Transition from Imported to Local Coal to Attain Energy Security in Pakistan: Opportunities & Challenges

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1 Executive Summary

The global energy landscape is undergoing a significant transformation, with increasing emphasis on renewable energy sources. However, fossil fuels continue to remain a predominant source of electricity generation due to their cost-effectiveness and capacity to provide stable baseload power. In 2023, fossil fuels accounted for over 60% of global electricity production, with coal-fired power plants contributing approximately 36% of this share, making coal the largest single source of electricity globally.

Pakistan, with its total installed electricity generation capacity of approximately 41,268 MW, relies heavily on imported fuels, which account for nearly 47% of its power generation mix. This heavy dependence on imported fuels, including Re-Gasified Liquefied Natural Gas (RLNG), coal and furnace oil, places a significant strain on the country's foreign exchange reserves, undermining its energy security.

Despite possessing substantial coal reserves, particularly in the Thar region, Pakistan has not fully utilized these local resources due to various challenges, including the perceived low quality, environmental concerns, and inadequate transportation infrastructure. Thar coal, a type of lignite with high moisture content, is often overlooked in favor of imported coal due to its better quality and existing infrastructure appropriate to its utilization.

This whitepaper explores the potential of transitioning from imported coal to local coal to enhance Pakistan's energy security. It delves into the technical, economic, and environmental challenges associated with the utilization of Thar coal and proposes actionable solutions to overcome these hurdles. By leveraging its indigenous coal resources, Pakistan can reduce its dependency on imported fuels, ensure a more sustainable energy supply, and mitigate the economic pressures of foreign exchange expenditures.

Objectives

- Assess the feasibility and potential benefits of transitioning from imported to local coal for electricity generation in Pakistan.
- Identify and analyze the key challenges, including technical, economic, and environmental factors, associated with utilizing Thar coal.

- Recommend actionable solutions and policy measures to facilitate the efficient use of local coal and improve Pakistan's energy security.

2 Global Power Generation Trends

Despite widespread discussions and initiatives aimed at transitioning towards renewable energy sources, fossil fuels persisted as the primary choice for electricity generation globally, attributed to their cost-effectiveness and ability to provide stable baseload. In 2022, fossil fuels accounted for over 60% of the total global electricity production output [1]. Notably, coal-fired power stations alone contributed approximately 36% to this share, solidifying coal's status as the largest electricity source globally [1].

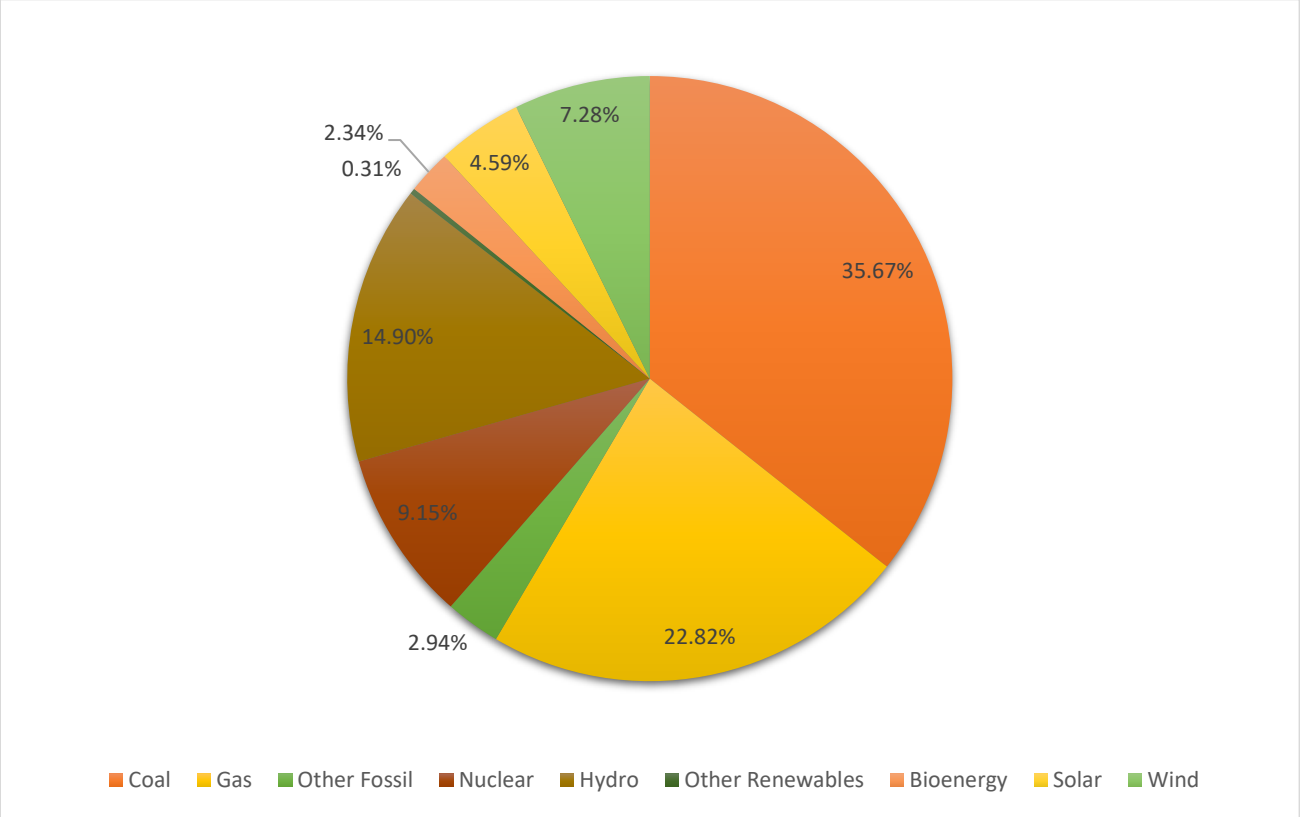


Figure 1: World Electricity Generation by Resource. (Source: Ember-Climate.org) [1]

2.1 Countries with Highest Coal Power Utilization

If we look towards individual countries, many nations including China, India, United States, Japan, Indonesia, Russia, Germany, and Poland among others continue to rely heavily on coal for power production.

