***	-0.237	-4.178***
LnEI	1.478	5.678***	-1.756	-7.586***	0.357	-6.367***
LnFDI	-0.956	-2.987***	-0.745	-7.235***	-2.034	-4.531***
LnTO	1.841	-8.561***				

*Note: *** indicates a significant level at 1%.*

4.3 Long run results

The models' normalized long-run equations will be shown in Table 7. Energy consumption price elasticity is associated with energy prices (LnPrice), gross domestic product (LnGDP), energy intensity (LnEI), net inflows of foreign direct investment (LnFDI), and trade openness are all estimated considerations (LnTO). Long-run coefficients are interpreted in the following way. All models indicated a negative relationship between energy costs and energy consumption. In both the aggregate and each sector studied, the energy price coefficients are significantly positive. Existing research substantiates this idea (M. A. Khan & Abbas, 2016; M. A. Khan & Ahmad, 2008; B. Lin & Ouyang, 2014; B. Lin & Wang, 2015; Tang & Tan, 2014). Price may be considered a powerful weapon in Pakistan to achieve aggregate and sectoral energy efficiency. Both negative and positive spillover effects of foreign direct investment on energy consumption have been shown in the literature. Our research findings are likewise mixed, as the coefficients of net FDI inflows are negative for the aggregate and industrial sectors but positive for the commercial sector. However, the net inflow coefficients in each model are quite insignificant. Our observations confirm what the research shows (Leitão, 2015). The business sector supports the positive spillover effects of FDI on energy consumption (Azam et al., 2015; Tang & Tan, 2014). The GDP coefficients are positive and statistically significant in both overall and sectoral models. The available literature contradicts our results (M. A. Khan & Abbas, 2016; Leitão, 2015; B. Lin & Ouyang, 2014; Mudakkar et al., 2013; Zaman et al., 2012). Our GDP coefficients correspond with the Environmental Kuznets Curve (EKC) theory which is based on (Kuznets, 1955). The estimated elasticity of energy intensity in aggregate and industrial sector models is huge and statistically significant. These findings are supported by the fact that Pakistan has a very energy-intensive economy, both at the aggregate and sectoral levels. The country has the second-highest energy-intensive economy among South Asian countries (Mirza & Fatima, 2016). According to the State Bank of Pakistan, the Pakistani economy's usage of natural gas is inefficient (*SBP*, 2014) in addition, the industrial and residential sectors use a lot of gas (Yearbook, 2014). Energy appliances in the corporate sector are inefficient, achieving just 20–25 percent energy efficiency ((Lanka, 2009); ENERCON) 2 . According to the current research, the elasticity of energy consumption concerning trade openness is positive and statistically significant (Raza, Shahbaz and Nguyen, 2015) (Sadorsky, 2011).

[2] Fordetailsseehttp://www.enercon.gov.pk

Table 5: Lag order selection criteria in VAR

Lag	LogL	LR	FPE	AIC	SBIC	HQ
Aggregate						
0	151.4253	-	7.89E-13	-9.12435	-7.33427	-
1	345.654	311.0478	6.98E-15	-18.4426	-12.762*	-9.563
2	420.456	52.1145*	4.32E-14	-19.0224	-13.7344	-16.135
3	440.6927	43.3976	2.02E-14*	19.9227*	-10.1714	-19.4521
Industrial Sector						
0	96.438	-	3.30E-08	-5.2264	-2.5602	-4.5298
1	276.342	312.459*	2.60E-12*	-12.6745*	-14.3456*	-12.0347*
2	312.3216	32.6803	2.03E-14	-11.465	-12.0356	-14.6092
Commercial Sector						
0	117.8097	-	1.03E-07	-5.4213	-5.2654	-4.51834
1	311.2245	319.9016	5.82E-13	-13.3541	-15.1128*	-13.0534*
2	342.8265	42.5468*	3.10E-13*	-15.2537*	-14.385	-12.3768

