

In-house Power Generation for Industry and its Economic Impact

Acknowledgements

This study is commissioned by All Pakistan Textile Management association (APTMA) to Socioeconomic Insights and Analytics (SIA) (PVT) Ltd for an independent review.

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Executive Summary

The emergence of in-house power generation facilities following the Power Policy 1994—classified as Captive Power Plants (CPPs) in 2019—empowered Pakistan's industrial landscape. Regrettably, to comply with structural benchmarks committed to the IMF, the disconnection of gas supply to CPPs has reportedly commenced. This study finds:

- **The energy sector, encompassing gas and power, is currently ill-prepared to directly confront the challenges posed by shifting industrial load from the gas to the power sector!**
- **The cost to the industry and exports will be enormous, and given BOP difficulties, Pakistan cannot afford such a rapid transition.**
- **Gas is being used as part of their industrial process and removing it will be highly disruptive.**

Grid electricity is not viable given its high costs and unreliability. Disconnecting gas to in-house power generation facilities and shifting the industry to the grid will make the industry globally uncompetitive—if it survives.

- **In-house power generation has become integral to industrial processes.**
- **Industries have invested billions of rupees in upgrading their generation systems to achieve high efficiencies; shifting them to the grid will waste this investment.**

In-house power generation facilities, particularly **combined heat and power (CHP) or cogeneration plants, are even more efficient than government RLNG power plants.**

In-house power generation is closely associated with industrial processes and value addition and should not be considered a separate category based on their effectiveness and benefits for industry.

- **Cogeneration plants undeniably fall under the category of industrial processes, showcasing remarkable technical and operational efficiency rather than being solely an electricity-generating source. Therefore, *these plants must be reclassified as industry (process)*.**
- **The Supreme Court has ruled that industrial consumers who generate electricity in-house for their own use are doing so as part of the industrial process.**

Cutting off gas supply to in-house power generation facilities and shifting the industry 100% to the grid will inevitably translate into:

- **Closure of over 1400 large units and unlimited smaller units in the textile sector supply chain, leaving around 3 million people jobless** (actual unemployment is even higher if smaller units are accounted for).
- **Cutting gas supply to industrial in-house power generation facilities will undoubtedly lead to further widespread deindustrialization.**
- **It will lead to a drop of 6% in export revenue which equates to a loss of around US\$3 billion in export earnings** (conservative estimate); the actual impact will be much greater.

In the gas sector, there is no market, and the sector is overregulated. Industrial power generation facilities are cross-subsidizing other sectors. It will not be financially viable even for the gas sector if industries switch to the grid.

- **The diversion of industries with gas-fired power generation facilities to the grid will result in a revenue shortfall of PKR 391 billion for Sui companies.**

Indigenous gas resources are dwindling quickly due to years of mismanagement, politically motivated decisions and policies, subsidies, and cross-subsidies. Pakistan is now relying on LNG imports. In the LNG sector, gas utilities' lack of proper planning and foresight and excessive government involvement in the supply chain have compromised the reliability and cost of gas/RLNG supply across sectors.

US\$ 0.11/ kWh is the energy-price threshold for the overall manufacturing industry in Pakistan. It is a critical threshold beyond which the industry can no longer sustain its operations and will be compelled to shut down.

Grid is not viable for productive sectors! Allow 3rd Party Access and wheeling of gas/power with open access for all market participants. Let the market develop—the market will create its demand.

Due to changing gas market dynamics globally, gas markets in several countries have shifted towards WACOG or price pooling formulas. Given Pakistan's dwindling local gas resources, and huge difference between the cost of local gas and RLNG, **WACOG is the best option for SNGPL and SSGCL consumers, as a starting point.**

- **Complete deregulation of the gas sector is the first-best solution!**
- **Open access and wheeling of gas is the only option for sector survival and growth.**

By deregulating and liberalizing the natural gas sector and its pricing structure, Pakistan can create a more efficient and competitive market, improving service quality and increasing investment in E&P sector.

CTBCM must be implemented fast, and wheeling costs should not factor in sector inefficiencies but based on the principle of marginal cost pricing.

In the textile sector, it will result in:

- **3% more investment**
- **3% growth in export revenue**
- **Reactivation of closed units, unlocking more job opportunities!** Reopening closed production units and activating idle capacity could **increase annual exports by up to \$9 billion.**

The cost of electricity under a B2B contract, equal to or less than 9 cents/kWh, would incentivize industries to shift away from gas-based CPPs without compromising their competitiveness. It will be feasible to cut off the gas supply to industries only after the development of the wholesale market in five years. Industries have made significant investments in CPPs and should be given sufficient time to recoup those investments.

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PREFACE

Background

The emergence of independent in-house power generation facilities has empowered Pakistan's industrial landscape. **The Power Policy 1994 incentivized industries to take charge of their energy needs by investing in independent power generation facilities.** By doing so, industries were able to combat the chronic challenges of power outages and grid inefficiencies that had long impeded their operations.

Notably, no policy since then has discouraged or banned in-house power generation, underscoring its pivotal role in driving industrial progress. Exporting firms rely more on in-house power generation! An estimated installed capacity of Combined Heat and Power Plants (CPP) exceeds 5500MW, with the majority located in the textile sector (PSIA, 2023).

A survey at PIDE found that firms rely on in-house power generation for over 50-80% of their energy needs. **Despite high gas costs, the average cost of power generation through in-house gas-fired plants is still cheaper than grid electricity due to the inefficiencies and cross subsidies embedded in power tariffs.** CPPs are on average more efficient in the use of gas than the counterpart power producers. Not just grid tariff, its unreliable supplies, and in many cases, especially in Karachi, its unavailability has driven industry away from the grid and towards its own generation.

Following the commitment made with the IMF¹, it is reported in print media and highlighted in correspondence between the petroleum division and gas utilities that **disconnection of gas supply for self-generation of power has begun, with the aim eliminate “captive power” by end-January 2025².**

The rapid expansion of power generation capacity under different power policies, particularly under CPEC, has introduced significant overcapacity during off-peak hours and in winter, leading to underutilization of power plants. The peak energy demands during summer and winter vary between 8,000 and 13,000MW. **Unplanned capacity additions without a corresponding increase in demand and necessary transmission infrastructure force plants to operate below optimal levels.**

A higher installed capacity than the system demand strains the entire energy sector. Capacity payments for 2024 are around PKR 2.1 trillion. Any capacity produced by these plants above the base load of around 12000 to 12500 MW (on average) reflects policy failure

¹ IMF Staff Report, 2024.

² <https://www.brecorder.com/news/40323863/commitment-with-imf-cpps-gas-disconnection-process-begins>

and wrong decisions. The issue of overcapacity significantly drives up the cost of electricity per unit, regardless of the amount consumed.

In fact, with this rise in tariffs, electricity demand has started going downwards (10,528GWh during FY23). This impacts everyone and underscores the urgent need for action. The current transmission and distribution infrastructure is inadequate, and struggles to manage electricity effectively, despite having excess capacity. The mismatch between generation capacity and transmission and distribution capability leads to financial losses. The high fixed costs in the tariff amplify these inefficiencies, resulting in suboptimal grid operations and hindering the grid's capacity to manage surplus power effectively at affordable tariffs.

Study Scope

The energy sector, encompassing both gas and power, is currently ill-prepared to directly confront the numerous challenges posed by shifting captive load from the gas to the power sector! In the short to medium term, it will not be economically viable for industry to shift to the grid. Furthermore, there is no gas market, and the sector is over-regulated. Industrial CPP tariff is cross-subsidizing other sectors. It will not be viable even for the gas sector to switch CPPs to the grid.

The study aims to evaluate the significance of in-house power generation for the industry and suggest a viable way forward for the industry and the energy sector.

The study will assess,

- Tariff design in power and gas sector - cross-subsidies across sectors
- The impact of shutting gas supply to industrial self-generation facilities on industry and the gas sector
- CPP - an industrial process or just an electricity generating plant
- Potential of renewables replacing fossil fuels in industry
- Impact of open access and wheeling of power/gas on industrial competitiveness and the energy sector

Chapter 1

INDUSTRY FOR EXPORTS

1.1. Pakistan's Economic Situation

As of December 2023, Pakistan's total debt and liabilities amount to PKR 81.19 trillion (SBP, 2024). Pakistan's external financial requirements exceed USD 120 billion over the next five years (PIDE, 2024). Pakistan's foreign exchange reserves stand at US\$13.4 billion as of April 09, 2024 (SBP, 2024). Its external financing requirement far exceeds its gross reserves.

Leaving aside domestic debt, the markup on foreign debt in FY2023 stands at Rs 511 billion. The Pakistani rupee against US\$ has dropped continuously from PKR 162.01 (end-period) in 2019 to PKR 286.14 (end-period) in 2023.

Limited foreign exchange reserves and rising debt burden are serious concerns for Pakistan's economy. PIDE (2024) emphasizes that **promoting exports and attracting investment should be a national priority. Currently, Pakistan's export competitiveness is declining, which is attributed high energy prices and misallocation of energy resources.**

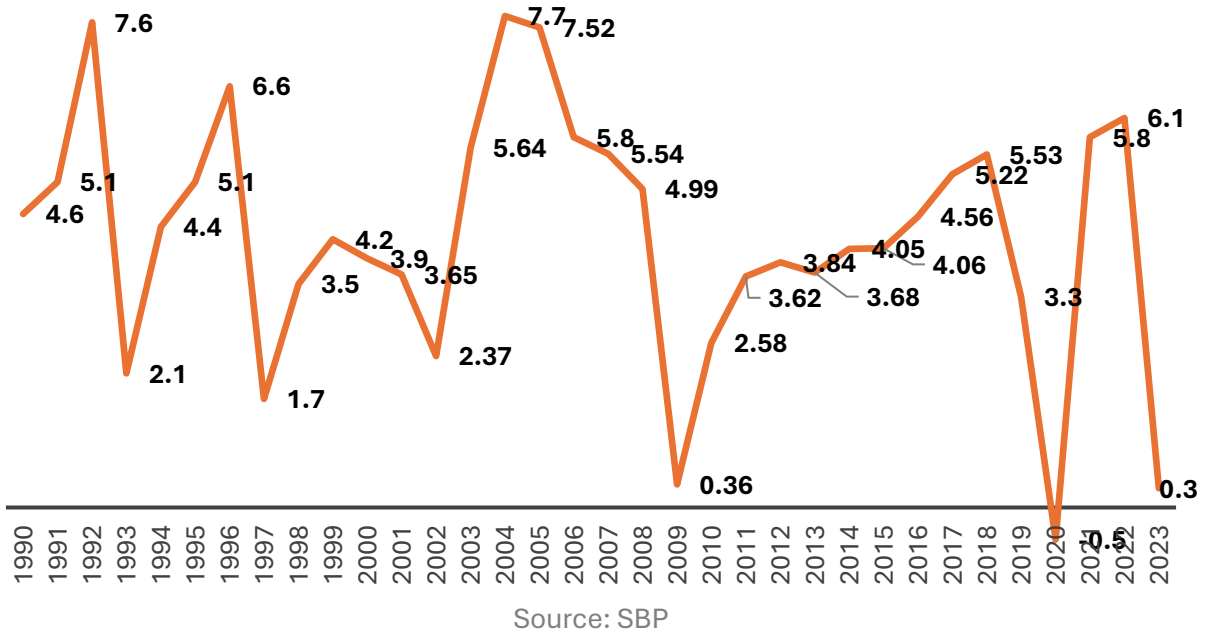
1.2. Industry & Growth

GDP growth over the years has remained inconsistent (Figure 1). Building a robust overall economy, maintaining a stable macroeconomic environment, and increasing export growth are crucial to achieving sustainable GDP growth.

Industrial contribution to GDP:

- 19.1% in FY2022
- 18.4% in FY2023
- 18.2% in FY2024

Figure 1. Real GDP Growth (%)



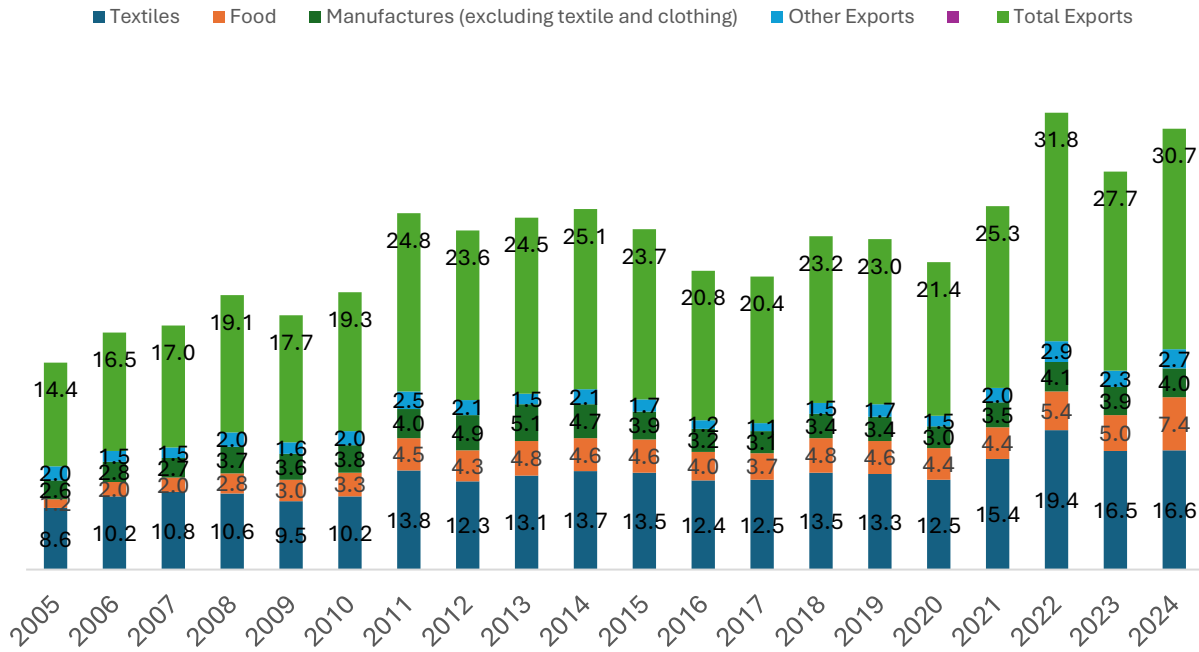
1.3. Exports Growth

High energy costs and energy unavailability became the reason behind the closure of about 100 textile manufacturing units between 2014 and 2018 (PIDE, 2021). Textile exports remained almost stagnant during this period.

Again, textile exports have become almost stagnant in the last two years; food exports have grown slightly (Figure 2). Pakistan needs all firms to be exporting firms (PIDE, 2024). Our energy policy must be pro-exports. It is critical to meet the gap between exports and imports (Figure 3). If the current trend persists, in addition to decreasing remittances, it is expected to exert additional pressure on our already meagre foreign exchange reserves.

Sustainable GDP growth relies on a robust economy, stable macroeconomic environment, enhanced export growth, and comprehensive reforms, especially in the energy sector.

Figure 2. Pakistan's Exports by Commodity (Billion US\$)



Source: SBP & FBS

Figure 3. Exports vs Imports (Billion US\$)



Source: WDI

1.4. Major Challenges for the Industry

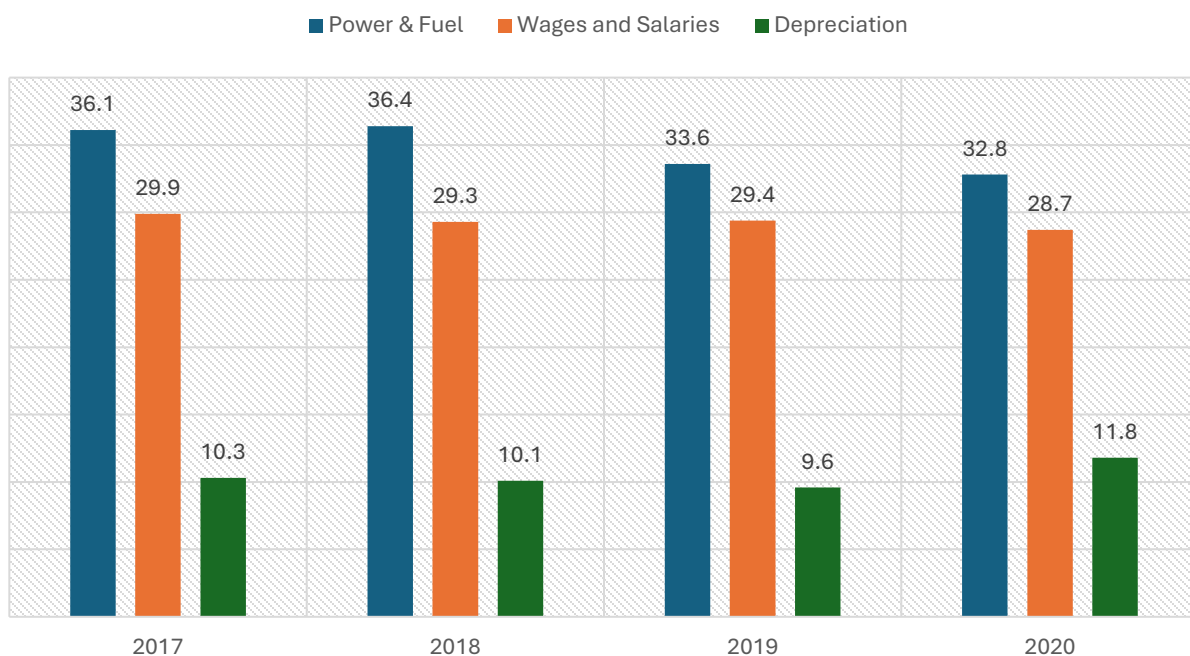
- High input costs and availability
- High finance costs
- Taxation issues
 - 18% sales tax
 - 2.5% advance tax (1.25% minimum turnover + 1% export proceeds + 0,25% export development surcharge)
 - 29% final income tax
 - up to 10% super tax
 - delays and shortcomings in FBR tax returns
- Regulatory & bureaucratic hurdles
- Inconsistent government policies

On top of these is

- **High energy costs and its availability**

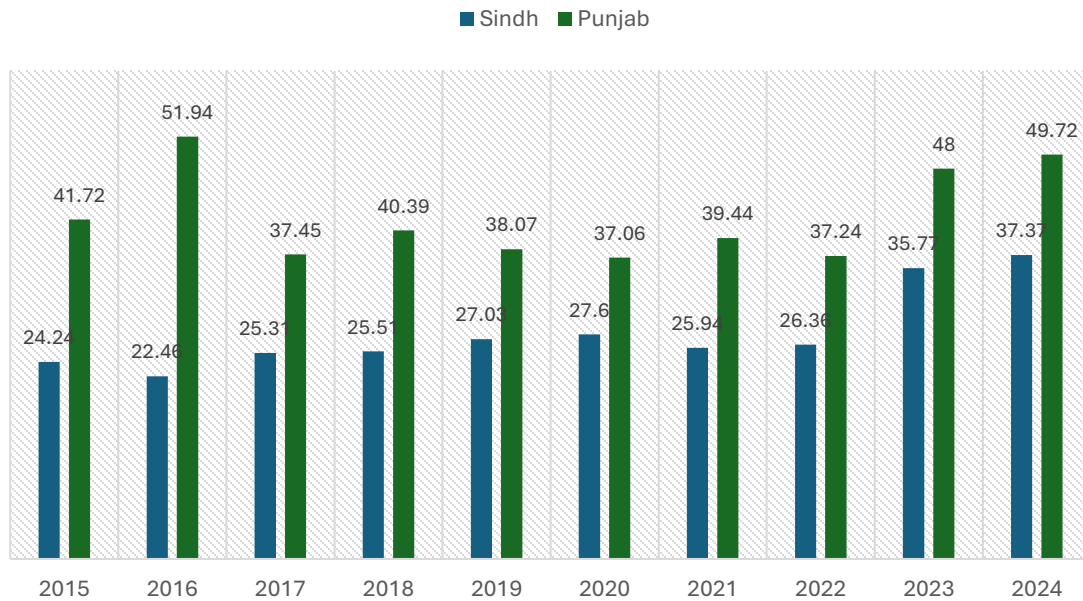
PIDE (2021) on Regionally Competitive Energy Tariffs and Textile Sector's Competitiveness finds **energy costs are the leading component in the conversion cost** (Figure 3). The variation between Punjab and Sindh (Figure 4) was due to the availability of indigenous gas in Sindh, as provided for in Article 158 of the Constitution. No financially viable energy source was/is available to industries in Punjab.