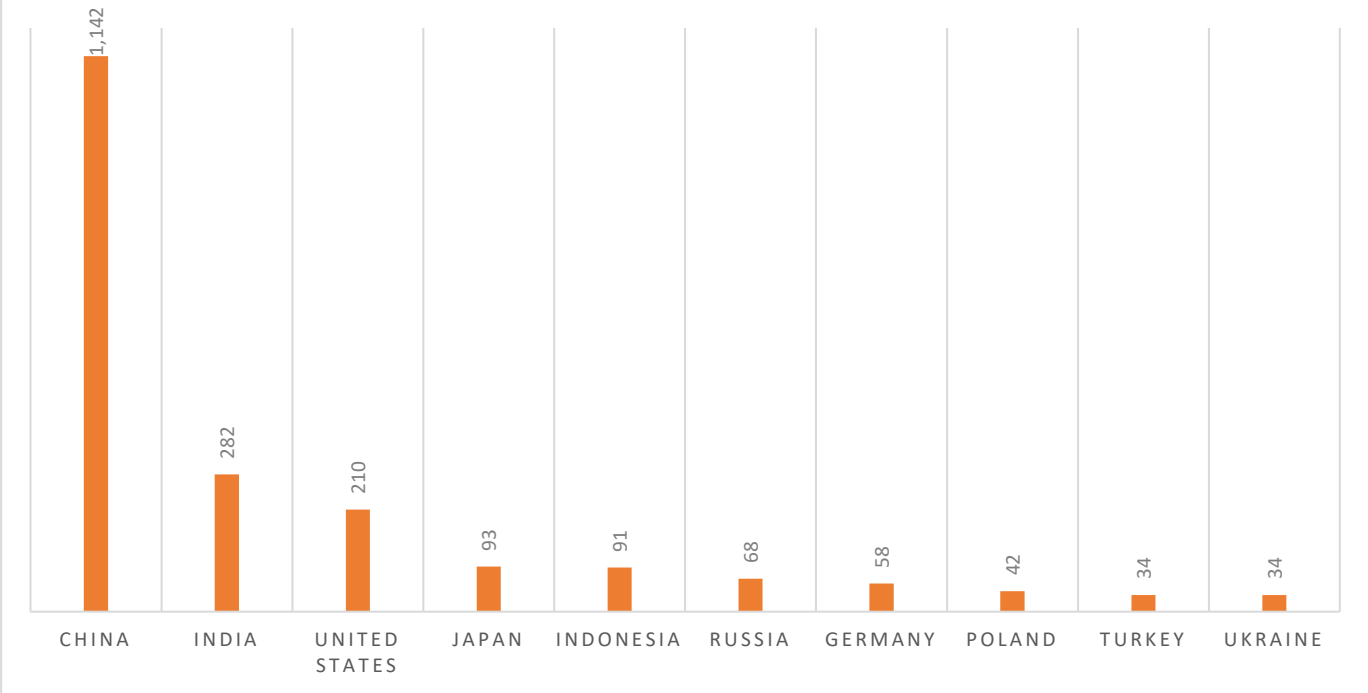


Figure 2: Countries with Highest Operational Coal Power Plants. (Source: Data as of July 2023 Statista) [2]

In 2022, China, India and United States alone produced 7,750 Terrawatt hours (TWh) of electricity combined through coal (Fig 3).

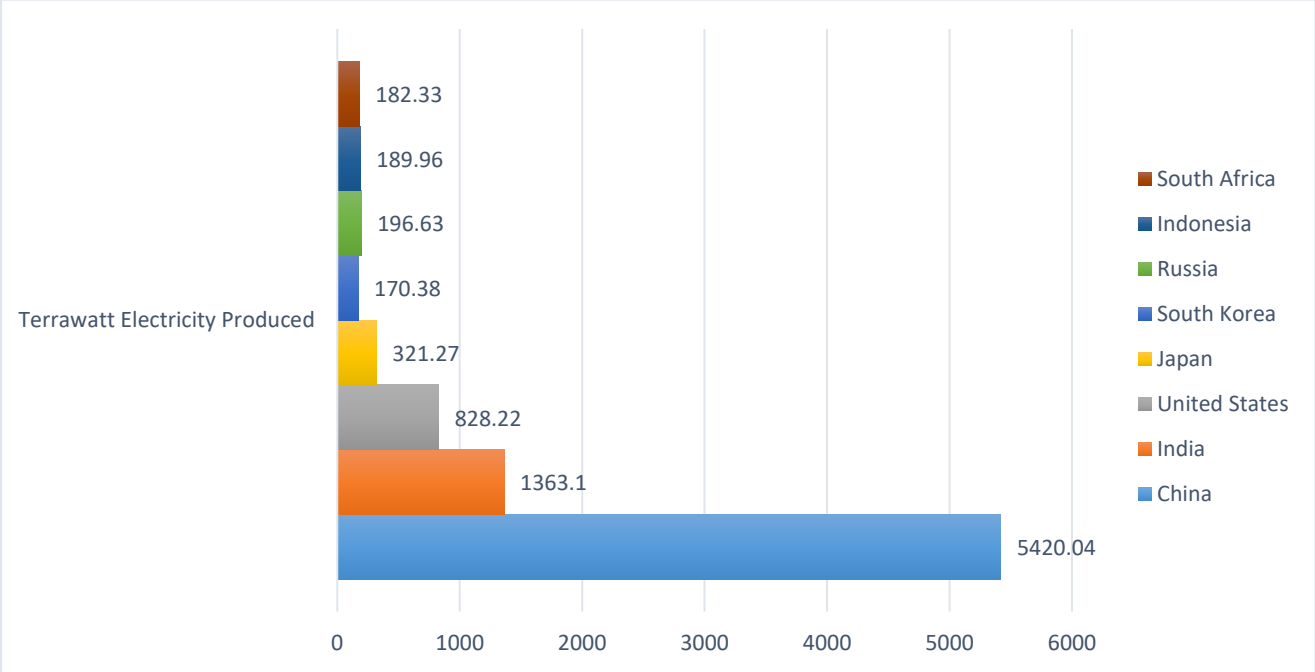


Figure 3: Largest Coal Electricity Generating Countries (TWh). (Source: Ember-Climate.org) [3]