4.4 Scenario analysis

As indicated in Table 8, we have classified yearly growth rates of exogenous variables in three scenarios for future forecasting: baseline, moderate, and advance. Our BAU baseline scenario (BS) is specifically defined by the Intergovernmental Panel on Climate Change (IPCC). The BAU baseline scenario's growth rate is the average annual growth rate of each exogenous series from 1981 to 2019. It denotes that under the BAU baseline scenario from 2014 to 2030, each variable will preserve its average annual growth rate assuming no policy changes. The formulation of a BS is enabled in the absence of assumptions by the fact that the series must pass through this growth rate in the future. The growth rates for each sequence in the advance scenario (AS) are based on Pakistan's economic facts. We provide an AS for CPEC-related economic performance and compliance with Pakistan's Vision 2025. Our scenario research strongly corresponds to the policy documents. The moderate scenario (MS) represents a kind environment and is situated between the advance and baseline scenarios. Its growth rate for each series is computed by averaging the baseline and advanced scenario growth rates. The following is a brief description of the growth rates of the exogenous variables under consideration.

4.4.1 Energy prices scenario

NTDC (2011) & Australia P (2015) forecasted that average power prices will rise 2.025 percent from 2011 to 2020 and 1.25 percent from 2020 to 2030 over the period 2011–2030. From 2011 through 2020, these prices will rise by 0.6 percent and 2.2 percent, respectively, in the industrial and commercial sectors. During the years 2020–2030, however, this sectoral price rise will drop to 0.3 percent and 1.1 percent, respectively. According to the AS, the average price growth rates for the overall, industrial, and commercial sectors throughout 2011 and 2030 will be 1.638 percent, 0.45 percent, and 1.65 percent, respectively. For all models, these growth rates will be lower than the BS. The forward scenario has a lower rate of rising energy costs, which is in line with CPEC since more renewable energy is forecast to join Pakistan's permanent magnet.

4.4.2 GDP scenario

Due to its enlarging working-age population, Pakistan is expected to have a good GDP growth rate Australia P (2015). Pakistan's Vision 2025 has set an 8 percent GDP growth goal from 2018 to 2025. Pakistan's Vision 2030 aspires to achieve a 7–8% GDP growth rate by 2030. The CPEC will increase current GDP by 2.5%, extending the level of progress to 7.5%. Given the goals in the Government statements and the CPEC, we have established a GDP growth rate of 7.5 percent for the AS and 6.144 percent for the MS.

Table 6: Johansen Trace and Max-Eigen test for cointegration.

H_0	H_1	Aggregate		Industrial sector		Commercial sector	
		Trace	5% CV	Trace	5% CV	Trace	5%CV
r = 0	r≥1	143.7429	94.5763	137.5328	87.3807	129.749	85.3076
r≤1	r ≥2	93.58076	68.18981	91.0217	64.7851	72.7099	62.7681
r≤2	r ≥3	47.08416	48.65831	52.15968	40.87252	42.2562	42.52591
r≤3	r ≥4	23.6295	28.70796	31.7044	26.21187	25.39204	25.11287
r≤4	r ≥5	11.4158	15.71449	11.18287	13.71698	9.76532	11.98516
r≤5	r ≥6	1.24363	2.41866				
H_0	H_1	Max.Eign	5% CV	Max.Eign	5% CV	Max.Eign	5% CV
r =0	r=1	52.2658	41.0577	48.4814	38.10133	54.6078	9.1037
r ≤1	r=2	45.8125	33.6878	38.1029	32.8321	30.1375	34.8321
r ≤2	r=3	24.5645	27.4348	21.2216	21.8232	17.2235	25.3212
r ≤3	r=4	14.7753	22.1623	18.7934	19.7043	14.3472	19.7048
r ≤4	r=5	8.3756	13.4627	11.8187	10.9696	12.1798	12.5673
r≤5	r =6	0.2973	3.4668				

4.4.3 Energy intensity scenario

The economy of Pakistan is largely reliant on energy. There have been no targets set for incorporating energy efficiency into the economy. Consequently, for the aggregate (0.931%) and industrial sector (0.895%) models, we maintained the same growth rate for electricity consumption as in the BS. Because the industrial sector's energy intensity has reduced since 2007, we have projected a 15% reduction in commercial energy intensity growth in the AS. Commercial energy intensity will increase by 0.646 percent and 0.594 percent in the MS and AS, respectively.