Figure 4. Three Main Heads of Conversion Costs (%)



Source: PIDE, 2021

Figure 5. Share of Energy in Conversion Cost (%)



Source: Malik et al., 2023 and APTMA

1.5. Energy for Industry and Growth

Gas/RLNG is a major source of energy (in some firms, the primary and only source) used by major industries like textiles to run their operations effectively.

In-house power generation facilities fired by gas/RLNG play a pivotal role in providing the stable voltage and frequency required for export-quality textile and apparel manufacturing. Their operation ensures no frequent interruptions, voltage fluctuations, breakdowns, or occasional brownouts and blackouts, thereby safeguarding the industry from costly disruptions in production processes and damages to expensive machinery. **Shifting entirely to the grid and shutting down in-house generation facilities will increase industries' operational downtime and maintenance costs.**

Other than being used as an electricity-generating fuel, natural gas is also used as fuel for boilers to generate heat and steam for the production process like dry & steam dyeing, and thermo sole dyeing. Gas/RLNG availability issues, particularly during winter when it is diverted to domestic consumers for heating load, significantly impact the performance of industries in the SNGPL network. These issues lead to disruptions in industrial operations, affecting productivity.

For other uses, in the absence of gas, industry must rely on alternative fuels, like coal, diesel or furnace oil, which are more expensive and frequently disrupt the industrial process. Fuel switching can prove highly detrimental to the productivity and competitiveness of the industry (textile or other sectors) in Pakistan.

Box 1. Enough Electricity for Industry?

About 80% of the industry in the South has gas connections. **30% of the industry in the South have only a gas connection and no electricity connection. Besides, there is not enough power available on the grid to meet the energy demand currently being fulfilled through captive generation.**

In the north, applications for load enhancement have been pending for over three years despite the demand notes having been fulfilled. In the southern region, there is a high demand for load enhancement applications, but the industry is facing challenges due to the unfeasible cost (billions of rupees) for liquidity-short (struggling) businesses.

Even though the maximum load allowed on 11kV lines has been increased from 5MW to 7.5MW through NEPRA, significant problems persist in accessing the required power supply from the grid. **The industry needs more than 4,000 MW of additional electricity and supporting infrastructure, including 11KV and 132 KV grid stations for transitioning to the grid. An investment of PKR 20 billion is needed for this project, with a completion timeline of up to two years.**

- In the SNGPL network, more than 60% of CPPs require additional infrastructure for complete switching to the grid.
- In the SSGCL network, 637 active CPPs with grid connectivity require additional infrastructure, which costs PKR 15.8 billion for complete switching to the grid.

Source: SNGPL, SSGCL, and Power Division

Roughly 50% of the industrial gas is used to generate electricity in in-house facilities, while the rest is used for various industrial purposes such as manufacturing fertilizer, cosmetics, plastics, pharmaceuticals, and synthetic materials.

Around 20% to 22% of the total gas consumed by the industrial sector is used explicitly for generating electricity for facilities not connected to the national electricity grid (PSIA, 2023).

The spinning sector in the textile industry uses gas at lower thermal conversion efficiencies in open cycle CPPs, consuming 31% to 34% of the total textile sector gas use during FY23. **Industrial in-house power generation facilities make a substantial financial**

contribution to Sui companies, generating PKR 420 billion in revenue. The industry also provides a cross-subsidy of Rs100 billion, which benefits protected gas consumers (Mustafa, 2024).

The total number of CPPs is 1,386, with 1265 connected to the grid (APTMA). As per government sources (SNGPL, SSGCL, and Power Division), the total number of CPPs is 1189. In Sui Northern, the number is 383, and the remaining are in Sui Southern. It is essential to note that not all CPPs are dual-fuel engines for electricity generation. It can be challenging to distinguish between the gas used in industrial processes and the gas used for electricity generation. In most cases, **gas's non-availability implies a complete shutting down of industrial operations.**

Chapter 2.

SELF-GENERATION OF POWER FOR INDUSTRY

2.1. Industrial In-House Power Generation in Pakistan

Industrial in-house power generation facilities (interchangeably referred to as CPPs), including co-generation plants, are crucial in ensuring a reliable supply of electricity for industries. They serve as a vital supplementary source to meet the country's electricity demand, underscoring their national significance.

Over the years, successive governments have supported industries in developing and operating CPPs; policies incentivized investment in self-generation and ensured continuous gas supply. **In-house generation facilities were promoted as a solution to the national energy crisis, and industries saw them as a way to meet their growing energy demand.**

There is a total of 1189 captive consumers³. Estimated indigenous gas consumption on systems of both gas utility companies is 242 MMCFD, of which,

- 59 MMCFD is on SNGPL network
- 183 MMCFD is on SSGCL network.

Estimated RLNG consumption is 156 MMCFD (SNGPL - 73% and SSGCL -27%).

2.1.1. Gas for Industrial In-House Generation Facilities

Currently, industrial in-house power generation facilities fired by gas are classified as captive consumers and provided different blend proportions of indigenous gas and RLNG on the Sui networks.

- **For SSGCL, 70% indigenous gas and 30% RLNG, which equals PKR 3258/MMBTU** (at RLNG tariff of US\$ 13.86, Sep- 2024 and exchange rate 278.45)
- **For SNGPL, 25% indigenous gas and 75% RLNG, which equals PKR 3645/MMBTU** (at RLNG tariff of US\$ 13.86, Sep- 2024 and exchange rate 278.45)

The blend ratio for both SNGPL and SSGCL varies depending on the availability of indigenous natural gas.

As per the data available for 1189 captive consumers, also connected to the grid, 55% are export-oriented units (Table 1).

³ As per some sources the number of CPP as 1368, with 1265 connected to the grid.

Table 1. CPPs in Pakistan

		No.	Load (MW)	Gas Consumption (MMCFD)
SNGPL	Export	278	666	96
	Non-export	102	139	20
SSGCL	Export	379	881	127
	Non-export	430	423	61
		1189	2109	304

Source: Power Division

SNGPL Network

- 383 CPPs under SNGPL, consuming 59 MMCFD indigenous gas and 114 MMCFD RLNG. Over 78% are cogeneration units.
- SNGPL survey of 169 units, 2% were found with no grid connectivity and electricity load of 57% was found to be less than their requirement, highlighting significant issues with grid connectivity.
- **CPPs are major RLNG consumers of SNGPL, after the Power Sector. Their departure would reduce SNGPL's RLNG sales, impacting its revenue and leaving around 115 MMCFD of surplus RLNG with no potential buyer, and lead to curtailment of domestic gas and diversion of RLNG to domestic consumers.**
- **If these units leave the network, it will reduce SNGPL's RLNG sales, impacting revenue and leaving around 115 MMCFD of surplus RLNG with no potential buyer. It will expose SNGPL to take-or-pay contractual risks with RLNG suppliers / sovereign default.**

SSGCL Network

- **Captive generating units in the SSGC are mostly off-grid.**
- After the captive power plants in off-grid industrial plants, the textile industry is the second largest gas consumer.
- Due to a shortfall in indigenous gas supply, the ECC, in its decision dated October 23, 2023, authorized SSGC to provide a blend of indigenous gas and RLNG to export and non-export industrial and captive consumers effective December 14, 2023.
- In FY23, about 24% of gas consumed in the SSGC network was by the captive consumers (almost 211 MMCFD).

2.2. In-house Power Generation—Advantages for Industry



Reliability



Cost-effectiveness



No transmission & distribution losses

2.3. Textile Sector – Self-Generation Types and Their Efficiency

In-house power generation facilities, which come in various types, are utilized for generating electricity and producing heat/steam for industrial processes.

In large vertically integrated textile units (i.e., those housing the full value chain, mostly owned by big business groups) producing value-added goods, heat/steam produced by self-generation facilities is used in industrial processes. In this subsector, the thermal efficiency of gas use goes up to 90%.

On the other hand, most spinning sector facilities are single-cycle power plants (owned generally by small and medium enterprises), where the heat generated is not used in further processes to enhance thermal efficiency.

For the weaving/knitting sector, heat/steam from power generation has limited reuse, and the overall thermal efficiency of gas ranges between 45% to 50%, in some cases even higher than government-owned RLNG plants (GPPs).

It is challenging to differentiate gas usage in in-house power generation facilities. **Heat/steam generated from power generation in weaving/knitting and integrated textile units is used in industrial processes; therefore, charging different prices does not make sense.**

In 2020, the Petroleum Division proposed the following revised thermal efficiency benchmarks for gas-fired CPPs. National Energy Efficiency and Conservation Authority (NEECA) was mandated to conduct third-party audits of all CPPs (exporting and non-exporting).

Petroleum Division Efficiency Benchmarks:

- 45% minimum net efficiency for units up to 50 MW
- 50% minimum net efficiency for units above 50 MW
- 60% minimum net combined efficiency for units where the steam is generated from gas-fired CPPs used in industrial processes

In August 2020, NEECA sent letters to gas-based CPPs identified by SNGPL and SSGCL in response. **As a result of the audit, 481 out of 1,141 CPPs surveyed declared their plants cogeneration facilities** (PSIA, 2023).

It's important to note that in response to NEECA letters, **industries (all types) invested billions of rupees in upgrading self-generation facilities, including their engines, turbines, etc., and expressed their willingness to undergo a third-party audit.**

- **For instance, Kohinoor Mills installed three 2.5 MW fuel-efficient Caterpillar Model G3520H Gas Engines and waste heat recovery systems within a year, investing more than PKR 420 million. Even if three-fourths of this amount is invested in 481 units, the total is approximately PKR 152 billion** (only a conservative estimate, actual CAPEX by firms is likely to be significantly higher than this).

In a sample of 325 textile industrial (APTMA Survey):

- CPPs, the connected grid load is 1281MW. The combined installed capacity of CPPs is currently 3,381.26 MW.
- **57% of these are using steam for further processes, that is, cogeneration (or combined heat and power (CHP)). This means that industries have already made huge investments in upgrading these generation facilities.**
- **CHP's efficiency can reach 90% despite its high CAPEX** (details in the next chapter). **These plants optimize natural gas use to achieve maximum economic output for each unit of energy consumed.**
- They simultaneously produce electricity and heat/hot water/steam for various industrial processes and outperform boilers, which consume 55-60% of process industrial gas.
- In the sample surveyed, the industrial sector consumes 1,469.9 MMCFD of gas and 514 GWh of electricity each month, showing their significant reliance on gas.

2.4. Gas Prices for Industrial Self-Generation: Captive vs Process

Table 2. Gas Prices (PKR/MMBtu)

	FY21	FY22	FY23	Q1-FY24	Sep-2024
Local Gas Industry (Process)	1054	1054	1200	1200	2150
Local Gas (Captive)	1087	1087	1200	1200	3000
Local Gas (EOU)	852	852	1100	1100	3000
RLNG Industry (Process)	1366	2710	3456	3692	3859
RLNG (Captive)	1366	2710	3456	3692	3859
RLNG (EOU)	1040	1127	2136	3692	3859

Source: PSIA (2023) and OGRA (2024)

As illustrated in Table 2,

- **Until recently, there was little difference between industry (process) and industry (captive),** probably because it is difficult to distinguish between them.
- Further, the table shows that Export Oriented Units (EOUs) are no longer eligible for subsidized gas or RLNG rates.
- **Local gas for captive units has been increased by 150% in a year, which is huge.**
- **For industry (process), local gas is 79% cheaper compared to RLNG.**

Table 3. Electricity Tariff—CPPs vs Grid

Fuel	Rate (PKR/MMBTU)	PKR/kWh (Heat Recovery Benefit Not Included)	PKR/kWh (Heat Recovery benefit Included)
Local Gas (Industry)	2150	25.17	17.31
Local Gas (Captive)	3000	33.74	24.71
RLNG (SNGPL)	3859	42.39	32.22
Blend (75%RLNG & 25% local) SNGPL	3644	40.23	30.32
Blend (30% RLNG & 70% local gas) SSGCL	3258	36.33	27.06
B3 Electricity Tariff (Peak) PKR/kWh	37.83		
B3 Electricity Tariff (Off-peak) PKR/kWh	29.39		

Source: PIDE estimates based on information provided by industrial sources, NEPRA and OGRA tariff determinations.

Table 3 shows:

- **Electricity generation from CPPs is more competitive than that of grid electricity.**
- Even if a CPP is a single-cycle power plant with a thermal efficiency of around 33% to 36%, the captive generation cost of electricity from domestic gas prices is lower than the peak grid tariff.
- But for a cogeneration plant with a thermal efficiency of more than 70%, even total RLNG is cheaper than the grid electricity rate in peak hours.
- Despite using expensive RLNG, the cost per unit of electricity generated in cogeneration power plant is more competitive than the grid electricity (PKR 37.83/kWh for B3 excluding other add-ons such as QTA, FPA, FC surcharge, etc.).
- **CPPs will transition to the power grid if they are offered competitive prices. If not, they may consider using alternate fuels. As of now, using alternate fuel like HFO, biogas and coal has become more competitive than gas blend** (Table 4).

This transition is only viable with the implementation of CTBCM and a reasonable wheeling cost without any sector inefficiencies (more details in Chapter 5).

In the Supreme Court case Civil Appeals No. 159-L to 214-L of 2018 (SNGPL vs. Bulleh Shah Packaging Pvt. Ltd. and others), **the Court ruled that industrial consumers who generate electricity in-house for their own use should be charged the industrial process gas tariff.** The ruling clarified that using gas for self-generation of electricity does not automatically classify these consumers as Captive Power Plants under NEPRA regulations. **Therefore, they are entitled to the lower gas tariff for industrial processes.**

Table 4. A case Study of Dual Fuel Cogeneration CPP (SNGPL network) in a Textile Sector

Month	Generation Source	Fuel Rate		Sp. Consumption		Fuel Rate	Unit	WHR Impact Approx	Fuel Unit Rate with WHR Impact
		Unit	Value	UOM	Value	Rs. / kWh		Rs. / kWh	Rs. / kWh
Jul-24	Blend of RLNG(75%) & Gas (25%)	Rs. / MMBTU	3,596	MMBTU / kWh	0.0088	32.85		(2.81)	30.04
Aug-24		Rs. / MMBTU	3,679	MMBTU / kWh	0.0088	33.50		(2.81)	30.69
Sep-24		Rs. / MMBTU	3,644	MMBTU / kWh	0.0088	33.14		(2.81)	30.32
Jul-24	HFO	Rs. / KG	149.49	KG / kWh	0.205	31.49		(1.97)	29.52
Aug-24		Rs. / KG	141.12	KG / kWh	0.205	29.72		(1.97)	27.75
Sep-24		Rs. / KG	138.76	KG / kWh	0.205	29.19		(1.97)	27.22

Note: WHR stands for waste heat recovery.

2.5. Shifting Industry from Self-Generation to Grid

In-house power generation facilities allow industries to produce their own electricity. These units provide a reliable and cost-effective alternative to grid power, especially in regions/ industries with limited supply.

In Pakistan, due to the unreliable grid and rising power costs, the industry is relying more on its own gas-based power generation (50% to 60%, in some cases 80% for those connected to grid). Gas power generation is also more cost-effective compared to grid (Table 3 in Section 2.4).

As explained in Section 2.3, many industrial units have made significant investments in upgrading their power generation infrastructure. They have converted their power generation units into cogeneration units. These units produce power and generate steam for use in the production process. **Shifting of industry to the national grid would result in already made investments going to waste. Beyond that, it will necessitate new capital expenditures which is impossible for the industrial sector, experiencing financial difficulties.**

It is rightly feared that such a transition may lead to widespread corruption , which could result in the unauthorized use of gas /RLNG for power generation. **Industries will seek cheaper energy sources, increasing operational costs, more carbon emissions (in the case of FO or coal), and reducing international competitiveness.**

PSIA (2023) found that the average estimated book value of combined heat and power (CPP) related assets on respective balance sheets of industrial units (surveyed) equal to PKR 36.8 million per megawatt. **A sudden shutdown of in-house power generation facilities could potentially result in an 'impairment loss' of approximately PKR 128 billion for the textile industry.**

After consulting with various industry stakeholders, it was determined that even for a highly efficient Combined Cycle Power Plant (CPP) with an efficiency of more than 80% (CPP already connected to the grid), **disconnecting gas and shifting 100% of the plant load to the grid will increase its running fuel cost by 11%. This additional cost will be even higher for plants with an efficiency in the range of 40% to 60%.**

In other words, **shifting industry with self-generation (gas-based) to grid implies an increase in energy cost by 11% or more.**

2.5.1. Revenue shortfall for Gas Utilities, if no gas for industrial self-generation

If industrial power generation facilities leave the gas network, Sui companies will face revenue shortfall equal to PKR 390.8 billion. **Who will bear the cost of this deficit, the remaining consumers (subsidized), or will it contribute to the already substantial circular debt?** In other words, **this is not the way forward!**

Table 5. Financial Impact of Shifting Captive Power to Grid

	Volume Consumed in CPP (MMCFD)		Total in MMBTU	Diversion Cost PKR Billion
	SNGPL	SSGCL		
RLNG	114	42	68.64	184
System Gas	59	183	94.38	206.8

Source: Estimates

Note: According to OGRA's SNGPL Revenue Requirement decision on May 20, 2024:

- RLNG diversion to domestic sector is PKR 3400/ MMBtu
- System Gas Diversion to Power Sector is PKR 1950/ MMBtu

2.6. Captive Power – Legal & Regulatory Aspects

The National Security Policy prioritizes economic security as central to national stability, *mandating energy policy alignment with industrial competitiveness to boost productivity, exports, and reduce external imbalances* (NSP, Section IV).

The Oil and Gas Regulatory Authority (OGRA) Ordinance, 2002 (Section 7), mandates the regulation of Pakistan's midstream and downstream petroleum sectors to minimize economic distortions and ensure efficient pricing. It also empowers OGRA to regulate tariffs and promote competition while safeguarding public interest in Section 6.

The National Electric Power Regulatory Authority (NEPRA) Act of 1997, as amended in 2018 (Section 2(ia)), defines a 'captive generating plant' as a facility primarily intended to meet the energy needs of a specific industry or commercial entity. This definition highlights the close connection between captive power plants (CPPs) and industrial processes.

- **Many industrial companies may have invested in self-generation facilities based on the longstanding regulatory position that in-house power generation is part of the industrial process.** By suddenly creating a separation, the principle (Estoppel

and Legitimate Expectation) is violated, as the industries had no prior expectation that this categorization would change.⁴

- Industries investing in in-house power generation facilities had legitimate expectations based on prior regulatory frameworks, which considered in-house power generation as part of the industrial process. Altering this framework would create uncertainty and impair previous investments, violating the principle of estoppel as industries relied on this regulatory consistency for long-term business decisions.

NEPRA regulates the power sector in Pakistan, while OGRA oversees the natural gas sector. Interestingly, combined-cycle power plants (CHPs) often operate on dual-fuel systems, utilizing both gas and other fuels. This unique setup creates a regulatory grey area, leading to potential conflicts in authority and increased compliance burdens for industries. Addressing this ambiguity is crucial to prevent economic inefficiency and promote a more streamlined regulatory framework.