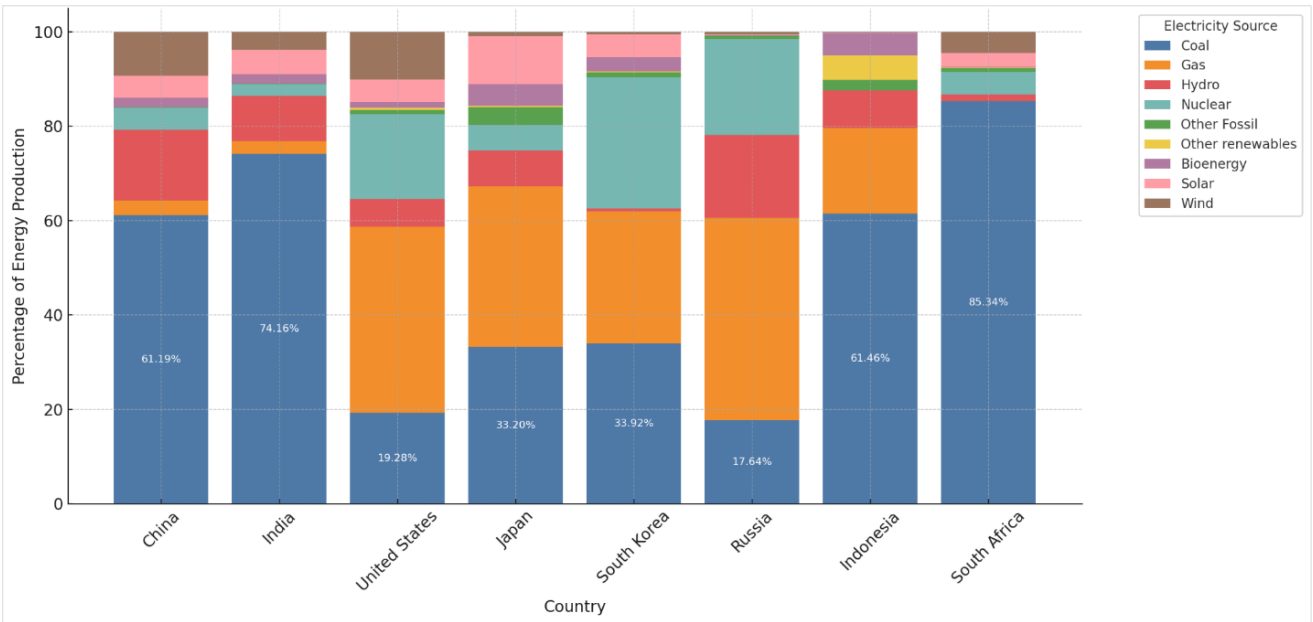


Figure 4: Energy Production by Source and Country. (Source: Ember-Climate.org) [3]

2.2 Pakistan's Current Energy Mix

On the other hand, Pakistan's total installed capacity stood at 41,268 MW [4] with only 13% coal share (both imported and local) while local coal share stood at just 3%. This share is far less in comparison to other developed and developing countries who continue to increasingly utilize coal for their power production needs (Fig 4 & 5).

It is also noteworthy that despite Pakistan's economic landscape stands on uncertain ground, with dwindling foreign exchange reserves casting a shadow over its financial stability, nearly 47% of its power generation capacity relies on imported fuel such as RLNG, Imported Coal and Furnace Oil. For a country like Pakistan with uncertain economy and limited foreign exchange reserves, an import-based energy policy is unsustainable.