4.4.4 Foreign direct investment scenario

A foreign direct investment (FDI) towards Pakistan is the China-Pakistan Economic Corridor (CPEC). Electricity and transportation infrastructure investments are classified as CPEC-related commercial FDI by all of us. We envisage the CPEC investment in Gwadar as a significant power source of future industrial FDI. The sum of the increase in the BS and the per year growth rate of FDI inflows due to CPEC is the future growth rate of the FDI series under the AS. The estimate is based on the assumption that the average increase in net FDI inflows from 1981 to 2019 will proceed in the future. As a result, we include it in the FDI inflows associated with the CPEC. In conclusion, in the AS, we set long-term FDI growth rates of 39.86%, 20.50%, and 39.84% for the absolute numbers, industrial, and commercial components.

Table 7: Present Long run Results

Dependent Variable: Energy consumption						
Series	**Aggregate**		**Industrial Sector**		**Commercial Sector**	
Variables	Coefficients	S. E	Coefficients	S. E	Coefficients	S. E
LnPrices	0.553	0.11233	0.223	0.10424	0.193	0.01512
LnGDP	-0.656	0.16938	-1.526	0.06815	-0.743	0.08536
LnEnergy Intensity	-2.06	0.34143	-1.335	0.0856	-0.698	0.05443
LnFDI	0.072	0.02235	0.193	0.00702	-0.018	0.04076
LnTO	-0.907	0.1326				
Constant			0.007	0.00274	-0.013	0.00206

Table 8: Shows Growth Rates of explanatory variables under three scenarios (2014–2030)

Variables Aggregate	Baseline scenario (%)	Moderate Scenario (%)		Advance Scenario (%)		
Prices	2.234	1.875		2.176		
GDP	4.678	5.441		7.4		
Energy Intensity	-0.875	-0.392		-0.391		
FDI	17.983	28.774		38.546		
TO	4.1235	5.672		5.288		
Variables	**industrial sector**			**Commercial sector**		
	B. Scenario (%)	**M. Scenario (%)**	**A. Scenario (%)**	**B. Scenario (%)**	**M. Scenario (%)**	**A. Scenario (%)**
Prices	1.784	1.057	0.39	2.106	1.765	1.56
GDP	4.636	5.431	6.8	3.876	5.243	8.2
Energy Intensity	-0.598	-0.798	-0.958	0.643	0.5864	0.6542
FDI	17.120	18.536	21.405	15.983	19.836	40.386

4.4.5 Trade openness scenario

Internal and external trade will expand as infrastructure improves as a result of the CPEC investment. Pakistan will become a regional commerce center once the Gwadar port is completed (Bhutta, 2015). In addition to CPEC economic growth, Vision 2025 plans to improve exports to $150 billion and the export-to-GDP ratio to 16–19 percent. The objective of the 2030 plan is to increase the trade-to-GDP ratio from 30 percent to 60 percent by 2030. This will only be possible if Pakistan secures FDI through the China-Pakistan Economic Corridor (CPEC). Suppose the trade-to-GDP ratio increases from 2013 to 2030, the annual growth in the AS would be 5.88%, while in the MS it will be 4.94%.

4.4.6 Forecasting within scenario approach

Our scenario method is valuable for anticipating average energy usage since each scenario has various growth rates. Our findings are comparable to those of (ETP, 2008; Hao et al., 2015; B. Lin & Xie, 2013; Zhou et al., 2014). Table 8 shows the predicted energy consumption based on the scenarios and cointegration results stated previously. In all future scenarios, if the exogenous variables increase in direct conflict with the trends given in Table 8, aggregate power consumption will rise. According to the BS, Pakistan would use about 41% more aggregated energy in 2030 than it would in 2013. Considering MS and AS, CPEC-related economic activity will increase energy consumption by around 48 percent and 57 percent from 2013 levels in 2030, significantly. According to the expectations, industrial energy consumption will grow by 136, 211, and 312 percent from 2013 levels by 2030 under the BS, MS, and AS.