- **Separating industrial in-house power generation as a distinct category creates practical regulatory inconsistencies. An industrial process cannot be disaggregated in this manner** without creating uncertainty and additional regulatory hurdles⁵.

The government policy (1994 Power Policy) incentivized in-house power plants to foster self-reliance and ease the burden on the national grid. Industries that invested in in-house power generation facilities did so with the assurance that these plants would serve industrial purposes. Altering their classification would contradict this initial intent and potentially deter future investments in self-generation solutions for industries, ultimately undermining industrial self-sufficiency⁶.

Various judicial precedents have highlighted the importance of industrial self-sufficiency in energy production. **The courts have consistently recognized and supported the integration of in-house power generation within the industrial process. They view in-house power generation facilities not just as independent power producers, but as essential components of the industrial entity's operational framework.** This validation from the judiciary reinforces the importance of CPPs in sustaining industrial activity.

- In PLD 2016 SC 808 (Karachi Electric Supply Co. vs. NEPRA), the court recognized the integral role of internal power generation (including captive plants) in sustaining industrial activity. The court emphasized that regulatory changes must not disrupt the

⁴ Asif Memon v. Sindh Public Service Commission discuss legitimate expectation when long-standing practices are suddenly changed.

⁵ NEPRA's and OGRA's regulatory roles in determining tariffs and overseeing the energy sector have been highlighted in various judgments, e.g., OGRA vs. M/s. Engro Fertilizers Ltd.

⁶ Pakistan's Integrated Energy Policy (2010-2025), aimed at encouraging captive power for industrial growth.

functional dynamics of industrial processes, especially when investments have been made based on existing regulatory frameworks.

OGRA's decision to separate in-house power generation from the industrial process without clear criteria raises significant legal questions. The absence of such criteria could be seen as arbitrary and whimsical, potentially violating Article 4 of the Constitution of Pakistan, 1973, which ensures equal treatment under the law⁷.

- If the separation of in-house power generation from the industrial process is applied retrospectively, it would violate principles of fairness and legal certainty. Courts in Pakistan have consistently held that retrospective application of new rules or regulations, particularly when it impacts ongoing operations or investments, is against constitutional guarantees.
- Therefore, any change in categorization that affects in-house power generation facilities should only be applied prospectively. Retrospective application would violate constitutional protections under Article 25 (equality of citizens) and undermine legal certainty⁸.

In Civil Appeals No. 159-L to 214-L of 2018 (SNGPL vs. Bulleh Shah Packaging Pvt. Ltd. and others), **the Supreme Court ruled that consumers who use natural gas for industrial purposes and have in-house electricity generation facilities for self-consumption fall under the category of industrial consumers.**

- These consumers should be charged the industrial tariff unless they qualify as a Captive Power Plant as defined by the National Electric Power Regulatory Authority (NEPRA) regulations.
- The Supreme Court's decision emphasized that merely generating electricity for self-consumption does not transform an industrial consumer into a Captive Power Plant. The Court dismissed SNGPL's appeal and affirmed the petitioner's entitlement to the lower industrial tariff.

2.7. In-house Power Generation for Industry—Future

Bulk gas consumers, especially industrial in-house power generation facilities, contribute a disproportionately large share of revenue to Sui companies because of their significant gas consumption and higher tariffs. If they leave, gas companies' revenue will sharply decline, causing operational challenges such as difficulties covering operational expenses and constraints on capital expenditure.

⁷ The principle of non-arbitrariness and procedural fairness was upheld in *Pakistan Workers' Federation vs. OGRA*, 2020 SCMR 2091.

⁸ The Constitution of Pakistan, Article 12 prohibits retrospective penalties, and this principle extends to regulatory decisions affecting business operations.

- **In-house power generation facilities going offline would result in a loss of PKR 391 billion.** The authorities would then need to find new consumers for 398 MMCFD of gas (Table 5).

It is currently challenging to find buyers for gas; gas consumption has decreased (Figure 8 to Figure 11). Electricity consumption is already going down. The industry is increasingly shifting towards solar captives, with industrial captive solar capacity standing at about 1000MW (rough estimate), and this number is evolving rapidly.

Cutting gas to self-generation units could lead to the closure of industry or cause large industrial units to switch to other fuels. They will not transition to the grid because it is financially unviable. This would not only result in Sui companies losing revenue but also decrease overall electricity consumption, thereby increasing the capacity payment burden for the remaining consumers.

Captive power plants (CPPs) or distributed energy are a significant development in Pakistan's approach to energy generation. CPPs offer a dependable and cost-effective alternative to grid power by enabling industries to generate electricity, particularly in areas with limited supply.

In Pakistan, the landscape of self-generation is undergoing a rapid transformation, embracing state-of-the-art innovations to boost efficiency and uphold environmental sustainability.

The integration of smart grid technologies and the Internet of Things (IoT) is enhancing the operational efficiency of CPPs globally and in Pakistan as well. These technologies enable real-time monitoring and management, optimizing energy production and reducing downtime.

The adoption of energy storage solutions, such as battery storage systems, is becoming increasingly prevalent. These systems not only stabilize the power supply but also enhance the utilization of renewable energy sources, particularly in areas with intermittent power generation like solar or wind.

Several nations, including India, Uganda, Nigeria, and Saudi Arabia, are harnessing the power of CPPs to fulfill their electricity needs. Moreover, India, Uganda, and Saudi Arabia are offering incentives to CPPs to sell their excess electricity to the grid (Amin et al., 2021).

Box 2. CPPs in India

- In India, captive power consumption, which currently represents 38% of total industrial demand, is on a trajectory of significant growth. The installed capacity of captive power plants (1 MW and above) has grown from 588 MW in 1950 to 78,508 MW in 2021.
- The average annual growth of captive power plants' self-consumption from 2010-11 to 2020-21 is estimated at 6.38%. Importantly, this growth is expected to accelerate, with a projected increase of more than 10% in the next ten years.
- High electricity tariffs for industrial and commercial consumers are the main driver of the increase in the installation of captive power plants, which is expected to continue.
- Captive power plants (CPPs) are revolutionizing energy generation in India by enabling industries to produce reliable and cost-effective electricity, especially in areas with limited grid power supply. The technological landscape of captive power plants in India rapidly evolves to enhance efficiency and environmental sustainability.
- Industries with high energy consumption are increasingly integrating solar rooftop installations and wind energy into their power systems to align with global decarbonization and sustainability efforts.

Captive power plants (CPPs) in many emerging and developing countries demonstrate remarkable resilience, playing a significant role in the electricity sector. They effectively

Captive power plants are closely aligned with the industrial process and should not be treated as a separate category based on legal principles and its effectiveness.

Given the unreliability of the grid and the high energy demand from export industries, it is crucial to maintain a stable and cost-effective gas supply for captive power plants.

The industry requires reliable and competitive energy as well as consistent policies.

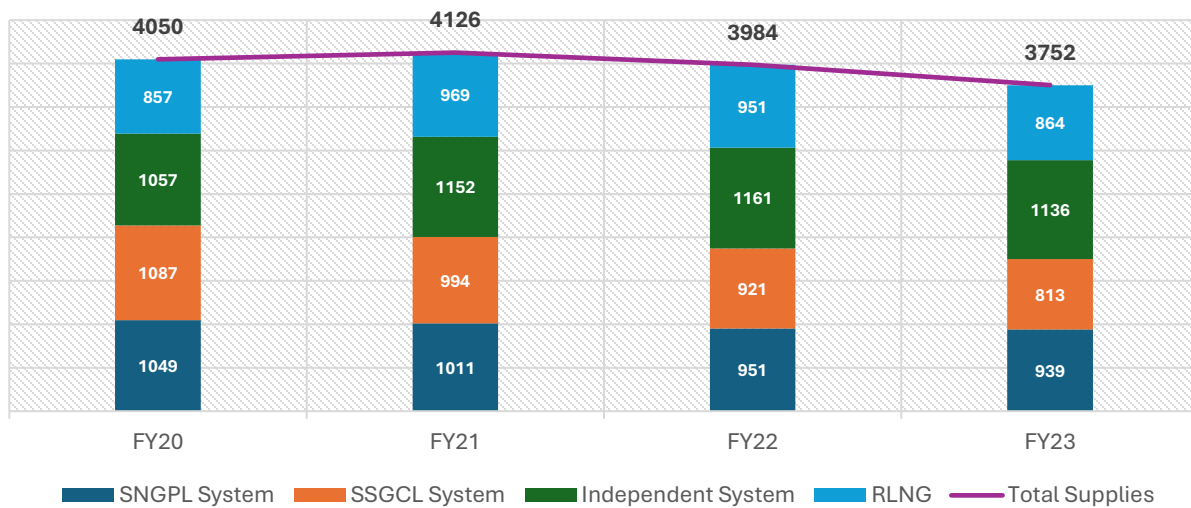
address the challenges posed by unreliable electricity supplies from state-owned utilities and difficulties in accessing the national grid, particularly in remote and rural areas. The integration of captive capacity with the on-grid supply is a testament to their adaptability and can significantly improve resource utilization in the electricity market (Amin et al., 2021).

Chapter 3

PAKISTAN'S GAS SECTOR

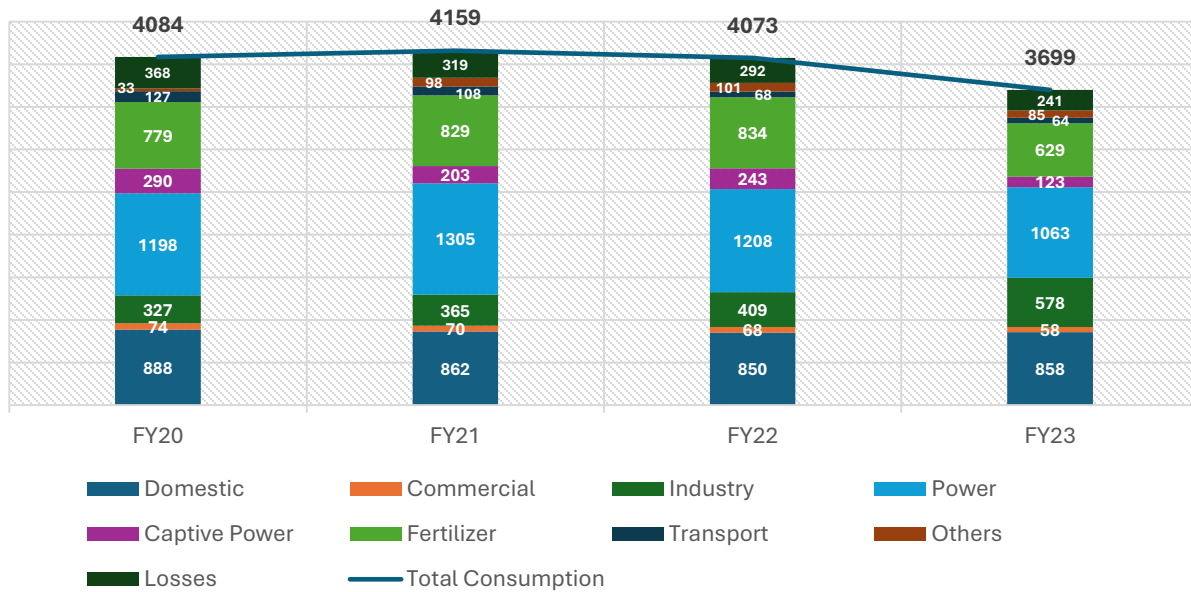
3.1. Pakistan Gas Sector: Demand and Supplies

Figure 6. Gas Supplies (MMCFD)



Source: OGRA State of Industry Report 2023

Figure 7. Gas Consumption (MMCFD)



Source: OGRA State of Industry Report 2023

As of June 2023, gas (including LNG and LPG) accounts for 40.5% of commercial energy supplies and about 31.2% of commercial energy consumed. Pakistan is the 22nd largest consumer of natural gas globally. In FY23, a total of 3.66 billion cubic feet per day was consumed, with 73.4% produced domestically.

In the last twenty years, gas consumption has increased by over 4% annually. Pakistan's gas production has been stagnant for over a decade and is declining since FY20, due to limited activities in the exploration and production (E&P) business. Since the fiscal year 2015, we have been importing liquefied natural gas (LNG). Due to distorted pricing and allocation policies, the E&P companies struggle to undertake large-scale exploration activities, as they have significant receivables from Sui companies and power producers.

Inadequate power infrastructure and political priorities in gas pricing and allocation has made Pakistan a gas intense country. After the significant gas discovery in Sui in 1952, the government of Pakistan (GOP) began developing a gas transmission and distribution network. The sustained growth in gas production in the early years led the authorities to become complacent, and they began providing connections to everyone.

The transmission network spans 13414 kilometers, and the distribution network covers 198,719 kilometers across the main urban areas of four provinces (OGRA State of Industry Report, 2023). India, which is four times larger in area and six times more populous, has a 24,000 km network. The industry primarily uses natural gas, and households use LPG broadly (APTMA, 2024).

There is **no market competition in the upstream, midstream, or downstream gas sector**. The indigenous gas resources are dwindling, but the two monopolies Sui Northern Gas Pipeline Limited (SNGPL) and Sui Southern Gas Company Limited (SSGCL) are still expanding their networks to increase revenues. **From FY2019 to FY2023, gas production decreased by 17%, while T&D assets increased by 11%.** By establishing new connections, the utilities are increasing their fixed assets, as the companies are assured a market-based return of 16.60% on their net operating fixed assets.

Thirty years ago, both the Asian Development Bank and World Bank provided loans to develop their infrastructure, with a condition of a guaranteed return on investment. However, this arrangement is no longer relevant and leads to inefficient investments by gas utilities.

Box 3. Midstream and Downstream Monopolies (SNGPL and SSGCL)

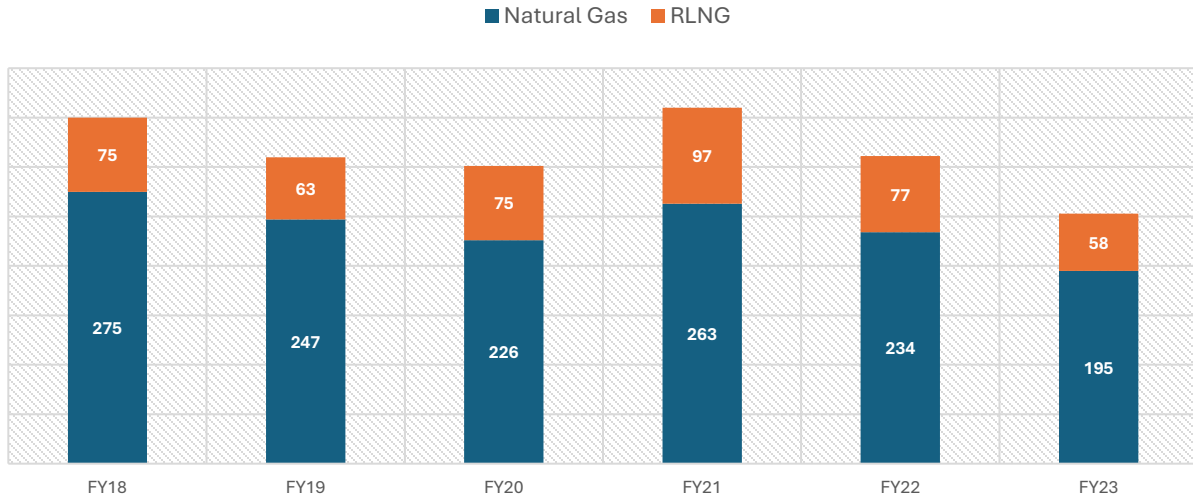
- Monopolies, no competition
- No business plan, guaranteed returns - financial returns linked to transmission & distribution network and not to their managerial, financial, and operational efficiency
- High UFGs – seven times higher than world average

The two monopolies are characterized by mismanagement, political interference, and no business plan. High unaccounted-for-gas (UFGs) are due to the lack of regulatory mechanisms linking financial returns with operational efficiency; OGRA has failed as a regulator to reverse the disastrous decisions taken decades ago.

In FY2023, T&D losses (UFG) in the gas system amounted to 41% of LNG imports, equivalent to approximately US\$1.54 billion. Since 2017, Sui companies have accumulated UFG losses of PKR 515 billion. The high UFGs are attributed to underground leakage from aging pipelines, poor maintenance, measurement errors, incorrect billing, law and order issues, and theft. Financial strain from UFG hinders investment in essential infrastructure upgrades, leading to a cycle of increasing UFG rates, financial strain, and reduced infrastructure investment.

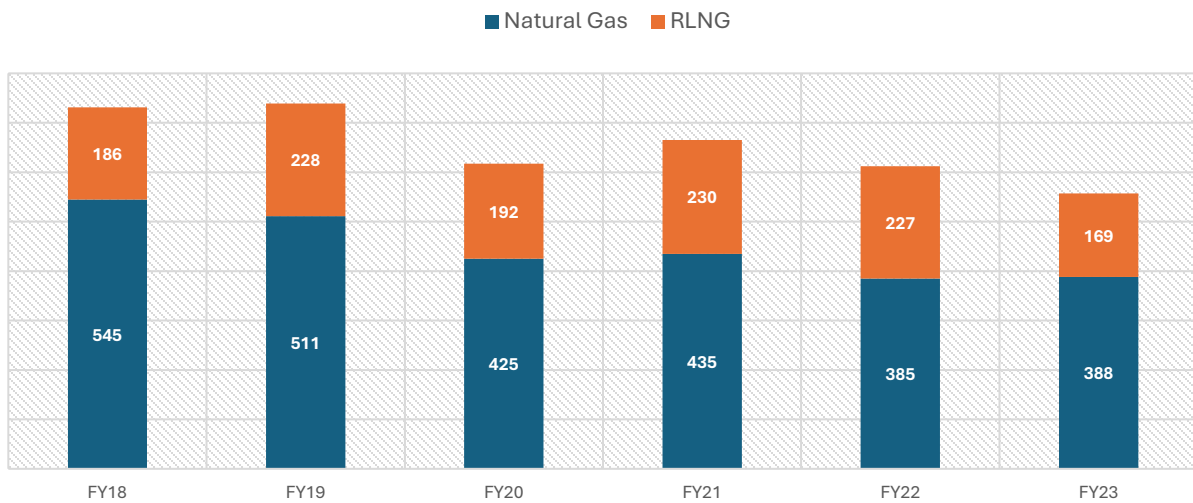
3.2. Sectoral Gas Consumption

Figure 8. Industrial Gas Consumption (Billion CFt)