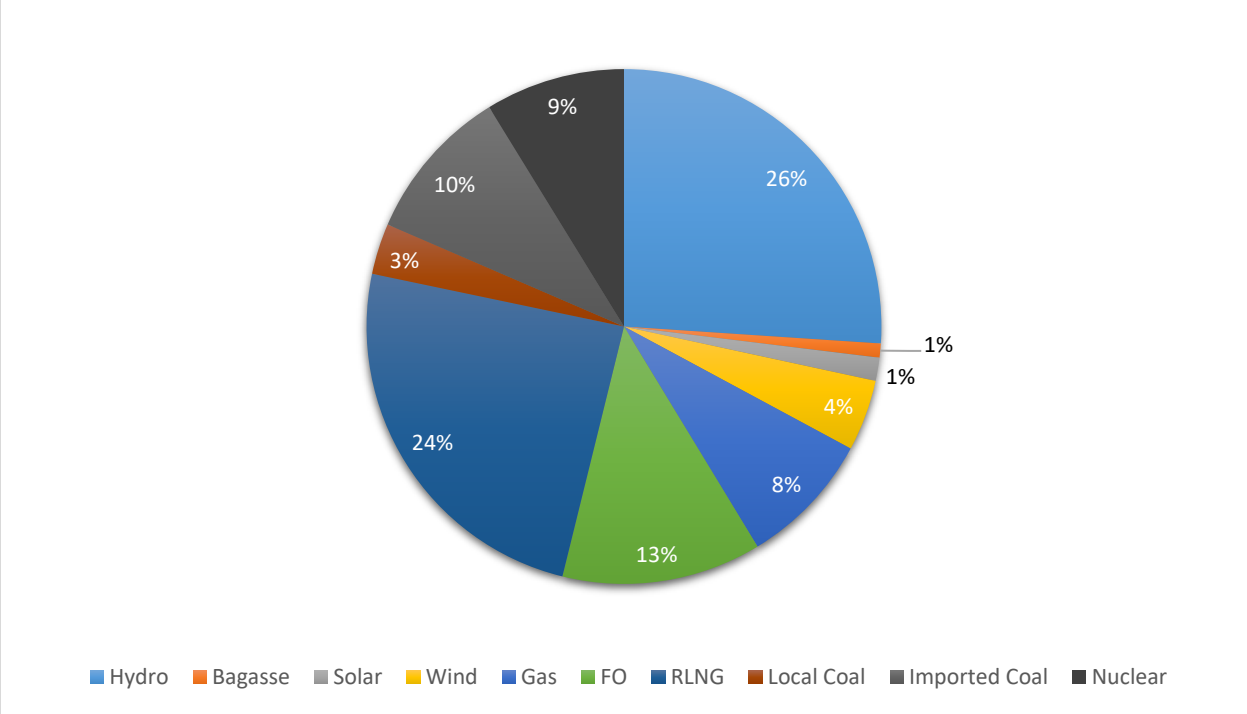


Figure 5: Source-Wise Installed Generation Capacity of Pakistan (2022-23). (Source: IGCEP 2022-31) [4]

3 Pakistan's Coal Reserves and Utilisation

Pakistan potentially possesses huge coal resources amounting to the tune of over 185 billion tonnes of coal in various parts of Pakistan including Lakhra, Thar, Eastern Salt Range, and Duki among

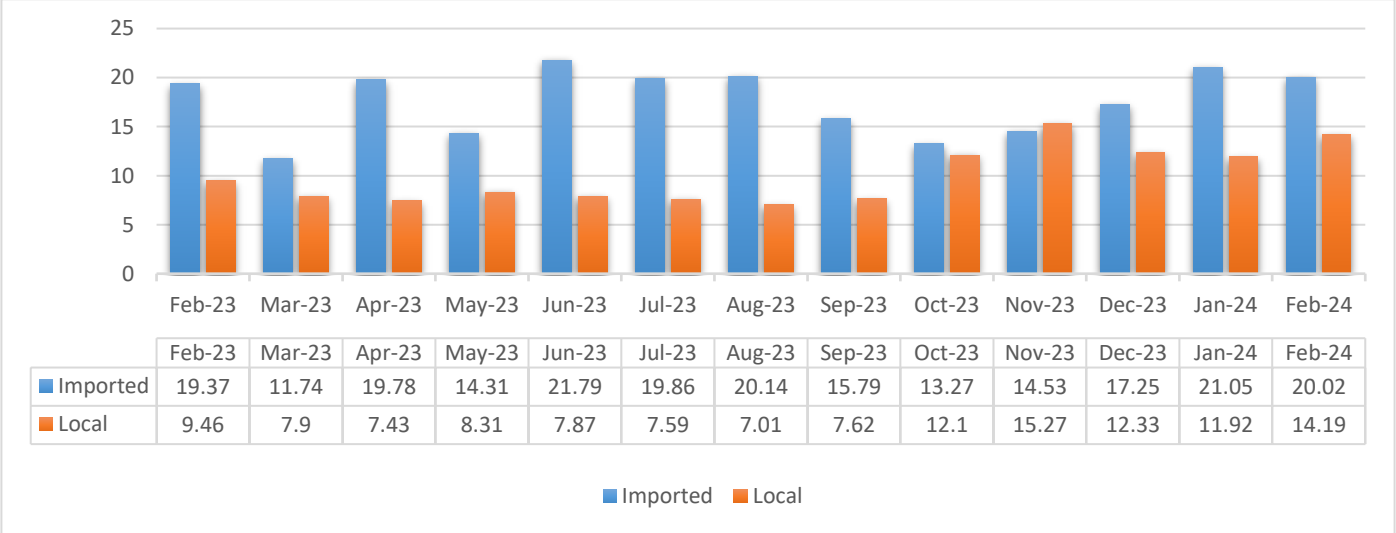
others but out of total reserves, around 175.5 billion tones are potentially found in Sindh's region Thar – making it one of the largest lignite coal (with more moisture content, up to 50%) reserves in the world; equivalent to 50 billion tons of oil, which is more than the oil reserves of Saudi Arabia [5] and can be used to generate 100,000 MW of electricity for over 200 years [6].

Table 1: Quality of Pakistan's Coal Reserves

Pakistan Coal Quality			
Location		**Million Tons**	**Heating Value**
Balochistan	Sor-Range/Degari	50	11,245 - 13,900
	Khost-Sharigh-Harnai-Ziarat	88	9,637 - 15,499
	Mach	23	11,110 - 12,937
	Duki	56	10,131 - 14,357
Punjab	Salt-Range	213	9,472 - 15,801
	Makarwal	22	10,688 - 14,029
Sindh	Thar	175,506	8,244 - 11,045
	Lakhra	1,328	5,503 - 9,158
	Sonda-Jherruck	5,523	5,219 - 13,555
	Meting-Jhimpir	473	5,219 - 8,613
	Indus East	1,777	7,782 - 8,660
	Badin	16	11,415 - 11,521
KPK	Hangu	82	10,500 - 14,149
	Cherat	9	9,386 - 14.217
AJK	Kotli	10.59	7,336 - 12,338

However, Pakistan continues to spend its precious foreign exchange reserves to import coal among other imported fuels. In last one year alone, Pakistan spent around $467 million [7] just to import