4.5 Future sectoral energy consumption in Pakistan

According to Table 9, electricity consumption in 2020, 2025, and 2030 will be 41.79, 48.10, and 56.05 million TOE, correspondingly, under the BS. The MS will increase aggregate electricity consumption by 1.5 percent, 3.4 percent, and 5.5 percent above the BS in 2020, 2025, and 2030. The aggregate electricity consumption in the AS will be 3.1 percent, 6.10 percent, and 11.3 percent higher than in the BS in 2020, 2025, and 2030, correspondingly. In all scenarios, industrial energy demand will rise around across the board from 2020 to 2030. In the BS, industrial electricity consumption will be 20.695, 26.366, and 33.591 million TOE in 2020, 2025, and 2030, correspondingly. In 2020, 2025, and 2030, industrial electricity consumption will be 10.90%, 21.06%, and 32.16 greater in the MS than in the BS. Industrial electricity consumption will be 22.99%, 46.57%, and 74.66% greater in the AS than in the BS in 2020, 2025, and 2030.

Table 9: Present Future sectoral energy consumption in Pakistan (Unit: Million TOE).

Aggregate			
Year	Baseline Scenario	Moderate Scenario	Advanced Scenario
2020	42.75	43.41	44.08
2025	49.2	48.74	52.45
2030	57.04	58.81	61.37
Industrial Sector			
2020	21.6	22.85	24.63
2025	25.45	31.91	39.49
2030	34.62	43.42	57.76
Commercial Sector			
2020	2.79	3.76	2.45
2025	4.84	4.36	3.24
2030	8.52	4.12	2.07

Commercial electricity consumption will grow from 2020 to 2030 in both the BS and MS. Conversely, in the perfect scenario, commercial energy use would rise to 2.82 million TOE in 2025 before dropping to 2.084 million TOE in 2030. Commercial energy consumption will be 5.09 percent, 20.68 percent, and 50.52 percent lower under the MS in 2020, 2025, and 2030, respectively, compared to the BS. According to the AS, in 2020, 2025, and 2030, commercial electricity consumption will be 9.91%, 37.08%, and 74.51% lower than in the BS.

As anticipated in the earlier phase of this research, we show that CPEC-related economic activity will improve power consumption in Pakistan's economy at both the aggregate and sectoral levels by integrating the data. Furthermore, there is great potential for saving energy that might be used to address the increasing energy supply and demand imbalance. Although the energy-related projects under CPEC would relieve energy generation shortages, the environmental impacts must be considered because most of the power produced in these projects will be generated using coal-related technologies.

5. Conclusion and recommendations

The CPEC is an effective economic program that aims to connect Pakistani and Chinese economic systems. The CPEC promotes both nations equally, and both countries must contribute equally to its development. Though an opportunity, the Corridor could be made even better by taking policy measures and removing any hurdles impeding its path. Furthermore, CPEC is more than just an economic corridor; it symbolizes China and Pakistan's strong bonds, their enduring friendship, and the high levels of confidence that both countries have in each other.