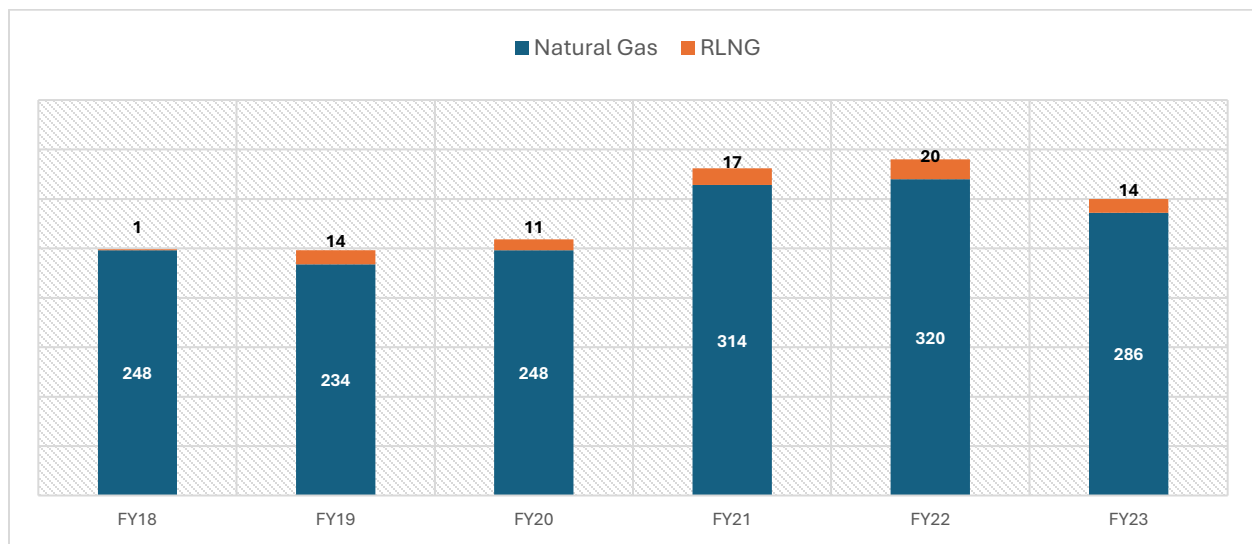
Source: OGRA State of Industry Reports

Figure 9. Power Gas Consumption (Billion CFt)



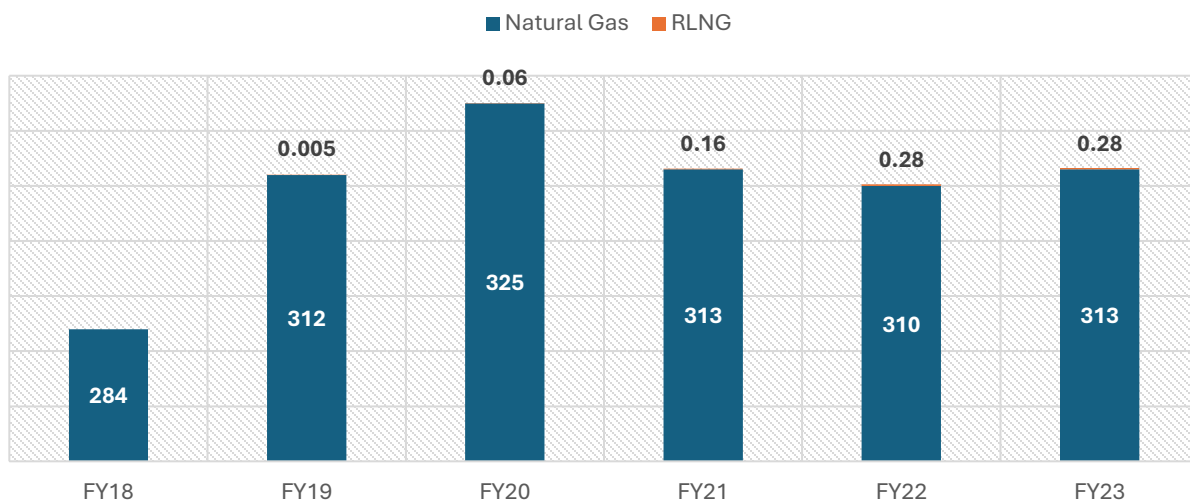
Source: OGRA State of Industry Reports

Figure 10. Fertilizer Gas Consumption (Billion CFt)



Source: OGRA State of Industry Reports

Figure 11. Residential Gas Consumption (Billion CFt)

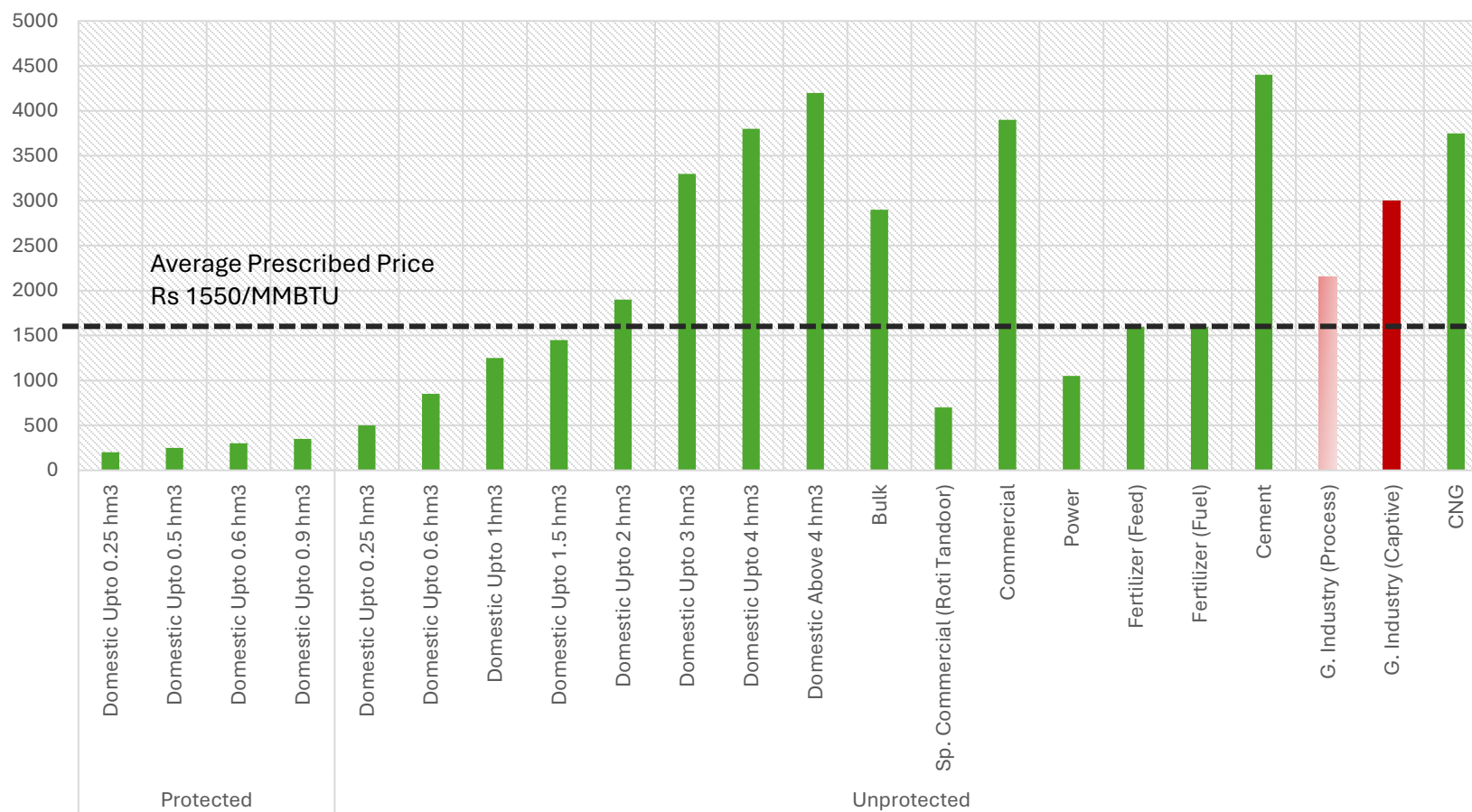


Source: OGRA State of Industry Reports

Note: The latest available data year for sectoral consumption in published reports is FY2023.

3.3. Gas Tariff Design – Massive Cross-subsidization

Figure 12. Gas Tariff (PKR/ MMBTU) FY2025



Source: OGRA Tariff Determination 2024

At the current notified consumer gas sale prices effective 01.02.2024 (revised in August for CPPs):

- **Industry (process) (SNGPL and SSGCL) will pay about 39% above the average sale price; and CPP will pay about 193% of the average prescribed price; a cross subsidy primarily to lower six slabs in the domestic sector (Figure 16).**

Assuming no further change in the prices in FY2025:

- **The estimated revenues of both Sui companies will be PKR 1,025 billion (SSGCL: PKR 364 billion and SNGPL: PKR 661 billion) leading to surplus of Rs. 133 billion (SSGC: PKR 75 billion, SNGPL: PKR 58 billion).**

On an annual basis, at the tariff of PKR 2,750/MMBTU, the estimated surplus revenue from CPP was PKR 76 billion and at the revised tariff of PKR 3,000/ MMBTU, the surplus is estimated at PKR 92 billion (Petroleum Division)

Following the commitment made with the IMF, **closure of CPPs by January of 2025, this surplus will translate into a shortfall in revenue requirements (RR) for Sui companies, requiring review of RR (e.g., it will increase SNGPL's RR by PKR 440/ MMBtu) and further burdening the remaining sectors (domestic slabs) or adding to the circular debt.**

3.4. Gas Price Anomalies

Gas consumer prices are based on socio-political objectives, with no economic basis.

Up to 70% of the domestic gas consumption is in the subsidized slabs. Gas cross-subsidization across sectors is distortionary. It encouraged inefficient use, and it continues.

In Pakistan, both power and gas (subsidized) are supplied at the household level. Providing two types of infrastructure at the domestic level is costly and encourages inefficiencies in the supply chain.

Subsidized gas supply to fertilizer is intended to promote food security and support small farmers. However, evidence indicates fertilizer prices are not always lower than the imported fertilizer costs (Raftaar, 2016). Further, poor farmers or low-income families do not gain much from this subsidy (Anjum, 2022). Meanwhile, local fertilizer manufacturers are profiting (Raftaar, 2016; Anjum, 2022).

Government influences demand through administrative pricing, cross-subsidies, taxation, and regulations. This influence has persisted even after the commencement of LNG imports in 2015.

The "Cost Plus" pricing model aims to ensure cost recovery plus profit but offers no incentives for efficiency and suppresses market competition by burdening industry with above service-cost tariffs and poor bill collection enforcement.

Box 4. Only Electricity for Household

Gas is primarily used for heating and cooking in households. During peak winters, 60% of the gas is used for space and water heating, while 40% is used for cooking. Gas-based appliances consume a significant amount of energy, with the efficiency level of gas-based geysers being less than 30% (Malik, 2023).

Both cooking and heating can be achieved using energy-efficient electric appliances. Pakistan has sufficient electricity capacity, and the underutilization of this capacity is resulting in a capacity payment burden.

Additionally, there is an 8000MW to 13000MW difference in electricity demand between summer and winter. During these seasons, gas demand varies by about 1000 MMCFD in the opposite direction. Not switching from gas to electricity for heating and cooking only reflects lack of integrated planning.

According to an estimate in the Ministry of Planning, Development, and Special Initiatives report, substituting only heating demand can generate 5,042 GWh of power, providing consumers with cost-effective electricity.

In Pakistan, gas is coming from three sources, indigenous gas from Sui gas transmission network (47%), and indigenous gas from dedicated fields (independent) (30%)⁹, and remaining 23% from RLNG in FY23. Prices are determined separately.

From FY21 to FY24, the government paid PKR 262 billion to SNGPL and PKR 2 billion to SSGCL to subsidize the domestic sector (PKR 102 billion), fertilizer (PKR 68 billion), and export-oriented units (PKR 95 billion). In the budget FY25, PKR 10 billion is allocated for RLNG supplies to domestic consumers in the SNGPL network.

The cost of RLNG is the highest and is determined separately for SNGPL and SSGCL. In September 2024, SNGPL's price was US\$ 12.92/MMBTU and US\$ 13.86/MMBTU for transmission and distribution, respectively. For SSGCL's it was US\$ 11.76/MMBTU and US\$ 13.42/MMBTU for transmission and distribution, respectively. Prescribed price for indigenous gas supplied through the Sui network is determined at PKR 1550/MMBTU (US\$ 5.6/MMBTU).

⁹ Low Btu, supplied to some fertilizer and power plants directly. The most recent price available for dedicated fields is PKR 957/ MMBtu.

There is a considerable difference between the RLNG and local gas prices. Further, the absence of full cost recovery from all sectors leads to system inefficiencies and the accumulation of government receivables. The gas sector's circular debt has reached PKR 2.1 trillion (Figure 17).

OGRA's repeated deferral of decisions regarding the cost allowance of late payment surcharge payable to indigenous gas suppliers, RLNG diversion cost, and RLNG cost actualization is leading to significant revenue loss and the accumulation of circular debt.

The Senate of Pakistan in February 2022 approved the Weighted Average Cost of Gas (WACOG) bill. Under WACOG, all gas sources, including Re-gasified Liquefied Natural Gas (RLNG) and local gas, will be pooled in, and a weighted average cost will be taken for gas purchase.

This law was designed to address the pricing disparity by ensuring that the cost of gas, including RLNG, is reflected in the price charged to consumers. Two and a half years have passed, but WACOG has not yet been implemented. It is crucial that the law be implemented to break the cycle of the gas sector's circular debt.

3.5. Gas Allocation policy

Gas allocation policy has been driven by political priorities rather than focusing on maximizing value addition, leading to inefficiencies, mismanagement, and inflated demand in subsidized sectors. This misallocation results in deadweight loss, rising circular debt, and the misuse of valuable natural resources.

In many countries, households receive only one type of energy source. However, in Pakistan, power and gas are provided at subsidized rates at the household level. This expensive dual infrastructure is leading to inefficiencies in the supply chain.

Indigenous gas reserves may be depleted within a decade, with reserves diminishing at 10-12% annually. A shift towards a policy that prioritizes maximizing value addition is not just desirable but necessary to address energy sector issues.

Table 6. Gas Allocation Policy 2018

Consumer Categories	Priority
Domestic and Commercial	1 st
Power and Zero-rated Industry	2 nd
Fertilizer, Captive Power , and General Industry	3 rd
Cement including its Captive Power	4 th
CNG	5 th

Table 7. Gas Allocation/Priority 2024

Consumer Categories	Priority
Domestic, Commercial (including special commercial), and Industry (process)	1st
Power and Fertilizer	2nd
Cement, CNG, Industry (captive)	3rd

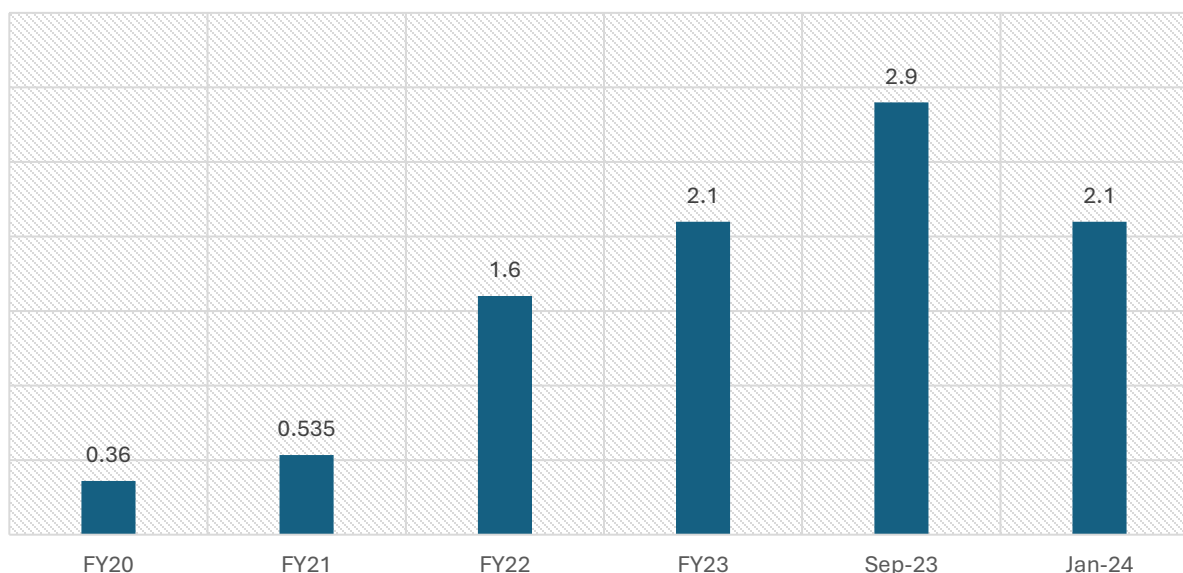
In September 2018, the industry was categorized into export and non-export sectors under the direction of the Cabinet's ECC. The export sector received a budgeted subsidy with RLNG capped at \$6.5 per MMBtu, which was later increased to \$9 per MMBtu during FY 2023. However, the subsidy (RCET) was discontinued on July 1, 2023, and a blend of indigenous and RLNG was offered to the industry by the ECC decision of November 2023.

In February 2024, the distinction between export and non-export industries was removed, and revised industry categories, industry (process) and industry (captive power), were introduced.

The Petroleum Division has suggested changing the priority for gas supply and increasing gas tariffs for captive power units. This is to encourage these units to transition to the power grid, given the installed capacity and anticipated increase in the near future. The Economic Coordination Committee (ECC) has approved (September 25, 2024) a new gas allocation priority, which places captive power alongside the CNG sector.

3.6. Gas Circular Debt (CD)

Figure 13. Gas Circular Debt (PKR Trillion)



Source: PIDE (2024) & IMF (2024)

Note: The decline in circular debt between September 2023 and January 2024 is due to the substantial increase in gas prices.

Residential gas subsidies have led to inefficient and unsustainable use, resulting in rapid depletion of reserves, seasonal shortages, and financial strain on the gas sector.

Pakistan's natural gas network is inefficient and reflects short-sighted energy policies. The gas supply cost to households is much higher than the industry's.

- **Due to natural gas shortages during winter, expensive RLNG is diverted to domestic consumers at a subsidy of about US\$ 12/MMBtu.**

The power sector and industry (captive) are the main off-takers of RLNG.

- **In the power sector, contractual, financial, and operational compulsions of RLNG supplies are not considered while determining its economic merit order (EMO) for purchasing power from various generation sources.**
- In EMO, priority is given to low-cost generation irrespective of the idle capacity of RLNG plants and idle supply of expensive LNG, have resulted in increasing gas sector circular debt.
- Electricity generation from RLNG plants decreased from 20834 GWh in FY21 to 17865 GWh in FY23, whereas capacity payments to these plants increased from PKR 49.3 billion in FY21 to PKR 81.5 billion in FY23
- Future utilization as forecasted by NTDC is only 18%.

Box 5. Circular Debt in the Gas Sector - Reasons

Gas companies are burdened with debt due to:

- Distorted tariff structure.
- Substantial government involvement in the LNG supply chain and political preference for gas distribution, making it difficult to recover gas/ RLNG costs.
- Flawed planning - excess RLNG is diverted to the subsidized domestic sector instead of productive sectors.
- Gas companies' mismanagement, high UFGs, and collection shortfalls.
- Lack of integrated planning.

Due to poor planning, excess RLNG is redirected to the subsidized domestic sector, contributing to circular debt. Additionally, to regulate gas pressure in the pipeline distribution system, **local gas flow from fields is reduced when there is surplus RLNG, discouraging the country's exploration and production (E&P) companies.** For instance, a reduction of natural gas flows from local fields by 350 MMCFD starting the second week of March (which increased to 400 MMCFD in April) instead of supplying gas for productive use in industry.

Power sector is the largest consumer of RLNG in Pakistan. However (as mentioned above), **ordering lowest cost power generation sources irrespective of idle supply of expensive RLNG plants, to reduce power circular debt, have resulted in increasing gas sector circular debt.**

On the other hand, prioritizing lowest cost power generation sources irrespective of idle supply of expensive RLNG plants is meant to reduce fuel costs in the power sector. **But the under-utilization of power plants operating on take-or-pay basis leads to capacity payment obligation even when plants are not operational. It contributes to an increase in consumer end tariffs, also leading to a build-up of CD in the power sector.**

In the gas sector, frequent diverting expensive RLNG to subsidized domestic and commercial sectors is adding to gas sector circular debt. As of June 1, 2024, PSO's receivables from SNGPL were PKR 542.8 billion (PKR 372.2 billion -principal, PKR 163.9 billion – late payment surcharge, and PKR 6.7 billion - exchange loss). PLL's receivables from SNGPL amount to PKR 147.29 billion, bringing the combined RLNG debt to PKR 690 billion.