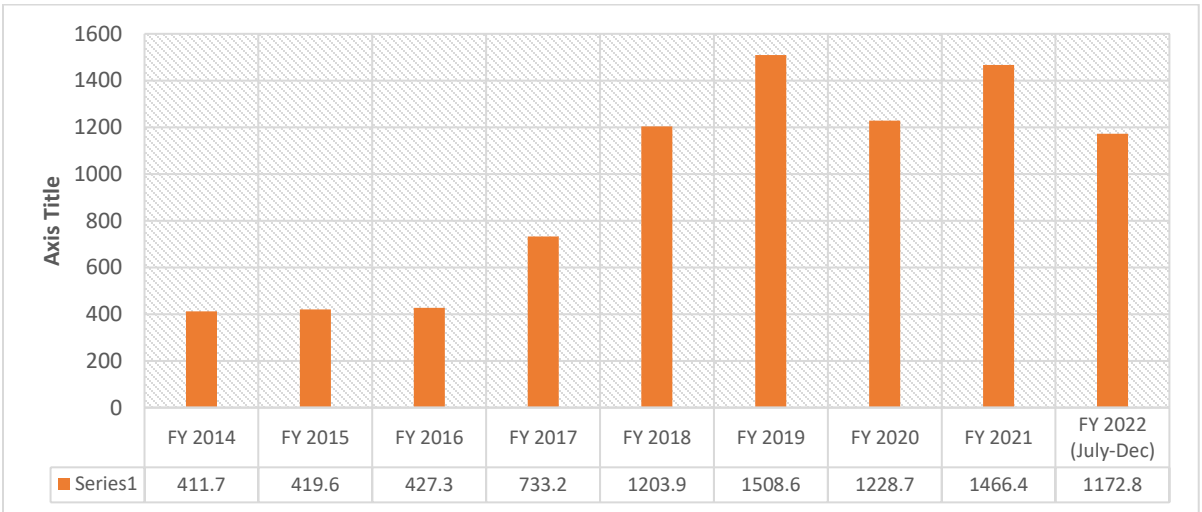
coal for its power production needs. Currently, electricity is being produced at a cost of PKR 20.02/kWh using imported coal as opposed to indigenous coal has a cost of i.e. PKR 14.19/kWh [7].



	Feb-23	Mar-23	Apr-23	May-23	Jun-23	Jul-23	Aug-23	Sep-23	Oct-23	Nov-23	Dec-23	Jan-24	Feb-24
Imported	19.37	11.74	19.78	14.31	21.79	19.86	20.14	15.79	13.27	14.53	17.25	21.05	20.02
Local	9.46	7.9	7.43	8.31	7.87	7.59	7.01	7.62	12.1	15.27	12.33	11.92	14.19

Figure 6: Coal Price in PKR - Imported Vs. Local (Feb-23 to Feb 24). (Source: Monthly Power Sector Report, Arif Habib Ltd.) [7]

Since FY 2020 till Dec 2022, Pakistan has spent around USD 3.86 Billion for Coal imports.



	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022 (July-Dec)
Series1	411.7	419.6	427.3	733.2	1203.9	1508.6	1228.7	1466.4	1172.8

Figure 7: Coal Imports (Million US$). (Source: PIDE) [8]

Given the potential of local coal in attaining energy security for the country, National Electric Power Regulatory Authority (NEPRA), on various occasions have stressed upon the dire need to utilize the indigenous resources for power production. In its State of the Industry Report 2023 (SOI 2023), states that "Promoting maximum local coal use is necessary to reduce the reliance on imported fuel, burden on foreign exchange reserves, and ensure a secure supply." [9]

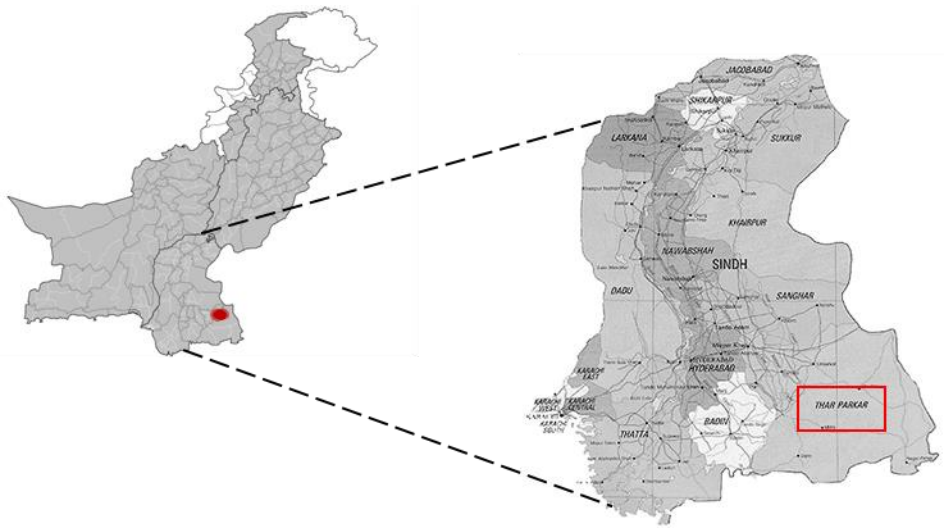


Figure 8: Geographical Location of Thar. (Source: Open Source Web)

The 16% of total Thar reserves are divided into twelve blocks with an area covering 1,121 sq. km. Blocking of the remaining 84% of reserves still needs to be done [8]. Table 2 lists the coal qualities of different blocks whereas table 3 gives a comparison of the quality of Thar coal with other major lignite coal mines of the world.