The purpose of this study is to predict the impact of CPEC-related economic activities on Pakistan's aggregate and sectoral energy consumption by 2030. We applied Johansen-Juselius Co-integration techniques to check the long-run connection between energy consumption and its predictors at the aggregate and sectoral levels, as well as scenario analysis to evaluate the impact of CPEC on future energy consumption in 2030. The conclusions of co-integration imply that the elasticity of power consumption concerning profitability is negative both at the aggregate and sectoral levels. In contrast, it is favorable for GDP and electricity consumption. The elasticity of energy consumption in responding to foreign direct investment has produced conflicting results. Trade openness has a massive impact on growing energy consumption in aggregate. According to the baseline scenario, Pakistan's electricity consumption would be 41% greater in 2030 than in 2013. Under the moderate and advanced scenarios, CPEC-related economic activity will grow energy consumption to around 48% and 57% from 2013 levels in 2030, correspondingly. The reduction in energy-saving potential in the moderate and advanced scenarios in 2030 will be 3.08 million TOE and 6.32 million TOE compared to the baseline scenario. According to sectoral research, energy consumption in the industrial and commercial sectors will grow by more than 136% and 414%, respectively, in 2030 under the baseline scenario. In advanced scenarios, electricity consumption in the industrial sector is anticipated to grow by 312% by 2030, compared to 2013. Under the advanced scenario, energy consumption in the commercial sector will be 26% higher than in 2013. We use

Monte Carlo simulation for evaluations. The outcomes of the Monte Carlo simulation are pretty close to the values of scenario creation based on co-integration. This justified our scenario BAU outcomes and the multiple prospective energy usage scenarios by 2030.

The CPEC-related investment in power generation capacity is expected to meet the rise in energy demand and decrease existing energy shortfalls; however, the environmental costs of these initiatives cannot be underestimated because most of the power generated in these project activities is based on coal-related technologies. To reduce the environmental consequences of these projects, targeted interventions with adequate abatement pursuits are needed. If these decisions are backed by concrete evidence, it can realize the dream of resolving Pakistan's energy crisis and environmental issues.

Policy recommendation

We suggest the following additional policy recommendations based on the findings of the current study.

- The government should perform systematic accounting and relevant planning for each sector of the economy to account for the planned increase in energy consumption due to CPEC-related economic growth. Moreover, because increased economic activity under CPEC is predicted to have environmental consequences, it is essential to consider and estimate the future GHG emissions to design effective abatement measures.
- Energy should seek energy conservation by promoting energy-efficient technologies through investment techniques and also motivate local investors in such initiatives.
- Long-term policies based on research evidence are required for renewable energy sector expansion.
- The CPEC should prioritize local development to create trust and public support, ensuring the project's success.
- The increasing economic activity will have to be watched at all levels to ensure the efficiency of investments and investor reliability so that there is a very little potential of tampering at any stage of growth.
- There is a need to establish that while governments may modify, policies should not modify or affect the growth of CPEC, and CPEC programs should continue running smoothly in all authorities. CPEC should continue every government's plan until it is completed.
- Pakistani governments should develop methods to maximize the advantages of CPEC while ensuring that the country does not become embroiled in the responsibilities of refundable borrowing again.
- If the major goal of the China Pakistan Economic Corridor is to establish a transit corridor, Pakistan should promote its country's interests.

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Abbreviations	
China Pakistan Economic Corridor	CPEC
Gross Domestic Product	GDP
Megawatt's	MW
Liquefied Natural Gas	LNG
China Machinery Engineering Corporation	CMEC
China Gezhouba Group Corporation	CGGC
To Be Decided	TBD
Belt and Road initiative	BRI
Balance of Payments	BoP
Pakistan Rupee	PKR
Water and Power Development Authority	WAPDA
Karachi Electric Supply Company	KESC
Tons of Oil Equivalents	TOE
Foreign Direct Investment	FDI
World Development Indicators	WDI
Impact Population Affluence Technology	IPAT
Stochastic Impacts by Regression on Population, Affluence Technology	STIRPAT
Energy Consumption	EC
Energy Price	EP
Energy Intensity	EI
Trade Openness	TO
Augmented Dickey-Fuller	ADF
Phillips-Perron (PP) unit root test	PP
Vector Auto Regression	VAR
Environmental Kuznets Curve	EKC
Intergovernmental Panel Climate Change	IPCC
Business as Usual	BAU
Baseline Scenario	BS
Advance Scenario	AS
Moderate Scenario	MS

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