Delay in payment from SNGPL create liquidity issues for PSO. To prevent, PSO secures high-cost financing, causing cash deficiencies and low profitability (interest cost of around PKR

40 billion) (KPMG, 2024). SNGPL prioritizes averting PSO's default, resulting in delayed payments to OGDCL (PKR 807 billion) and PPL (PKR 895 billion).

- **The prioritization of payments for LNG imports over those to domestic producers perpetuates a cycle of debt within the natural gas sector, ultimately eroding incentives for domestic exploration and production (E&P).**

The gas sector in Pakistan is encountering numerous challenges due to its arbitrary administrative pricing mechanism, lack of integrated energy planning, and the monopolistic control of gas utilities operating under a return-on-asset business model. Political considerations heavily influence gas pricing and allocation rather than economic priorities. Misallocation, mismanagement, and inflated gas demand in subsidized sectors have led to increased circular debt, higher tariffs for industrial consumers, and slowed down economic growth.

3.7. De-regulate Gas Sector

Unfortunately, Pakistan's gas production is on the decline. This is due to the depleting known reserves, a low reserve replacement ratio, insufficient investments in exploration and production (E&P) activities, and various managerial, operational and regulatory challenges. Action needs to be taken to address these issues and secure a sustainable energy future for Pakistan.

With the departure of foreign E&P companies, local E&P companies are mainly involved in this business¹⁰. Due to the distortionary pricing structure and allocation policy, these companies are burdened with significant receivables from Sui companies and power producers, damaging their ability to undertake large-scale exploration activities.

By deregulating and liberalizing the natural gas sector and its pricing structure, Pakistan can create a more efficient and competitive market, potentially improving service quality and increasing investment.

¹⁰ A few years back, there were 22 foreign companies in exploration & production activities.

Market reform is not just a desirable option but a necessary step in the evolution of the natural gas sector. It is a complex legal, political, and economic process that demands consistency in policies, political commitment, and an effective regulatory framework. The open-access regime is more crucial for deregulating SOE-dominated markets.

Over-regulation, short-sighted policies, and adhocism are hindering the sector's growth. **Government must deregulate and liberalize the sector.**

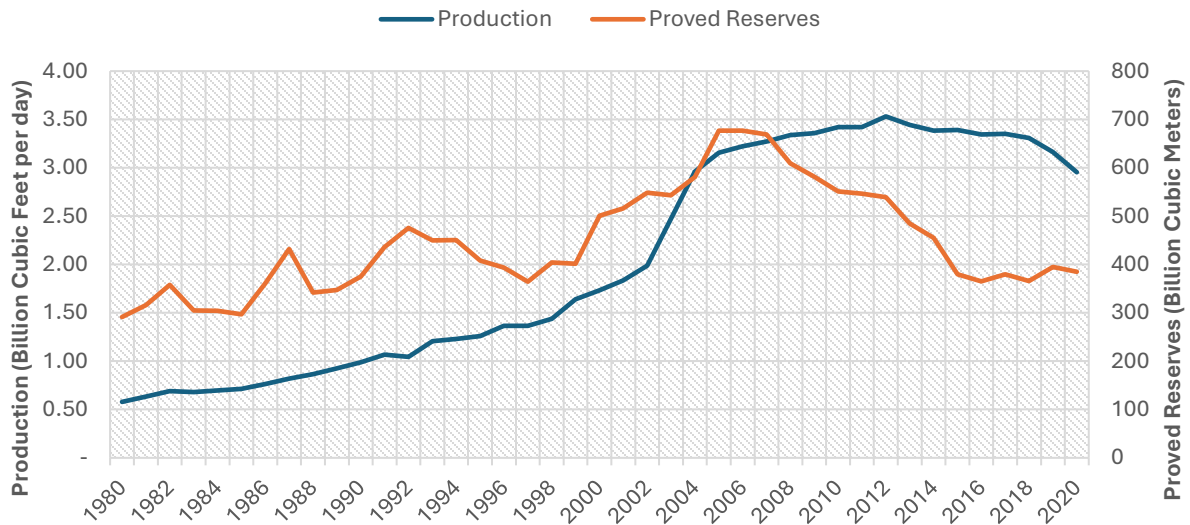
Complete deregulation of the gas sector is the first-best solution!

Chapter 4

RLNG IMPORTS BUT NO MARKET

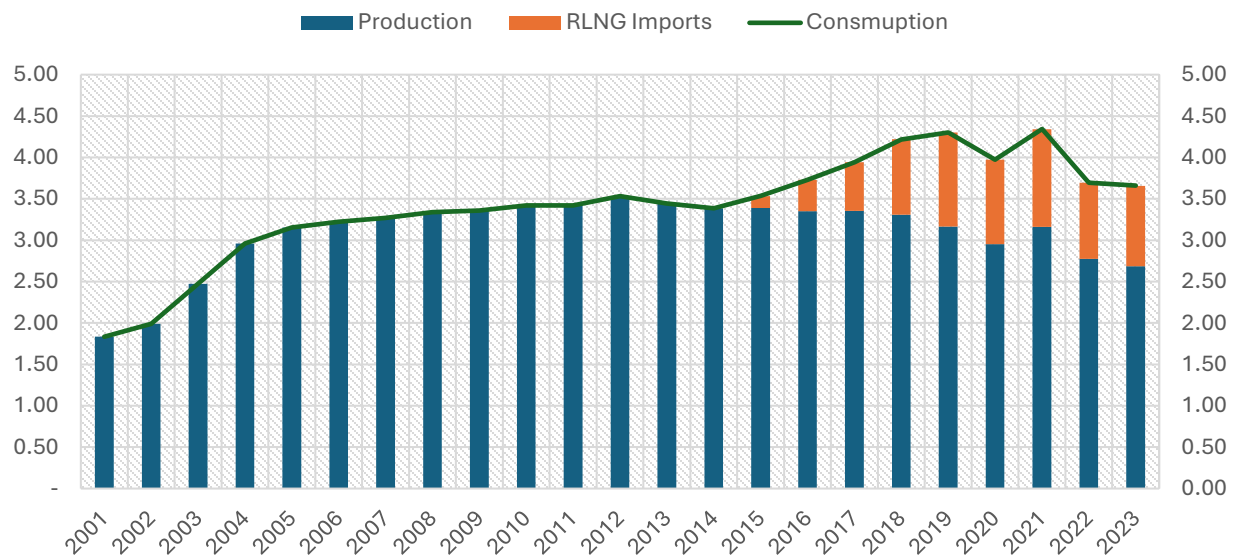
4.1. Depleting Gas Resources and RLNG Reliance

Figure 14. Gas Reserves and Production



Source: BP Statistical Review 2023

Figure 15. Gas Consumption, Production, and LNG Imports (Billion Cft per day)



Source: BP Statistical Review 2023

In recent years, no significant gas discoveries have been made, leading to a decline in gas production after reaching a peak in FY2012. Additionally, proven gas reserves are also decreasing (Figure 18). Compounding the issue, the government's deliberate curtailment of gas from indigenous fields and diversion of expensive RLNG to other sectors (in recent months) has led to negative consequences (Box 6).

Box 6. Mismanagement & Lack of Planning

The intentional decrease in gas supply from domestic fields and the redirection of costly RLNG to other sectors have severely affected the gas industry. For instance, to accommodate LNG at the DES price of \$9.78 per MMBtu (April 2024) under SPA, 400 MMCFD of indigenous gas priced at \$4 per MMBtu was curtailed in April 2024; RLNG off-take was inconsistent in May 2024 as well.

- Indigenous gas production in January 2024 was 3,282.37 MMCFD, which dropped by 19.5% to 2,641.53 MMCFD by the end of April 2024, partially due to an oversupply of RLNG.

In other words, **indigenous natural gas is available, but supplies are restricted, which affects industry and discourages exploration and production (E&P) companies.**

- The curtailment from indigenous gas is resulting in revenue loss for local E&P companies and damage to local oil and gas reservoirs.
- Further, if this gas if had been diverted to industry would have enabled industry to generate electricity at competitive rates and kept the export sector viable.

Furthermore, despite depleting indigenous gas resources, gas prices remained almost constant from 2008 to 2018; 2018 onwards, prices started rising. To bridge the supply demand gap, LNG import contracts were signed in 2015, with annual committed quantities of LNG for power sector consumption. If there are no major gas discoveries or significant restructuring in the sector, Pakistan's reliance on LNG imports will further increase in the upcoming years.

Box 7. LNG Sales Price Agreement (SPA) & Its Off-take

Pakistan State Oil (PSO) had signed two long-term sales price agreements (SPA) with Qatar for the import of LNG.

- First SPA was signed in 2015 for 15 years at 13.37% slope of Brent (3.75 MTPA or 500 MCFD).
- Second SPA was signed in 2021 at 10.20% slope of Brent for 10 years (3MTPA or 400 MMCFD).

Currently, 75% of RLNG is used for electricity generation, 45% by power plants and 26% by industrial captive power plants.

- If RLNG has been acquired by the power sector as per its commitments, the net loss in revenue of PKR 97(from Jan 2019 June 2023) billion due to RLNG diversion could have been avoided.
- CPP consumes 176 MMCFD (RLNG) and 173 MMCFD (natural gas) from Jan 2024 to Mar 2024. Closure of CPP will leads to more pressure in the supply network.

Meanwhile, K-Electric is the off-taker of Pakistan LNG Limited (PLL)'s ENI contract for 0.75 MTPA (100 MMCFD) at 12.14% of Brent Mean.

Total LNG long-term SPAs are 7.5 MTPA per annum (1,000 MMCFD).

- In February 2026, there is price re-opener of Qatar (900 MMCFD) SPAs but there is no walk-away clause. **The sector will experience even more significant financial losses if the government fails to re-negotiate a new LNG price.**
- In the case of PLL, there is a walk-away clause after 10 years.

4.2. RLNG Imports for Power Sector & Industry

LNG was envisaged to replace High Speed Diesel (HSD), and Furnace Oil (FO) power plants and Government Power Plants (GPPs) were the main off-takers of RLNG; four GPPs were commissioned to replace HSD and FO based plants.

However, due to high RLNG prices, RLNG plants **(GPP) were demoted in Economic Merit Order (EMO) which resulted in the inability of power sector to consume committed RLNG and hence excess RLNG became available without any consumer.**

Further, power sector RLNG demand has substantially reduced as it has diversified away from RLNG to cheaper alternatives like coal, nuclear, hydro, and solar. Power sector RLNG consumption has been reduced by over 150 MMCFD. In the power sector, contractual, financial, and operational compulsions of RLNG supplies are not considered. **There are take-or-pay arrangements at the upstream level but no take-or-pay arrangements at the**

downstream level (e.g., RLNG-based power plants); consequently, there is no potential consumer to purchase surplus RLNG at full price. To make room for expensive LNG, indigenous gas has recently been cut off (Section 3.6 and Box 6).

To reduce pipeline pressure and consume the excess RLNG, RLNG is being diverted to the domestic and commercial sector in SNGPL System, thus increasing the RLNG diversion volumes. **SNGPL estimates that Revenue Requirement (RR) on account of diversion of 115 MMCFD RLNG to domestic Sector alone will be around PKR 100 billion¹¹.**

CPPs are the major consumers of RLNG after the power sector:

- **If CPPs also leave the gas system, it will reduce RLNG sales (at actual prices), exposing them to take-or-pay contractual risks with RLNG suppliers and sovereign default.**

Box 8. CPPs – Potential RLNG Consumer

CPPs not only provides additional revenues in the form of cross-subsidy to the domestic sector in the absence of budgeted subsidy but also consumes RLNG, which often becomes surplus due to the inconsistent off-take of power plants (GPPs), as happened from March 2024 onwards.

Industries were also encouraged to utilize RLNG for captive power plants (CPPs). **Large industries made substantial investments in combined heat and power plants (CHP) to reap returns in the form of consistent and cheaper electricity and steam for their production.** RLNG has become expensive for industry due to dollar escalation. However, for efficient CHP plants, it is still more viable than grid electricity (Table 3 in Chapter 2), with the additional benefits of a reliable electricity supply, such as water heating, steam generation, etc.

Captive consumer account for approximately 20% of total RLNG off-take in the Sui network.

The industry is the only off-taker of RLNG without economic (price) distortion. In contrast, the power sector operates as a single-buyer market with a basket price of energy mix.

¹¹ SNGPL comments on the transition of gas/RLNG based captive power plants on power grid (May 2024).

According to the Commerce Division, based on data from PRAL (Pakistan Revenue Automation Pvt. Limited), **349 units (with 523 gas connections) exported US\$13.31 billion during FY2022**¹² (Annex A2).

4.3. Regulatory Framework for Competitive Market¹³

Policy formulation regarding natural gas, liquefied petroleum gas (LPG), liquefied natural gas (LNG) and compressed natural gas (CNG) is done at the Directorate General of Gas. The directorate is also responsible for the assessment and management of gas demand & supply, allocation of gas from new fields to SSGCL and SNGPL, and the allocation of natural gas from different sources to various sectors of the economy.

Article 158 of The Constitution of Pakistan says:

“The Province in which a well-head of natural gas is situated shall have precedence over other parts of Pakistan in meeting the requirements from that well-head, subject to commitments and obligations as on the commencing day”.

The LNG Policy (2006) was modified in 2011 to expedite LNG projects. Under the LNG Policy, 2011 allows the LNG import project structure as

- Integrated Project Structure- where the LNG Developer (private/public) procures LNG from the supplier, transports it to the LNG regasification terminal and supplies RLNG to the domestic market or for its own use.
- Unbundled Project Structure- where a government designated buyer, gas utility company, consumer or LNG supplier (LNG Buyer) can import LNG from the international market by entering into an LNG Sale Purchase Agreement (SPA).

Under the unbundled structure the LNG buyer can enter into a Sale Purchase Agreement (SPA) on either delivery ex-ship (DES) basis, free-on-board basis (FOB) or C&F (Cost and Freight) basis. Under the LNG Policy, 2011 an LNG Buyer can procure LNG through one of the three approaches:

- Direct negotiations with one or more LNG suppliers
- International competitive bidding
- Direct purchase from the LNG spot market based on market and commercial considerations

OGRA under section 41 of the Oil and Gas Regulatory Authority Ordinance 2002 enacted the *Third-Party Access (TPA) Rules, 2012*, but, suspended in 2015 due to technical issues. Later, OGRA Gas (Third Party Access) Rules, 2018 adhere to transparency, competition, fairness and a level playing field in the gas sector, yet not implemented.

¹² Cited in Gas Pricing Summary for FY2025 (effective from July 01, 2025), Directorate General of Gas, Petroleum Division, Ministry of Energy.

¹³ This sub-section draws significantly from Competition Commission of Pakistan (2018) and Malik & Ahmad (2022).

The LNG sector in Pakistan is highly regulated. Unlike mature markets like Japan, South Korea, and even India, where higher private sector participation is facilitating cheaper fuel availability, smooth procurement processes and allow market-based price discovery (SBP, 2021).

4.4. LNG Market Development – Barriers

- Government is the only player in the LNG-importing business - no competition.
- Procedural delays in making import decisions due to bureaucratic hurdles - PPRA Rules do not allow to take benefit from low prices in the spot market. **Under PPRA rules, the complete import process (on average) takes more than 60 days.**
- Demand projection is critical in procuring LNG in the spot market. In Pakistan, it is challenging due to ambiguities associated with LNG consumption in the power sector.
- Long-term contracts: the spot LNG market exhibits more volatility than other fuels; prices can move substantially in either direction when the LNG vessel arrives.
- There are structural barriers, including high capital investment requirements, high sunk costs, lack of trained human resources, economies of scale, and control of essential raw materials.
- Enormous gap between the indigenous gas and RLNG price. Well-head gas prices are not market driven.
- Although prices for domestic gas have increased significantly, substantial cross-subsidy still exists. Consumers on the natural gas connections of SNGPL and SSGCL pay the natural gas tariff, irrespective of what type of gas they are using. The gas received by gas consumers is a blend as the molecule of indigenous or imported LNG cannot be differentiated.
- Unlike natural gas prices, RLNG price is determined by OGRA each month, based on the weighted average price of Brent of last three months. The price of RLNG is ring fenced, meaning that there is no segregation of consumers. All RLNG consumers within the transmission or distribution networks of SSGCL or SNGPL, pay the same price, as per the price determination¹⁴.

Monthly price variation in RLNG places the RLNG consumers at a disadvantage compared to indigenous gas consumers¹⁵. Further, there is a controversy over the definition of LNG that needs to be resolved¹⁶.

¹⁴ SSGCL consumers are given preference in indigenous gas allocation under the Article 158 of the Constitution.

¹⁵ After the relaxation of the moratorium in 2017 all new connections (industrial, commercial, captive, and housing societies) are on RLNG, paying higher price for RLNG. This results in discrimination between the consumers as the new consumers having RLNG gas connection pay higher price than the consumers on the SSGC and SNGPL network of natural gas. Moreover, due to article 158, the price differential between SSGC and SNGPL, gives a competitive disadvantage to consumers on the RLNG network.

¹⁶ Sindh infrastructure Cess is exempted on “petroleum products” however it is not exempted on LNG. LNG is not defined as a petroleum product however in pursuance of SRO 405(I)/2015 on May 07, 2015, issued by the

- The exemption given to petroleum products but not to LNG is discriminatory and therefore creates a barrier to effective competition.

Long-term Brent-indexed contracts; due to oil linkage, LNG prices are also vulnerable to the volatility in oil markets¹⁷.

Take-or-pay clause in Sales Purchase Agreement (SPA).

- Market changes significantly, consequently, the difference between the contract price and the competitive price; in PSO-Qatar there is a contract price review only after 10 years, coming next year

Port charges are built in the DES price (which is to be paid by the seller) and the remaining is added to the RLNG price. Comparing the port charges paid by both PSO and PLL it is evident that PSO pays a higher amount compared to PLL as port charges.

Further, the port charges being charged by Port Qasim Authority for LNG are amongst the highest in the world¹⁸. This raises serious competition concern in the domestic LNG market since higher port charges will be reflected in inflated LNG/RLNG price.

To import LNG no license is required as the importer can get into a contract with the exporter however to transport the natural gas after regasification at the terminal the importer has to get into a contract with the Sui companies for RLNG transportation, whereby he would pay wheeling charges and buy the capacity.

Under the existing pipeline infrastructure where the federal government has bought the (1.2 BCFD of RLNG to be transported to consumers in Punjab) pipeline capacity of the Sui companies, the market to transport RLNG by a private firm to end consumer is foreclosed.

There is no separate UFG benchmark for RLNG at distribution which results in excessive and unfair financial burden passed onto the RLNG consumers. The imported LNG is with higher btu in comparison to the indigenous gas produced. Yet, the pipeline infrastructure to handle both is the same. The SSGC network is not equipped to handle the high btu RLNG. Resultantly, the pipeline losses of SSGC have increased.

Using outdated data to manage Unaccounted for Gas (UFG) for RLNG consumers (industry) has led to significant inaccuracies. UFG requires real-time reporting to ensure lawful and transparent management. Failing to implement modern technological systems eternalizes

Federal Government RLNG is included in the schedule of petroleum product and the names of both SNGPL and SSGCL have been inserted as petroleum companies. Accordingly, OGRA determines the price of RLNG under Petroleum Product (Petroleum Levy) Ordinance 1961 and Petroleum Product (Petroleum Levy) Rules, 1967.

¹⁷ There is no hedging arrangement to reduce the level of future risks in the event of an adverse price movement.