Table 2: Thar Coal Qualities (Source: PIDE) [8]

Block	Area (km^2)	Total reserves (billion tons)	Moisture (%)	Ash (%)	Volatile Matter (%)	Sulphur (%)	Heating Value (Btu/lb.)	Fixed Carbon (%)
I	122.0	3.56	43.13	6.53	30.11	0.92	6,398	20.11
II	79.6	2.24	47.89	7.37	25.15	1.12	5,008	19.68
Ill-A	99.5	2.00	45.41	6.14	28.51	1.12	6,268	19.56

111-B	76.8	1.45	47.72	9.30	25.49	1.15	4,808	16.79
IV	82.0	2.47	43.24	6.56	29.04	1.20	5,971	21.13
V	63.5	1.39	46.82	8.92	30.24	1.20	5,682	13.26
VI	66.0	1.65	46.80	5.89	29.34	0.90	5,727	16.60
VII	100.0	2.17	48.27	8.03	25.30	1.16	5,440	25.30
VIII	100.0	3.03	49.57	7.78	24.32	1.44	5,302	18.10
IX	100.0	2.86	48.60	5.92	29.03	0.96	5,561	15.73
X	100.0	2.87	48.99	6.35	30.79	1.17	4,840	13.54
XI	101.0	1.61	49.97	8.07	24.16	1.61	5,228	17.26
XII	100.0	2.34	50.82	5.71	25.00	1.11	5,459	17.26

Despite the tremendous potential of Thar coal, several misconceptions and concerns have developed blockades and hesitation to fully leverage it:

4 Issues Associated with Non-Utilization of Thar Coal

a) **Issue 1 – Quality Concerns**: Thar coal is lignite, which has a high moisture level, necessitating the burning of larger quantities to generate the same amount of power.

   While this stands true, that does not make Thar coal completely unusable or unreliable. Many regions with high lignite resources continue to utilize it for power production and to meet other needs.

Table 3: Thar coal comparison with other major lignite coal mines (Source: PACRA Data Base) [10]

Deposit	Heating Value	Sulphur	Ash	Moisture
Region	(Net)(Kal/kg)	%	%	%
	Higher is better	Lower is better	Lower is better	Lower is better
Thar Block II	2770	1.07	7.8	47.46
Gujrat, India	2600-3000	3.4-5.9	9-12	38-40
Hambach, Germany	1911-2747	0.2-0.4	2-5	48-52
Martiza East, Bulgaria	1550	4.5	19 - 35	54

Case of Kosovo

Kosovo, a small country in Southeast Europe, and home to nearly 2 million population, possesses nearly 14,700 billion tons of lignite. Despite being in size of just 10,887 km^2, contains the fifth largest lignite reserves in the world [10].

Currently this country's 90% of electricity needs are fulfilled through production using lignite [11]. Its region Kosovo Basin has around 12 billion tons of lignite, primary source of coal for the country, with moisture levels as high as 45-47% and Ash rate reaching as high as 18% [12].

b) **Issue 2 – Environmental Concerns:** The combustion of Thar coal, like other lignite sources, leads to higher emissions of CO_2 and pollutants, contributing significantly to climate change and environmental concerns.

Per 2022 global data available, Pakistan's power sector only contributes to 0.35% to global Greenhouse gas (GHG) emissions [13] as opposed to other countries such as China's 40%, India's 8.5%, USA's 11%, and Russia's 5% contribution to global GHG emissions.

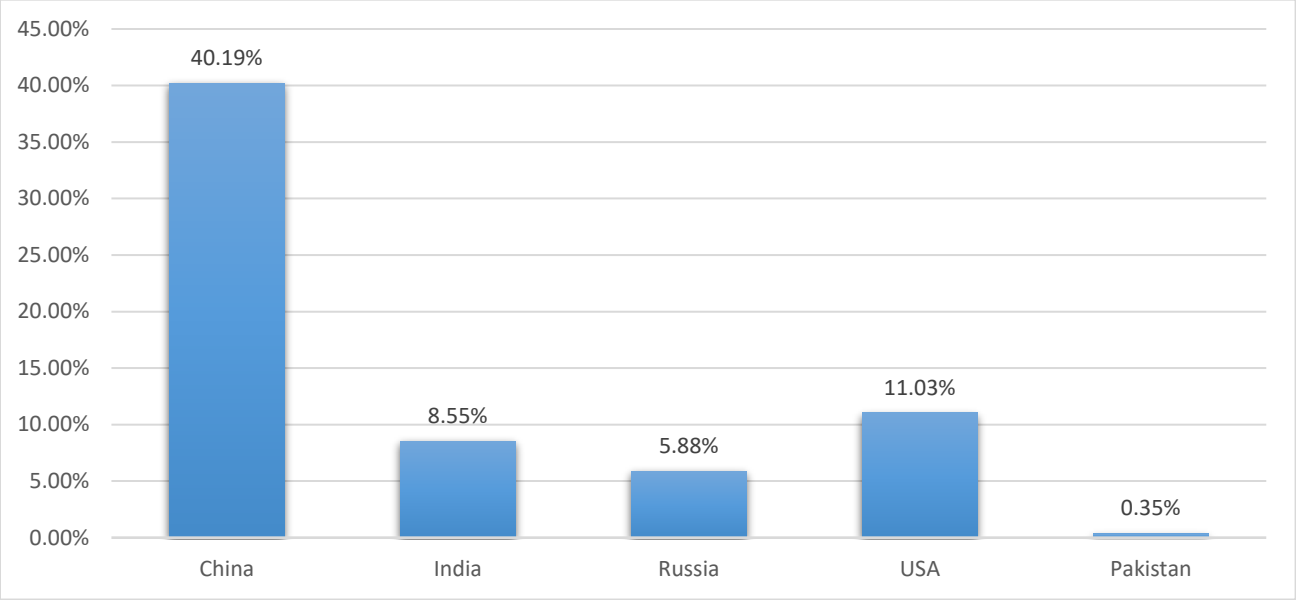


Figure 9: Power Sector Contribution to GHG Emissions in 2022. (Source: Edgar - Emissions Database for Global Atmospheric Research Report 2023) [14]

While it is true that utilization of lignite leads to higher GHG emissions; Pakistan, as one of the most vulnerable countries to climate change, continues to pay a hefty price already despite being quite insignificant contributor to the global GHG emissions landscape especially if we look at the power sector. If Pakistan needs to attain energy security by utilizing indigenous resources, it must find a way to enhance the utilization of these resources while balancing the GHG emissions.

Fortunately, advancements in the power sector have introduced various new efficient technologies for the coal-based power plants that provide higher efficiency even for lignite coal by considerably reducing GHG emissions.

In Pakistan, most of the coal-based power plants utilize either sub-critical or super-critical technology [9]. Only two operational coal-based power plants are currently super-critical namely Lucky Electric Power Company (660 MW) with a plant efficiency of 39% and Sahiwal Coal Power Project by the name of Huaneng Shandong Ruyi (1320 MW) with a plant efficiency of 40% [9].

Table 4: Efficiency Comparison of Different Boiler Technologies in Power Plants. (Source: JETIR, Performance Analysis of Subcritical, Supercritical, and Ultra-Supercritical Coal Power plants) [15]

Category	Efficiency %
Sub-Critical Power Plants	~ 38%
Super-Critical Power Plants	~ 43%
Ultra Super-Critical Power Plants	~ 47%
Advanced Ultra Super-Critical Power Plants	~ 50%

Note that Siemens, the energy giant, reported that just a 1% gain in efficiency for a typical 700MW plant reduces 30-year lifetime emissions by 2,000t NOx, 2,000t SO_2, 500t particulates and 2.5 million tonnes of CO_2 [16].

Case of China's Yuhuan 4,000 MW Supercritical Power Station

Located in China's Zhejiang Province, Huaneng Yuhuan power station is China's first ultra-super critical power station with 4 units having capacity of generating 1,000 MW each. The overall net efficiency of this power plant is calculated at 46% [16].

Case of World's First Advanced Ultra Supercritical Power Plant in India

As part of its National Action Plan on Climate Change, India has announced the construction of world's first 800MW power plant based on Advanced Ultra Supercritical technology. Phase I, the R&D Phase, has been completed successfully while second phase of its construction is currently underway [17].

c) **Issue 3 – Limited Availability of Transportation Infrastructure:** The Thar region lacks the necessary transportation infrastructure, making it challenging to efficiently move large volumes of coal to power plants or export terminals.

While countries that heavily rely on coal for power production, such as India, have started to fast deplete its coal resources [18], Pakistan is still in need of developing a sustainable transportation linkage, such as a railway, between its largest coal reserve in Thar and major consumption centers in other parts of the country.

Currently, coal transportation relies heavily on trucks, which proves to be an expensive and time-consuming method, unsuitable for large-scale bulk supply increases [19].

If Pakistan becomes successful in building a sustainable railway track to bridge a connection, the supply of Thar coal to fertilizer and cement manufacturers will also be possible, while offering the potential for coal-to-gas conversion bringing tremendous economic prospects for the country [19].

Citing the potential economic benefits to the country, NEPRA in its SOI Report 2023, has also stated that "Nuclear and Thar Coal-based plants stand as the most viable options for base load power, necessitating concerted efforts towards further developing Thar Coal mines and associated infrastructure such as railways." [9]

In December 2023, the Executive Committee of the National Economic Council (ECNEC), led by the then interim Finance Minister Dr. Shamshad Akhtar, approved Coal Railway Connectivity project for Thar with the existing railway network at the total rationalized cost of Rs. 53.7 billion [20]. The Thar Coal connectivity project aimed to construct around 105-kilometer long new single-line railway track infrastructure from Thar Coal Mines to New Chhor Station and a construction of an 18-kilometer long double-line track from Bin Qasim to Port Qasim. The proposed railway system was envisaged to have the capacity of transporting 10 MTPA of coal which would save the national exchequer from importing fuel amounting to $1.50 billion per annum [20].

Ironically, the approval of the project was not part of this year's Public Sector Development Programme (PSDP) and there was no allocation in national budget for it that leaves the fate of this project in the hanging [21].

Indian Railway System and Coal Supply

In March 2023, Indian Railways had decided to purchase over one lac additional wagons to ensure swift coal transportation to different power plants across the country.

In the financial year 2017-18, the railways transported 555.20 million tonnes (MT) of coal to the power sector. While in FY 2018-19, 2019-20, and 2021-22, it supplied 605.84 MT, 586.87 MT, 541.82 MT, and 652.80 MT of coal respectively [22].

5 Current Coal-Based Power Plants in Pakistan

5.1 Overview

Per Performance Evaluation Report (PER) of Operational Power Plants for FY 22-23 by NEPRA, Pakistan currently has 8 coal-based power plants installed [23]. Out of which 4 are based on local coal while 4 are based on imported coal.

As shown in the table 5, all local coal-based power plants are currently utilizing sub-critical (with lowest efficiency) technology except one. While, imported coal-based power plants are utilizing Super-Critical technology (with relatively better efficiency) but due to lack of transportation infrastructure, there is an inherent hinderance for blending local coal in the exported coals despite having the possibility.

Table 5: Coal Based Power Plants Operational in Pakistan

S#	Power Plant	Installed Capacity	Plant Efficiency (%)	Technology
Local Coal				
1	Engro Thar	660 MW	35.20%	Sub-Critical [24]
2	Thar Energy	330 MW	37% [25]	Sub-Critical [26]
3	Thar Coal Block-1	1,320 MW	39% [27]	Super-Critical [28]
4	Thal Nova	330 MW	37% [29]	Sub-Critical [29]
Imported Coal				
5	Sahiwal Power Plant	1,320 MW	40.69%	Super-Critical [30]
6	Port Qasim Power Plant	1,320 MW	39.10%	Super-Critical [31]
7	China Power Hub	1,320 MW	38.34%	Super-Critical [32]
8	Lucky Electric Power	4,620	37.35%	Super-Critical [33]

Source: SOI Report [9], CPEC [24, 26, 28, 30-32]

Blending Ratio:

Super-Critical power-plants are designed to utilize 100% sub-bituminous coal. Based on global experiences in boilers firing sub-bituminous coals, a moisture content of 30% is the maximum limit for such boilers to avoid any damage to the boiler. In SC plants in Pakistan, Thar coal can be mixed up to 20% [34].