¹⁸ The federal government collects 19.35% of the total LNG tariff through advance income tax, GST, customs duty, and the Federal Excise Duty. In addition, port charges are borne by the supplier and by the customer (PSO or PLL). Likewise, PQA Wharfage, LNG measurement cost, clearing agent cost, and LC charges.

operational inefficiencies and leads to unlawful pricing practices. The absence of automated mechanisms/ separate infrastructure to differentiate between RLNG and local gas exacerbates the issue of UFG and results in incorrect tariff determination for RLNG, breaching legal obligations.

Box 9. UFG - Industry

The gas utilities routinely pass on excess UFG to RLNG consumers.

Actual UFG around 1.5% for 70 % of the textile industrial units. On average, UFG at the industry is about 4%

Currently, **the blend of natural gas and RLNG is manual, at the discretion of Sui companies; molecules are also in their control.** ECC (June 27, 2016) set the parameters for RLNG price determination:

"The RLNG pricing will be ring-fenced, with all directly attributable costs charged/ recovered from RLNG consumers without impacting consumers reliant on domestically produced gas."

There are no specific benchmarks for UFG in determining the price of re-gasified liquefied natural gas (RLNG). Despite ECC directives, UFG is considered a component of RLNG price, unfairly burdening RLNG consumers.

The lack of proper planning and foresight by gas utilities, excessive government involvement in the LNG supply chain has compromised the reliability of gas supply across industrial and commercial sectors.

4.5. Open Access & Wheeling of Gas

Instead of implementing the policy proposal under the amended Exploration & Production (E&P) Policy 2012 that allowed "third party access to 35% of domestic gas discoveries to the private sector over seven years," it has recently been retracted by the Petroleum Division. Instead, new guidelines require E&P companies to recover depleted gas before selling 35% of additional output to the private sector.

This move goes against the spirit of deregulating the oil and gas sector and is primarily meant to protect the two state-owned gas companies. Under the newly announced framework, Sui companies will continue to receive 65% of future discoveries without bidding.

Liquidity issues caused by outstanding dues have long hindered E&P activities. This decision (rather politically motivated) will lead to more distortions that discouraged investment in domestic E&P and resulted in no significant gas discoveries.

Past decisions to set a gas price ceiling have had a detrimental impact on the exploration business. This policy change will disincentivize exploration and production activities and potentially reverse the depletion of domestic gas resources. The upstream industry faces liquidity issues due to unpaid dues, hindering E&P activities¹⁹. The decision to set a gas price ceiling in 2006 discouraged investment in the E&P business (Sattar & Ali, 2024). This retraction will not help either. It is likely to discourage further E&P activities and could lead to a further decline in domestic gas production.



Likewise, allow all market participants in the LNG sector to have open access on a non-discriminatory basis. Implement the concept of 'wheeling' for bulk power consumers (industry). Pakistan must take inspiration from Japan and South Korea, where the pipeline service business was unbundled, allowing new entrants to use the pipeline networks. The reforms in these countries encouraged retail competition in the pipeline, import, and terminal networks.

Terminal owners must allow third-party use and report and publish their annual utilization plans to promote third-party access to LNG terminals.

Through the unbundling of the downstream gas sector, an open access policy, and the removal of tariff restrictions, new entrants in the retail sector will be free to sell gas in any area at the market-determined price.

A level playing field for both the public and private sector in the LNG market. Increased competition will result in greater choice and lower prices for the domestic RLNG consumers.

¹⁹ Currently, only a few local companies remain, as most of the foreign companies have departed. State-owned companies primarily dominate exploration.

The concept of multiple users on LNG terminals is being introduced through OGRA LNG Terminal and Storage Access Rules and Code (drafted by OGRA). The said rules shall play a pivotal role in liberalization of LNG/ RLNG market and promote uniform principles of transparency, fair and non-discriminatory practices in all transactions concerning use of LNG terminals and ensuring safe and reliable supply of gas, thus contributing to the country's economic growth. All what is required is its implementation.

4.6. Gas Markets & WACOG

Globally, due to changing gas market dynamics, gas markets in several countries have shifted towards WACOG or price pooling formulas. This shift underscores the potential of these formulas as the best short-term solution against the declining local gas resources in Pakistan.

WACOG can also promote E&P activities by ensuring timely payments to indigenous gas suppliers. This is particularly significant given the recent discoveries by Mari Petroleum and other exploration and production companies, which indicate a substantial potential for increasing natural gas supply from within Pakistan. As a result, known structures have not been drilled where there is a fair chance of discoveries.

Box 10. Natural Gas Reserves

- Basin studies indicate a total gas resource potential of 282 trillion cubic feet (Abbasi, 2018).
- According to Sattar (2020), only 8% of the total gas potential (1400TCF) has been discovered.

Cross subsidy and diversion of RLNG to domestic consumers is not economically sustainable for the sector. Recently, some recovery of diverting RLNG from indigenous gas consumers through Revenue Requirements has been allowed, but significant cross-subsidy still exists.

The resolution of these issues hinges on establishing a system-wide WACOG of RLNG and system gas. This will prevent further debt accumulation and ensure that gas prices adjust automatically with changes in international prices.

Over 50% of the energy-deficient North, particularly Punjab, is supplied by RLNG. This expensive imported gas is continuously diverted to the domestic sector for most of the year. In winter, more indigenous gas is needed to meet domestic demand, leading to a massive diversion of RLNG. The diversion of RLNG to the domestic sector due to massive fluctuations in demand by the power sector is not just a cause but the primary reason for the liquidity crunch and circular debt plaguing the gas sector.

Implementing WACOG will also address the issue of shutting down gas fields to accommodate contracted LNG volumes when the power sector does not meet the demand. With the current fragmented approach, we will inevitably accumulate sovereign debt.

Pakistan receives approximately 10 LNG cargoes monthly, around 1 BCF of the total LNG supplies. This accounts for over 50% of the supplies for SNGPL. Moreover, SSGCL increasingly turns to supplies with a 20% to 25% LNG blend. This situation is expected to worsen as their domestic gas supplies are decreasing rapidly. Applying the weighted average cost of gas across the country and the sectors is crucial.

Providing actual fuel prices to industry stakeholders can enhance economic activities. Globally, bulk consumers benefit from reduced prices compared to individual households, a phenomenon currently disproportionate in Pakistan. Implementing WACOG can help stimulate economic activity. **WACOG will be around PKR 2,200/MMBtu.**

This will increase domestic prices for some categories, but they will still be far less than the prices of RLNG. This will help resolve market distortions. Pakistan can no longer afford to sell expensive resources at subsidized prices. In the SSGCL network, WACOG will bring about positive changes for consumers. Process and captive will be charged (in FY25) PKR 2,150/MMBTU and PKR 3,000 / MMBTU, respectively. With captive consumption in SSGCL double that of the process industry, introducing WACOG is a much-needed solution for these consumers.

In the light of Article 158 of the constitution of Pakistan, provinces can be compensated through some profit-sharing formula or compensation through taxes as suggested in PIDE (2024)²⁰.

Increased private sector participation and the addressing of structural and operational barriers are crucial to ensuring the sustainability of the natural gas sector.

WACOG – Starting Point!

²⁰ A property tax for the local government where the hydrocarbons are produced (taxed on the value of all assets, but not more than 1 percent of the value); severance tax on the fuel value (oil, natural gas, or any other gaseous or liquid hydrocarbons) extracted to be paid to the province (3 percent or less); and sharing of income taxes by both Federal and Provincial Governments.

Chapter 5.

IS GRID ELECTRICITY VIABLE FOR INDUSTRY?

5.1. Electricity Price for Industry

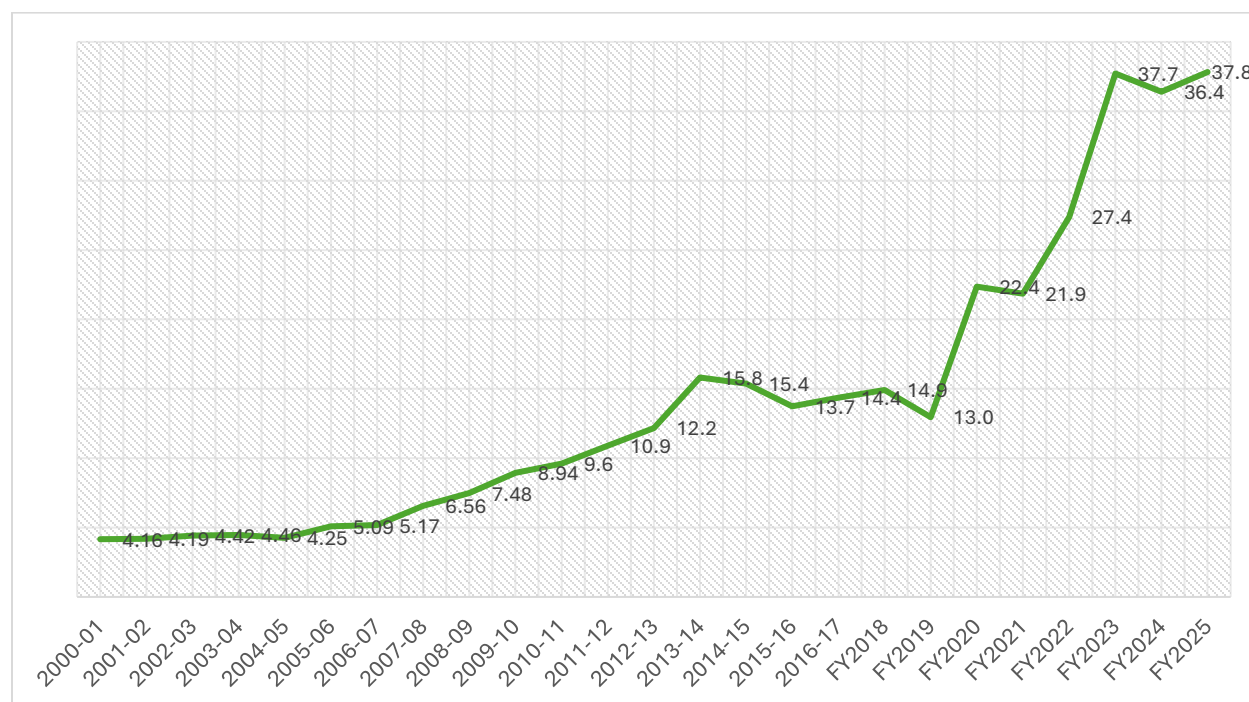
Energy prices can significantly impact on the economies' competitiveness, particularly for energy-intensive sectors in export markets. Additionally, the availability and cost of energy can affect the productivity and efficiency of industrial units, potentially leading to deindustrialization.

The Circular Debt Management Plan (2023) implementation (under IMF) aimed to reduce untargeted subsidies, resulting in withdrawal of support package and policies for zero-rated industries. **Exporting firms are losing competitiveness after the withdrawal of the US 9 cents Regionally Competitive Energy Tariff (RCET).** Due to budgetary limitations, providing RCET to the industry may not be possible.

he

- No subsidy for industry (not even for zero-rated) in Budget FY2024-25.

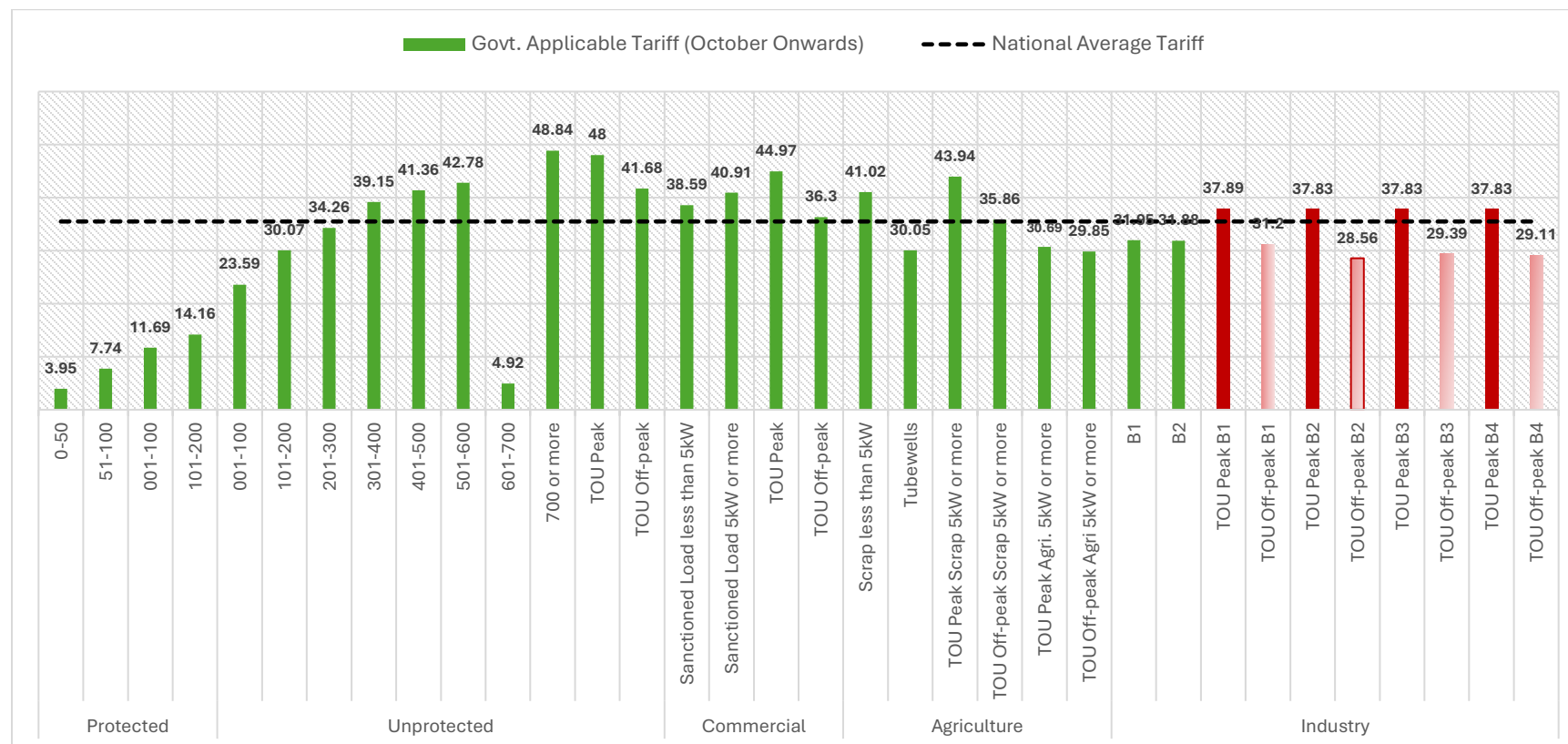
Figure 16. Industry Average Electricity Sale Price (PKR/ kWh)



Source: NEPRA; for FY24 and FY25 are the determined prices for B3

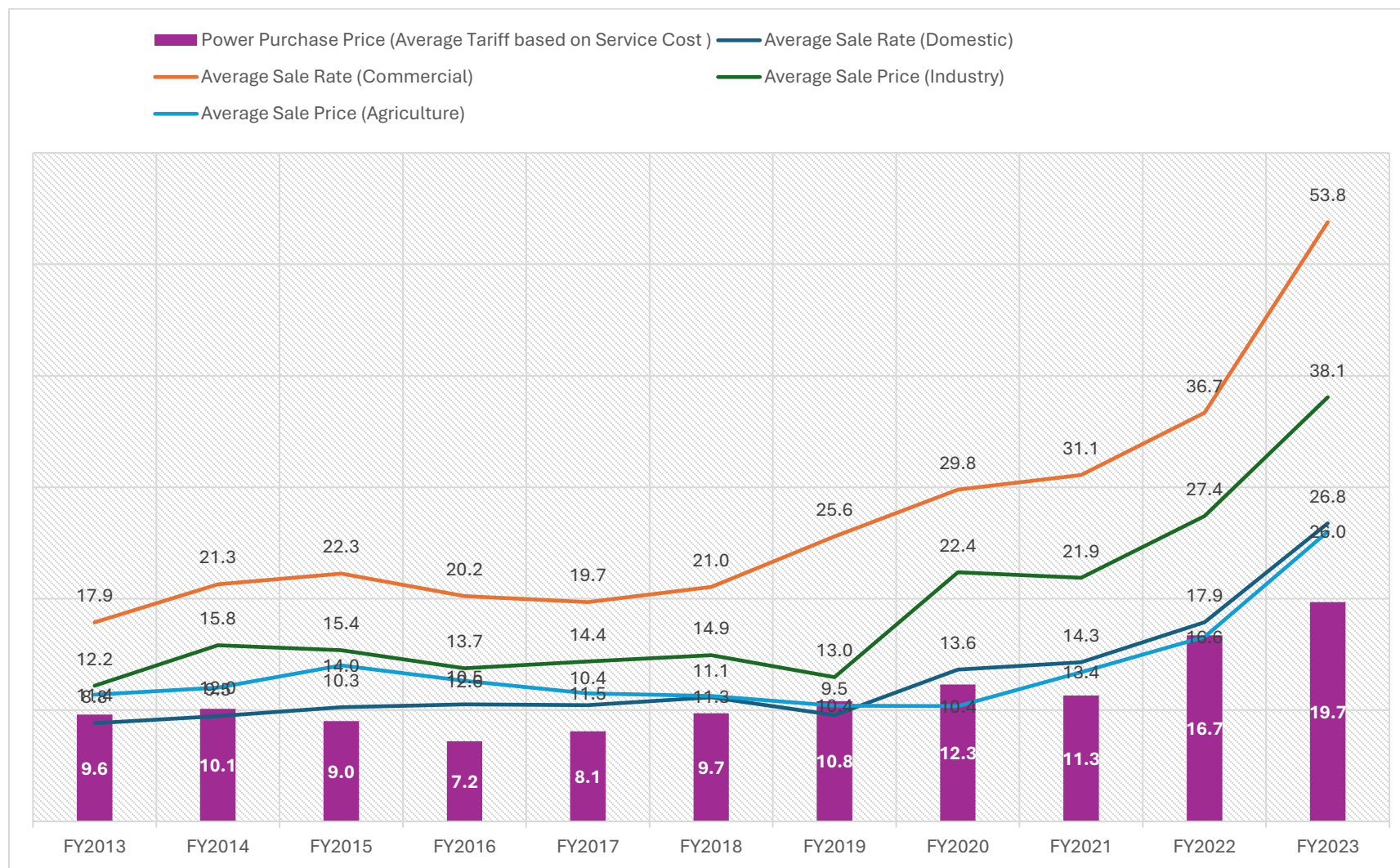
Figure 17. Electricity Tariff (PKR/kWh) (FY25 – Oct. onwards)

It is a base tariff, does not include fuel price adjustments, quarterly tariff adjustments, fuel cost surcharge, taxes, etc.