Given the current scenario, it remains critical for Pakistan that technological upgradation of existing indigenous coal-based power plant is made for better efficiency for economic and environmental benefits, meanwhile any upcoming coal-based power project should be based on indigenous resources.

5.2 Comparison between CFPC and PCC Boilers

The coal fired power plants utilize either pulverized coal combustion (PCC) or circulating fluidized bed combustion (CFBC) systems. The efficiency of CFBC compared to PCC is generally higher. CFBC technology offers better fuel flexibility, lower emissions, and higher efficiency than traditional PCC boilers. The combustion efficiency in CFBC boilers is generally higher, often exceeding 99%, due to the efficient mixing of fuel and air in the fluidized bed. On the other hand, PCC combustion, while well-established and widely used, may result in higher NOx and SOx emissions due to higher combustion temperatures, impacting overall efficiency. Therefore, in terms of efficiency, CFBC is typically more efficient than PCC combustion. The boilers in Pakistan use Pulverized Coal Combustion (PCC) coupled with either subcritical or supercritical boiler technology. However, Circulating Fluidized Bed Combustion (CFBC) technology, used by modern industries and power stations, offers lower environmental hazards and greater efficiency in power generation. Moreover, CFBC technology has several advantages over PCC few of them are [35];

i. It fires high ash content, high moisture content, and high sulfur content lignite coal without losing the reliability of plant.
ii. It tolerates the declining quality of mine coal.
iii. SOx and NOx emissions are ultimately reduced because SOx removal is carried out inside the boiler by directly injecting limestone and no issues are faced with the NOx emissions because of lower furnace temperature i.e. 800–900 °C.
iv. Separate Baghouse filter for boilers to control particulate matter.
v. Dust suppression system.
vi. Separate Continuous Emission Monitoring System (CEMS) for boilers.

Conventionally, lignite is used with PCC subcritical boilers which have the least efficiency of all the boiler setups currently active globally. However, studies have shown that lignite can be used with supercritical and ultra-supercritical boilers [36]. GE also offers ultra-supercritical boilers with both CFBC and PCC configuration capable of operating on lignite coal. Therefore, it is essential that the boiler technology being used in Pakistan be upgraded to CFBC with supercritical or ultra-supercritical boilers to maximize the efficiency and lower the carbon footprint.

6 Local Coal Potential in Reducing Burden on the National Exchequer and Consumers

Since February 2023 through February 2024, Pakistan has allocated approximately USD 2.7 billion (according to the current dollar rate against the Pakistani Rupee) to import fuel for power production [7]. Remarkably, this expenditure nearly matches the USD 3 billion loan secured by Pakistan from the International Monetary Fund (IMF) in July 2023 [37]. Consequently, harnessing local coal resources could significantly reduce the financial burden on the national exchequer, presenting a strategic opportunity to enhance energy self-sufficiency.

Furthermore, recent estimates by government authorities suggest that converting imported coal-based power plants to local coal could save $800 million (PKR 222.572 billion) annually and reduce electricity prices by Rs. 3 per unit [38]. According to NEPRA's SOI Report 2023, there were 112,891.20 GWh consumed in FY 22-23 [9]. Had these imported coal-based power plants were converted to local coal, power consumers could collectively save approximately USD 1.2 billion (PKR 338.67 billion) per year.

Case in Point: Jamshoro Power Company Limited (JPCL) Alone Has the Potential to Save USD 2.54 billion with Conversion to Local Coal

Conceived before 2013 with 2 units of 660MW each, the project design envisages that it would utilize 80% imported coal and 20% local coal. The Commercial Operation Date (COD) of the unit 1 of this power plant was November 2023 yet is currently facing a delay. It is expected that once it comes online, the Government of Pakistan would require to arrange approximately USD 3 billion for procuring imported coal for the operation of this plant. However, K-Electric, being its power purchaser, has expressed its strong desire to have this power plant converted a 100% on local coal, which, as per estimates, would bring a saving of around USD 2.54 billion through the 30 years life of this project. K-Electric has evaluated that the conversion of JPCL's Unit-1 to Thar coal would require investments in modification in the power plant, railway track for transportation of coal to the project site from Thar coal mines, expansion of Thar coal mine, and the Coal Drying equipment. The combined investment required for these infrastructure enhancements are estimated to be $ 402 million for Unit-01 [39].

Moreover, the conversion of Unit-01 on Thar coal would also create a unique opportunity for the GoP, to facilitate the conversion of currently installed 3,600-MW capacity on imported to Thar coal, by creating template for others to emulate [39].

7 Proposed Solutions

Pakistan faces a significant challenge with its energy imports, which strains its energy security. Tapping into the country's energy resources is essential to address this issue. Following are some of the challenges and recommendations for the transition to local Thar Coal.

- Commissioned subcritical power plants or pipeline technology must be upgraded or retrofitted to more efficient supercritical and ultra-supercritical. The power companies must be facilitated and incentivized to upgrade their technology.
- Upcoming coal-based power plants such as JPCL must be converted to local coal as it would set a precedent for others to follow.
- Process to convert imported coal-based power plants to local coal should be expedited as they could save $800 million annually and reduce electricity prices by Rs. 3 per unit which can bring enormous savings to the nation as well.

- Until the conversion is not achieved, 20% blending of Thar coal should be made mandatory in commissioned supercritical plants to conserve foreign exchange reserves. These savings should than be utilized to upgrade the technology of installed power plants.
- A robust railway link / transportation system needs to be established from Thar coal fields to the power plants to ensure continuous supply of coal with minimum cost.
- No new coal fired power plants be approved unless they utilize Thar coal with ultra-supercritical boilers preferably with CBFC instead of PCC.

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