Source: Government Notified Tariff, July 2024

Figure 18. Cross-subsidy Across Sectors



Source: Estimated based on data available in NEPRA State of Industry Reports and NEPRA Tariff Determinations

Table 8. Average Tariff and Cross-Subsidy paid by Industry

	EPP	CPP	UoS	PPP (Average Tariff based on Service Cost)	DM	PYA	Average Tariff	T&D Losses	Average Tariff (after adjusting T&D losses)	B3 (Peak)	B3 (Off-Peak)	B4 (Peak)	B4 (Off-Peak)	Cross-Subsidy (B3 Peak)	T&D Adjust. Cross-Subsidy (B3 Peak)
FY2023	9	9.77	0.895	19.7	1.92	0.32	21.91	2.91	24.82	45.1	39	45.1	39	23.19	20.28
FY2024	6.73	15.01	1.21	22.95	2.73	0.59	26.27	3.51	29.78	36.4	30.8	36.4	30.8	10.13	6.62
FY2025	9.69	16.29	1.37	29.34	3.26	0.83	31.44	4.06	35.5	37.83	29.39	37.83	29.11	6.39	2.33

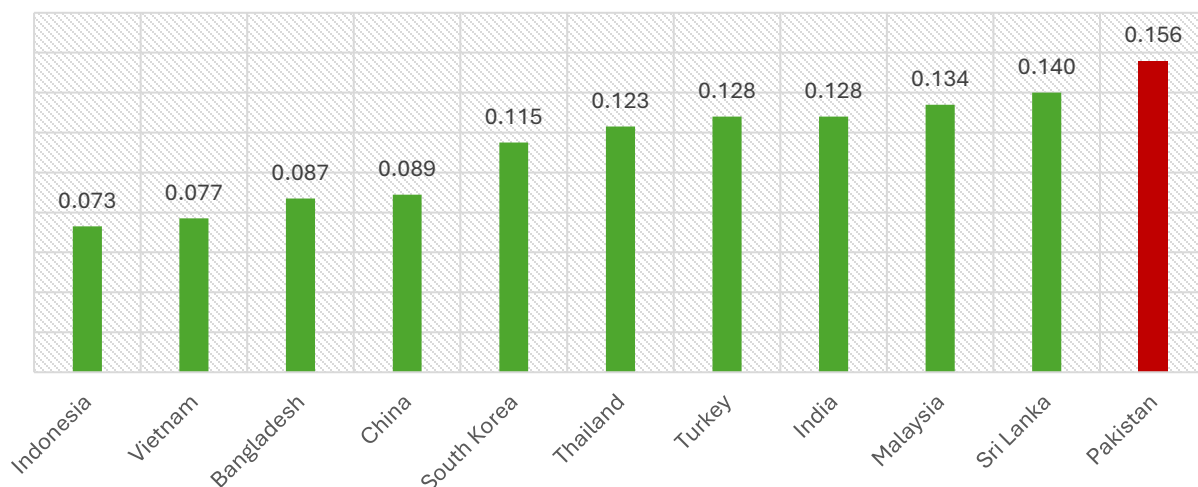
Source: NEPRA Tariff Determinations

5.2. Cross Subsidization across Sectors: Energy Pricing must Change

For years, Pakistan's tariff structure has been a major problem in the energy sector and is behind many of our serious problems in the system. **Massive cross-subsidization across sectors has forced the transfer of funds from industrial and commercial consumers to domestic and agricultural consumers** (Figure 17). Overall, the recent reduction in industry cross-subsidies to other sectors (even elimination during off-peak hours) will have an insignificant impact on the industry. It has been offset after the additions of financial cost surcharge, taxes, fuel cost adjustments, etc. It is anticipated to be further offset by high quarterly tariff adjustments in the coming months since generation is down by 20% relative to NEPRA's reference level. The industry will still maintain higher rates compared to its regional competitors (Figure 19).

- In the FY25 power tariff rebasing, the cross-subsidy in industrial power tariffs was reduced by PKR 150 billion.
- The average electricity rate is still much higher than regional competitors after adjusting for surcharges and taxes, exceeding 15 cents/kWh (equal to PKR 44/kWh at exchange rate of 278 as of Sep. 19, 2024) (Figure 19), making grid electricity financially unviable for most industrial plants.

Figure 19. Electricity Rate (US\$/ kWh) (Average for Small, Medium and Large Firms) as of December 2023



Source: <https://www.globalpetrolprices.com/electricity/prices>; Sattar (2024)

Substantive cross-subsidization over the years has skewed consumption toward less-productive domestic consumers over the years, consuming about 48% of total electricity consumed. In comparison, industry consumes 25%.

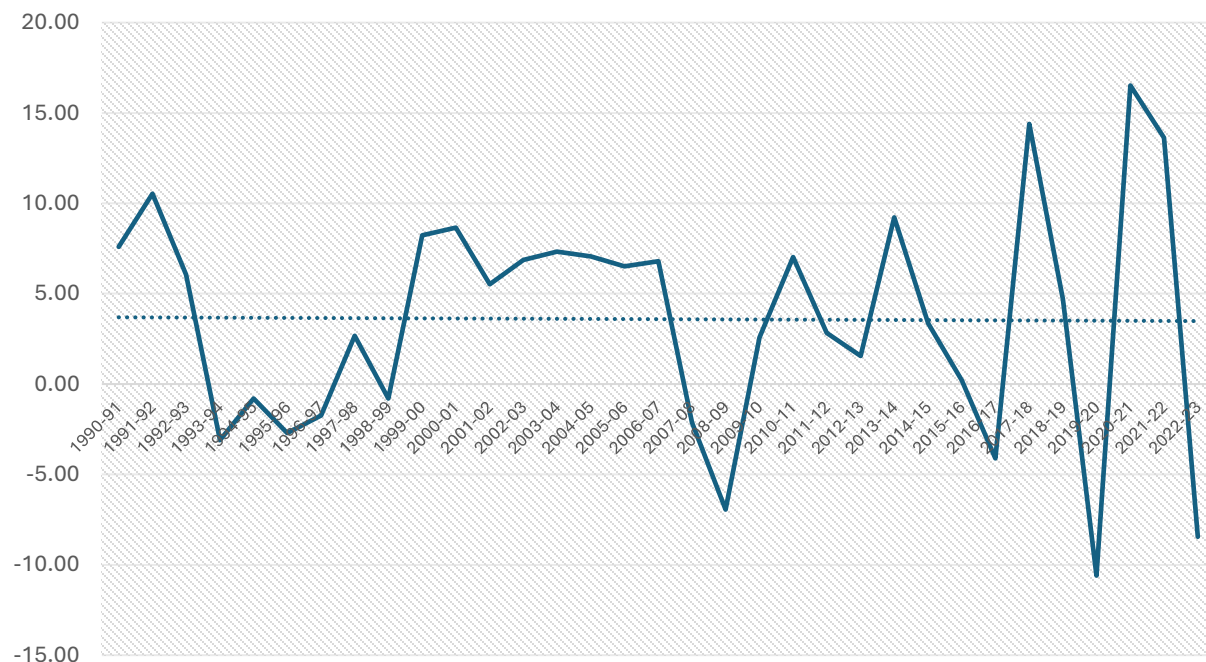
More than 70% of the domestic consumption is in the subsidized slabs, which may not necessarily be poor. Of 29 million domestic power consumers, around 17 million are protected, representing approximately 30% of total grid demand while contributing just 12.6% of power sector revenue (APTMA, 2024).

Increasing Block Tariff (IBT) to subsidize low-income individuals and disincentivize higher consumption creates conflict between efficiency and distributional goals. It results in a deadweight loss relative to direct cash transfers for those experiencing poverty.

A robust connection has been observed between grid electricity tariffs (Figure 16) and industrial electricity consumption (Figure 20) – competitive tariffs and availability have always encouraged industries to use more grid electricity. In the 1990s, large industrial units were encouraged to install their power plants running on gas due to electricity shortages. This move reduced their reliance on grid electricity. Tariffs remained frozen between FY2003 and FY2007 at a very low level. This period was also a consumption-led growth period. Industries increased their reliance on the grid.

However, when the energy prices started rising in 2008, accompanied by the electricity shortage, many large industrial units either ceased operations or relocated to other countries. Some increased their reliance on captive power plants, reducing their dependence on grid electricity. In recent years, the consumption of power by industrial users increased after the government introduced zero-rated industrial tariffs. However, the trend has reversed with the withdrawal of the RCET regime.

Figure 20. Industrial Electricity Consumption (% Growth)



Source: Malik & Mustafa (2024)

Secondly, consumer-end tariffs have significantly risen in recent years, with average sale prices increasing by over 700% since 2007. The average tariff for industry has increased by about 640 % in the same period. **In Pakistan, electricity tariffs for industries are 30-50% higher than its regional competitors (Figure 19).**

5.3. High Electricity Prices but Unreliable Supplies

Even more significant than the tariff is the reliability and availability of electricity for industry. The productive sectors require a continuous electricity supply; otherwise, they must restrict production or rely on other sources. **High tariffs and unreliable supply have led large industry to establish self-generation facilities which are now an integral part of industry.**

However, when gas/RLNG is not available (particularly for SNGPL consumers), large industries (left with no other option) relied on the grid, affecting their competitiveness. Small industries in Punjab, with no alternate source, with an increase in tariff, move towards contraction. They have contracted significantly since 2016 (Malik et al., 2023).

Unannounced shutdowns or power fluctuations lead to production loss and damage to computerized gadgets attached to the latest machinery. **A breakdown of one-minute stops works in spinning units for 20 to 25 minutes, resulting in a production loss of 10 to 15% (PIDE, 2021).**

Each power outage leads to monetary losses of PKR 35,000 to PKR 50,000, depending on the process and equipment. Equipment damage, especially electronic control cards (costing up to PKR 1 million each), is vulnerable to voltage spikes and frequency variations (PSIA, 2023). However, APTMA says monetary loss due to power outages depends on many factors and is much larger than PKR 50,000.

5.3.1. Enough Electricity for Industry?

About 80% of the industry in the South has gas connections. 30% of them have only a gas connection and no electricity connection. Besides, **there is not enough power available on the grid to meet the energy demand currently being fulfilled through self-generation.**

In the north, applications for load enhancement have been pending for over three years despite the demand notes having been fulfilled.

In the southern region, there is a high demand for load enhancement applications, but the industry is facing challenges due to the unfeasible cost (billions of rupees) for liquidity-short (struggling) businesses.

Even though the maximum load allowed on 11kV lines has been increased from 5MW to 7.5MW through NEPRA, significant problems persist in accessing the required power supply from the grid. The industry needs more than 4,000 MW of additional electricity and supporting infrastructure, including 11KV and 132 KV grid stations for transitioning from CPP to grid. An investment of PKR 20 billion is needed for this project, with a completion timeline of up to two years (Power Division, cited in Mustafa, 2024).

- In the SNGPL network, more than 60% of CPPs require additional infrastructure for complete switching to the grid.
- In the SSGCL network, 637 active CPPs with grid connectivity require additional infrastructure, which costs PKR 15.8 billion for complete switching to the grid.

5.4. Implement CTBCM

Exporting industries are losing competitiveness after withdrawing the US 9 cents/kWh Regionally Competitive Energy Tariff (RCET). Due to budgetary limitations, providing RCET to the industry would not be possible. Likewise, shifting CPPs to the grid will not be viable for the industry.

The current market structure is a single-buyer model; instead of motivating efficiency, it transmits inefficiency to consumers through increasing tariffs. **The burden of capacity payments on compliant consumers due to excess installed capacity underscores the urgent need for a competitive market in Pakistan's power sector.**

On the generation side, there is capacity available for trading in B2B contracts. Furthermore, IPPs (under 1994 and 2002 policies) have agreed to transition towards the business-to-business market once the Competitive Trading Bilateral Contracts Market (CTBCM) is implemented.

A competitive tariff can be provided to the industry while implementing CTBCM. Power wheeling and its associated costs are the primary issues that must be addressed. Efficient pricing is essential in a competitive electricity market. Inefficient pricing fails to effectively signal and encourage appropriate levels of consumption and supply and the necessary levels and locations of new generation and transmission investment.

To ensure the market functions effectively, we must treat electricity as a commodity, thereby minimizing government intervention in the marketplace. The Competitive Trading and Bilateral Contracting Market (CTBCM) should allow Bulk Power Consumers (BPCs) the freedom to choose their preferred power supplier after paying the Wheeling or Open Access Charges.

CTBCM should start with bilateral contracts, keeping transmission constraints and participants' capacities in mind. The 'wheeling of power' – electricity transmission from a producer to a user in the same balancing area or from one location to another should be allowed immediately. **CTBCM will only succeed if the wheeling charges (pricing) are priced appropriately.**

Box 11. Wheeling Charges under CTBCM

- Wheeling charge should not try to cover all ancillary deficits including the costs of excessive employment – legacy costs.
- Cross-subsidy should not be a part of bulk power consumers in B2B contracts.
- Not all stranded costs can become part of the tariff in a competitive market. Therefore, flexibility in the stranded costs can also be allowed.
- Only fixed costs resulting from universal service obligations (such as investments made by high-cost producers (baseload) to enhance generation capacity, enabling all consumers to be served) can be charged to wheeling customers.
- Further, electricity wheeling can be successful only when there is transparency, fairness, and predictability. A governance framework that instills trust in the regulatory structure and motivates new market participants is necessary to achieve this. In a competitive market, market players must be informed of bids and offers and transactions in real time. This is easy to achieve in a digital age.

By implementing CTBCM, **starting with large bulk power consumers (B3 and B4 - consuming 1MW plus), the exporting industry would be able to receive competitive tariffs without putting any additional financial strain on the government.**

Once this is successfully established, more suppliers will come. **In the second stage (after 12 to 18 months), B1 and B2 consumers should be allowed to purchase from the market directly.** Establish a fully operational wholesale market in five years.

Once these factors are considered, the tariff in B2B market (including wheeling costs) will not be more than PKR 22 / kWh for renewable plants like Zhenfa or plants relying on indigenous clean fuels.

The urgency for transitioning to cleaner energy has now become more critical, with the EU planning to introduce the Carbon Border Adjustment Mechanism (C-BAM) in 2026. The transition to green energy is crucial for Pakistan's industrial sector to meet global environmental regulations and engage in the international market.

Implementing the CTBCM may facilitate off-site renewable setups, empowering industries to secure affordable green energy through special arrangements like reduced wheeling charges, all without the burden of cross-subsidies.

The ‘wheeling of power’ for the Bulk Power Consumers (BPCs) must forcefully overcome all obstacles, including those created by the Power Division, within 2-3 years. This would pave the way for the full-fledged wholesale power market. As a result of this initiative, the country's small BPC population would benefit from reduced energy costs and improved access to standard supplies. Open access to all market participants on a non-discriminatory basis will attract new investments competitively.

5.5. Impact of Electricity Prices

APTMA reports:

- The textile exports grew by 54% between FY20 to FY22, driven by regionally competitive energy tariffs.
- With rise in electricity prices in FY23 (average sale price for industry increased by 39% excluding taxes), grid consumption of APTMA members in the North contracted by 70% YoY since Oct. 2023.
- Out of 133 units in Punjab, 78 units have reduced their energy consumption by 25 to 50% in a year.
- Only a few large composite units experienced an increase in electricity consumption (5 to 10%).
- SMEs are being wiped out.

A recent survey by PIDE of small and medium enterprises (SMEs) in Faisalabad confirms APTMA’s observation. Almost half of small and medium textile units have been closed over the last two to three years

Further, using a sample of 129 industrial units (2018 to 2023) in Pakistan (details in Annex A1), assuming other variables as constant, we estimated that:

If there is no gas for CPPs, and the industry is shifted 100% to the grid:

- PKR 44/kWh²¹ (49% increase from the base tariff in FY23²²) will translate into (for all firms)
 - A contraction in sales revenue of 3.2%
 - Investment by 4.8%

²¹ Taxes and surcharge included

²² Impact is calculated using a base tariff PKR 29.3 in FY23 (based on blend of 60% gas based CPP and 40% grid electricity (PKR 38.1/kWh); for CPP we used blend of 75%RLNG and 25% local gas tariff. The impact of energy tariff is estimated, assuming other variables as constant.

- Exports revenue by 6.3%
- A firm (on average) will lay off 95 workers.

In the textile sector – cutting gas to the industry (CPPs) will lead to de-industrialization.

- A contraction of sales revenue by 2.2%
- Investment by 5.9%
- Exports revenue by 5.7%
- A textile firm (on average) will lay off 292 workers.

In the textile sector, a 5.7% decline in export revenue translates into a loss of about US\$3 billion in export earnings. These are very conservative estimates, as all firms (as explained earlier) are not connected to the grid and will not switch to the grid. **The actual impact will be much greater.**

An increase in electricity tariffs for the industrial sector is anticipated to raise manufacturing costs, potentially leading to a liquidity crisis due to reduced profitability. This will make exports less competitive, ultimately causing the industry to shrink, negatively affecting employment. The textile and apparel industry are not only heavily reliant on energy but is also one of the largest employers in the country, providing jobs for millions of people both directly and indirectly.

- With a 49% increase in electricity tariffs, each firm will lay off about 292 employees. **The total number of unemployed with a 49% increase in energy tariff will be 117,676 in 403 working textile units (organized sector) in Pakistan²³ in a year. In other words, on average, it means the closure of about 49 units in a year²⁴.**

Textile Commissioners Organization (2023) reports about a highly fragmented cottage/small-scale textile sector in addition to the organized large-scale textile industry. According to the Census of Manufacturing Industries (2015-16), 7503 textile units in the country employ (on average) 2144 individuals (indirectly 2144 families). The same survey reports 2371 wearing apparel units in the country employ (on average) 1598 Individuals (indirectly 1598 families). Based on these figures:

- **With a 49% increase in electricity tariffs, about 2.2 million will be unemployed in textile units in a year. On average, the closure of 1022 textile units in a year.** Likewise, with this tariff increase, **about 0.69 million will be unemployed in wearing apparel units; on average, there will be a closure of 433 apparel units in the country.**

²³ Reported in Textile Commissioners Organization (TCO) Annual Report 2023.

²⁴ Average number of employees in sample textile firms are 2400.

In other words, shifting industry to grid will lead to deindustrialization, a significant contraction of the primary export sector, and massive unemployment.

According to the Labor Force Survey 2020-21, about 4.12 million are employed in the textile sector (formal and informal) in Punjab. Going by these figures, the magnitude of unemployed only in Punjab with a 49% increase in electricity tariff will be even more than the above figures for the whole country – massive unemployment a complete economic disaster.

If CTBCM implemented, and wheeling cost does not include sector inefficiencies as explained in previous sub-section the impact will be:

- PKR 22/kWh (25% decrease from the base tariff in FY23) will translate into (for all firms)
 - Sales revenue will increase by 1.6%
 - Firms will increase investment by 2.5%
 - Exports revenue will go up by 3.2%
 - A firm (on average) may expand its operations, generating more employment opportunities

For textile sector

- Sales revenue will increase by 1.1%
- Firms will increase investment by 3%
- Exports revenue will go up by 3%
- **More employment opportunities in the textile sector. The closed units will reactivate.**

As per APTMA (2023) estimates, reopening closed production units and activating idle capacity could increase annual exports by up to \$9 billion.

Table 9. Impact on Firms, if no Gas for Captive Consumers in FY2025

	All Firms	Textile	All Firms	Textile
	% Impact (if no gas) Grid Tariff PKR 44/ kWh		% Impact if CTBCM implemented Tariff at PKR 22/kWh)	
Investment	-4.802	-5.929	2.5	3.0
Total Sales Revenue	-3.185	-2.156	1.6	1.1
Exports Revenue	-6.272	-5.733	3.2	2.9
Employment²	-95.55 (No.)	-291.746 (No.)	49(No.)	149 (No.)

Source: Author's estimation based on firm level data from 2016-2023

5.5.1. If Gas Supply is Not Disconnected to CPPs

Using the methodology described in Annex A1, the impact of various gas tariffs for CPPs is estimated. It is assumed that firms will generate electricity using CHPs (combined heat and power, with 70% efficiency) and single-cycle CPPs where no heat recovery benefit (efficiency 30% to 40%). Results are illustrated in Table 10 and Table 11.

Impact is calculated using a base tariff PKR 29.3 in FY23 (based on blend of 60% gas based CPP and 40% grid electricity); for CPP we used blend of 75%RLNG and 25% local gas tariff for SNGPL. The impact is estimated, assuming other variables as constant. **The impact of the increase in gas tariffs is negligible for high-efficiency CPPs.**

Even the negative impact on single-cycled CPPs is much less compared to if they are shifted 100% to the grid. These units can mitigate the negative impacts by enhancing the efficiency of their captive units.

- **The best option for firms with CPPs (all types) is WACOG.**

For combined heat and power CPPs in textile units with WACOG:

- **Investment will increase by 5%**
- **Sales revenue will Increase by 2%**
- **Exports will also go up by 5%**
- **More employment generation, and reactivation of closed units.**

Even with CPPs with no heat recovery benefit, WACOG is the best option (Table 11).

In SSGCL Network:

Firms with self-generation of power will receive a blend of local gas and RLNG in the ratio of 75:25 in FY25 if gas is not disconnected. Even for them, the per-unit cost of electricity from the blended gas tariff will be in the range of PKR 27.06/kWh to PKR 36/ kWh, depending on their plant efficiency. As the blend between RLNG and local gas varies depending on the availability of local gas. Again, WACOG will be the most viable option for gas-fired self-generation units in the SSGCL network.

Table 10. Impact of Different Gas Tariffs on Firm's Performance (Gas Prices – September 2024)

For firms connected to SNGPL Network

Heat Recovery Benefit Included (CHP); assuming 70% energy efficiency						
	WACOG		Blend RLNG & Gas (75:25) (SNGPL)		RLNG	
PKR/MMBtu	2127.25		3644		3859	
PKR/kWh	16.98		30.32		32.22	
	All Firms	Textile	All Firms	Textile	All Firms	Textile
	% Impact		% Impact		% Impact	
Investment	4.1	5.1	-0.34	-0.42	-0.98	-1.21
Total Sales Revenue	2.7	1.8	-0.23	-0.15	-0.65	-0.44
Exports Revenue	5.4	4.9	-0.45	-0.41	-1.28	-1.17

Table 11. Impact of Different Gas Tariffs on Firm's Performance (Gas Prices - September 2024)

Heat Recovery Benefit Not Included						
	WACOG		Blend RLNG & Gas (75:25) (SNGPL)		RLNG	
PKR/MMBtu	2127.25		3644		3859	
PKR/kWh	24.94		40.23		42.40	
	All Firms	Textile	All Firms	Textile	All Firms	Textile
	% Impact		% Impact		% Impact	
Investment	1.46	1.80	-3.65	4.51	-4.38	-5.41
Total Sales Revenue	0.97	0.65	-2.42	1.64	-2.91	-1.97
Exports Revenue	1.90	1.74	-4.77	4.36	-5.72	-5.23

Source: Author's estimation based on firm level data from 2016-2023

During our discussion with industry stakeholders, they said that if CTBCM is implemented in true spirits, the whole industry will move towards B2B contracts.

Grid is not viable for productive sectors! Open access for all market participants is essential to attract bulk power consumers and use excess capacity. Let the market develop—the market will create its demand.

Chapter 6

COGENERATION (COMBINED HEAT AND POWER): AN INDUSTRIAL PROCESS?

6.1. Single-Cycle Power Plant & Combined-Cycle Gas Turbine

A single-cycle power plant is a type of natural gas power plant that generates electricity by propelling hot gas through a turbine. Unlike combined-cycle gas plants, the waste heat from a single-cycle plant is released into the atmosphere rather than powering another external heat engine. A single cycle steam power plant is limited to efficiencies from 35 to 42%, in some cases up to 45%.

Combined cycle gas turbines (CCGT) are claimed to reach around 64% real thermal efficiency at full-load operation. The real-world efficiency of CCGT often differs from claims. Partial loading of these plants prevents them from operating at their most efficient point on the heat rate curve, resulting in higher heat rates and lower efficiency.

- Actual operational efficiency of CCGTs ranges from 51-53%, significantly lower than 64% under ideal conditions.
- Changes in grid frequency can result in fluctuations in turbine speed, leading to less efficient combustion processes and decreased overall plant efficiency. Frequent starts and shutdowns can contribute to increased wear and tear on machinery, resulting in inefficient fuel use during non-steady-state operations and reduced overall efficiency.
- Drains and blowdown processes in the Heat Recovery Steam Generator (HRSG) lose steam and energy, further reducing the efficiency of CCGT.

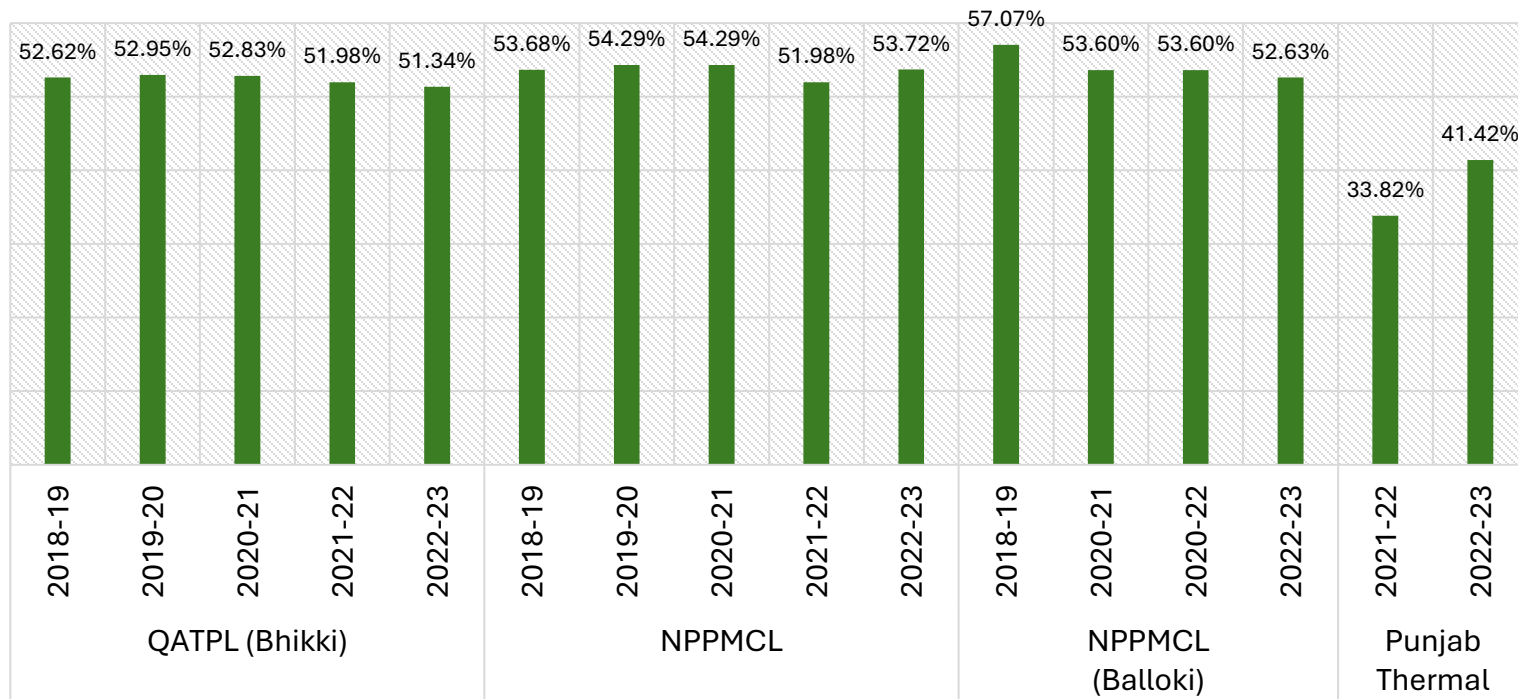
6.1.1. Thermal efficiencies of RLNG-based Government Power Plants (GPPs)

GPPs achieve 33.8% to 53% efficiency in real-world operations, lower than 60-61% in ISO conditions; some RLNG-based Government Power Plants (GPPs) have recorded efficiencies as low as 41% (Figure 17). Reasons being:

- Grid frequency fluctuations, frequent start-ups/shutdowns, steam losses in HRSG, high ambient temperature/humidity and fuel quality variations all contribute to low real-world efficiency.

- Partial loading by e.g., National Power Control Center (NPCC) prevents plants from operating at their most efficient point on the heat rate curve, resulting in higher heat rates and lower efficiency.
- Aggregate Technical and Commercial (AT&C) losses in Pakistan's power sector are approximately 17%, primarily due to technical inefficiencies and commercial factors due to theft and non-payment, adding to the inefficiencies of GPPs.

Figure 21. % Efficiency in Government Power Plants (GPPS)- RLNG based

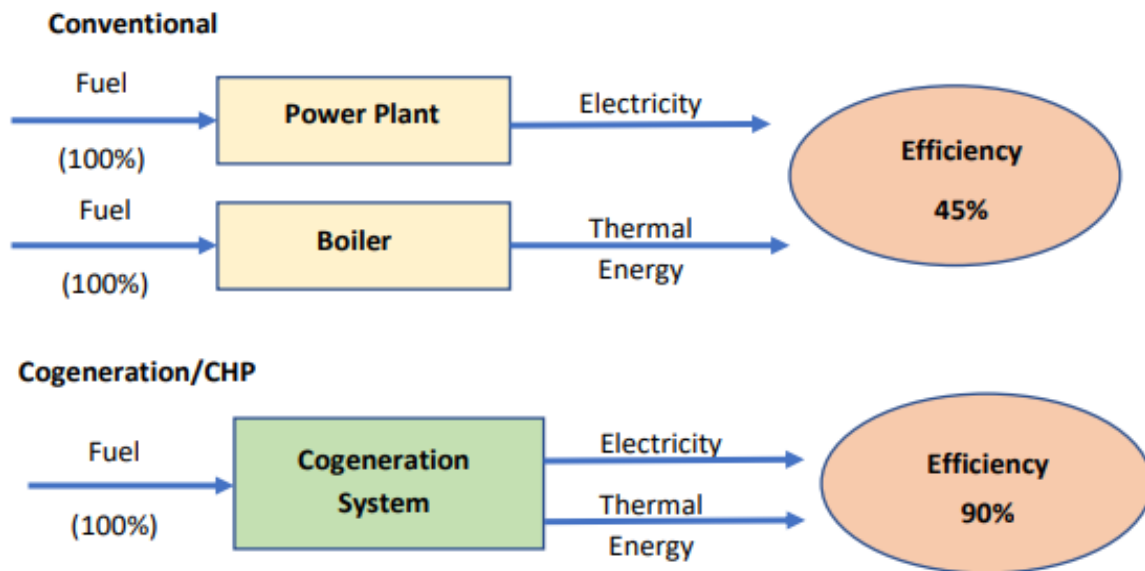


Source: Estimates based on NEPRA State of Industry Reports

6.2. What is Cogeneration (CHP)?

A Cogeneration Combined Heat and Power (CHP) plant generates mechanical energy (converted to electricity) and useful heat simultaneously from a single fuel source. The waste heat recovered from flue gases is used for industrial processes, making CHP more efficient than boilers by producing two forms of energy from a gas molecule. It gives flexibility, uses energy more efficiently, lowers costs, reduces carbon emissions, and cuts transmission and distribution loss.

Figure 22. Efficiency Comparison



Source: Kimura et al., 2023

- 70% of total energy demand in industry is for heat and electricity.
- Electrification is not effective in most of the industrial processes.
- CHP avoids heat wastage and minimize grid losses.
- It generates 40% more productive energy than the average boiler and power plant.
- 30% of the primary energy can be saved through CHP compared to separate heat and power plants, this translates into a saving of 30% fuel costs.

Based on the sequence of energy use, a cogeneration system can be classified as either a topping or a bottoming cycle. In a topping cycle, the fuel supplied is used first to produce power and then thermal energy, which is the by-product of the cycle and is used to satisfy

process heat or other thermal requirements. Topping cycle cogeneration is widely used and is the most popular method of cogeneration.

6.2.1. CHP – Technical Aspects

Typical fossil fuel power plants have an average thermal-to-power efficiency of about 35% to 45%. Steam turbine can only extract so much electrical energy from high-pressure steam, low-pressure steam that exits the turbine cannot be used.

In industry, usually have several processes that can use the lower pressure outlet steam. In cogeneration plants, steam passing through the turbine is maintained at an outlet pressure high enough to be used by process units.

Since turbine outlet steam energy is re-used, this increases cogeneration plant efficiency and allows industrial plants to generate electrical power at lower than market costs.

The heat is typically recovered at higher temperatures (above 100°C) and used for processing steam or drying duties. This is more valuable and flexible than low-grade waste heat, but there is a slight loss of power generation.

The increased focus on sustainability has made industrial CHP more attractive, as it substantially reduces carbon footprint compared to generating steam or burning fuel on-site and importing electric power from the grid.

6.2.2. CHP – Advantages

High Efficiency : Properly designed CHP – overall efficiency of 65-90 %

Fuel Savings: Less fuel requirement, reducing operational costs, and making operations more competitive

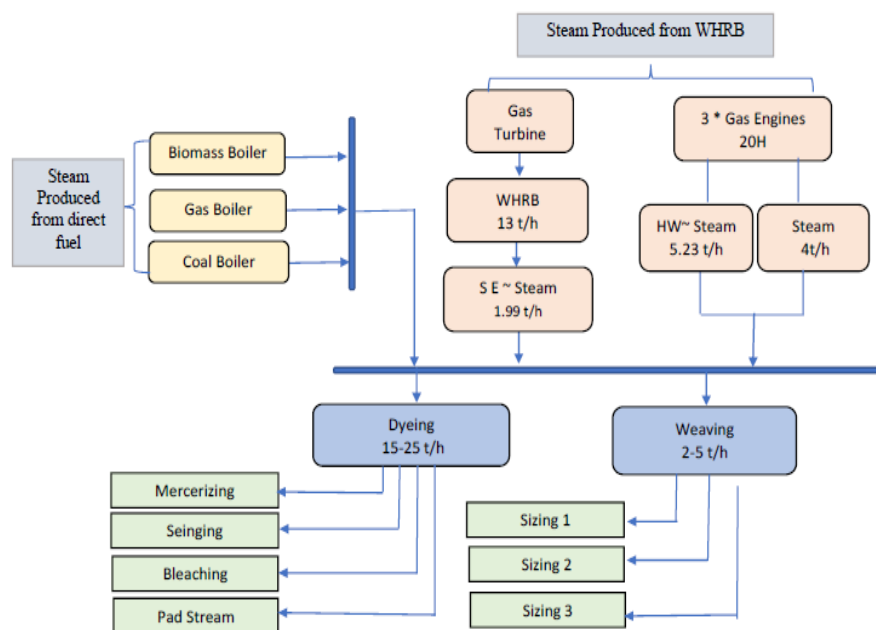
No T & D Losses: CHP (on-site generation) – no losses associated with long-distance electricity transmission infrastructure associated with grid connected IPPs

Reliability: Resilience from grid outages – dependable heat & power supply for industry

Flexibility and Scalability: CHP can be customized for various applications and energy needs, supporting the integration of renewable energy sources like solar and wind

Box 12. Cogeneration - A case of Kohinoor Textile Mills Ltd.

Kohinoor Mills Ltd. has optimized its operations by implementing state-of-the-art electric generation and waste heat recovery systems for its downstream processes. With the recent replacement of outdated 20C engines with the latest 20H models, the plant's overall efficiency has now exceeded 90%, ensuring optimal performance.



Kohinoor Mills Ltd. , 8-KM , Manga-Raiwind Road , Distt. Kasur				
Plant Efficiency	Unit	Prime Option		
		3xG3520-H	1xGas Turbine-T70	
Electrical	Engine Electric Output	KWh	6,000	6,400
	Fuel Consumed	mmbtu	54	83
	Gas GCV	btu/ft³	990	990
	Engine SFC	btu/KWh	8,925	13,020
		Sm³/KWh	0.254	0.371
	Gas LHV	btu/ft³	893	893
		Kj/Sm³	33,261	33,261
	Heat Input To Engine	Kj/KWh	8,448	12,324
		KW	14,080	21,909
	Gross Electric Effic. (η)	(%)	42.6%	29.2%
JW/AC		M³/hr	66	44
		In °C	30	30
	Hot Water Recovery From	Out °C	77	38
	Engine Jacket Water Heat	ΔT	47	8
		TPH	4.7	0.53
		KW	3,605	409
	(η)	(%)	25.6%	1.9%
Sec Economizer		M³/hr	44	44
		In °C	77	38
	Hot Water Recovery From	Out °C	85	60
	Engine Exhaust Gas Heat	ΔT	8	22
		TPH	0.53	1.46
		KW	409	1,125
	(η)	(%)	2.9%	5.1%
Boiler	Waste Heat Steam Recovery	TPH	4.00	13.0
		KW	3,085	10,027
	(η)	(%)	21.9%	45.8%
	Gross Thermal Efficiency (η)	(%)	50.4%	52.8%
Plant Gross Effic. (+0,-5%)		(%)	93.0%	82.0%

Figure 23. RLNG-based GPPs vs Interloop Cogeneration Power Plant



Table 12. Comparison of Combined Heat and Power (CHP) Characteristics

Characteristic	Technology				
	Reciprocating Engine	Gas Turbine	Microturbine	Fuel Cell	Steam Turbine
Size Range	10 kW–10 MW	1 MW–300 MW	30 kW–330 kW (larger modular units available)	5 kW–2.8 MW (larger modular units available)	100 kW–250 MW
Electric Efficiency (HHV)	30–42%	24–36%	25–29%	38–42%	5–7%
Overall CHP Efficiency (HHV)	77–83%	65–71%	64–72%	62–75%	80%
Total Installed Cost (\$/kW) [3]	\$1,400–\$2,900	\$1,300–\$3,300	\$2,500–\$3,200	\$4,600–\$10,000	\$670–\$1,100 [4]
O&M Cost (¢/kWh)	0.9–2.4	0.9–1.3	0.8–1.6	3.6–4.5	0.6–1.0
Power to Heat Ratio	0.6–1.2	0.6–1.0	0.5–0.8	1.3–1.6	0.07–0.10
Thermal Output (Btu/kWh)	2,900–6,100	3,400–6,000	4,400–6,400	2,200–2,600	30,000–50,000
Fuel Pressure (psig) [5]	1–75	100–500 (may require fuel compressor)	50–140 (may require fuel compressor)	0.5–45	n/a
Part Load Efficiency	Good at both partload and full-load	Better at full-load	Better at full-load	Better at full-load	Good at both partload and full-load
Type of Thermal Output	LP steam, hot water, space heating, chilled water	LP-HP steam, hot water, process heating, chilled water	LP steam, hot water, chilled water	LP steam, hot water, chilled water	LP-HP steam, hot water, chilled water

Source: US Department of Energy. "Reciprocating Engines: DOE CHP Technology Fact Sheet Series." 2016

6.3. CHP for Decarbonization

70% of thermal power production wastes 55% of energy inputs as heat released into the atmosphere.

- Additional energy is wasted as centrally produced electricity is transmitted over long distances and distributed to end users. Cogeneration ensures that more than 75% of primary energy is converted into useful power and heat that is produced locally and then consumed on-site or nearby, thus minimizing conversion, transmission and distribution losses.

CHP systems play a key role in meeting climate goals and transitioning to a low-carbon economy (Box 13 and Box 14).

- CHP's high efficiency and high annual capacity factor currently results in significant annual energy and emissions savings; fewer greenhouse gases and pollutants (CO₂, SO_x, NO_x, PM), helping to meet environmental standards and reduce carbon footprints.

CHP can be integrated with other clean resources, including as part of a net-zero energy facility.

By utilizing indigenous gas sources efficiently while integrating with Solar PV and Solar water heating, CHP systems can reduce dependence on imported fuels and improve national energy security.

By integrating renewables and battery energy storage systems (BESS) with low carbon fuel (gas/RLNG), it can reduce carbon emissions and help achieve CBAM targets, thereby increasing exports.

6.4. CHP & Renewable Integration

CHP can be paired with renewables and storage to become a resilient baseload anchor for multi-technology microgrids, particularly those incorporating renewable sources like solar PV or wind.

Net-zero-fueled CHP can decarbonize critical facilities that need dispatchable on-site power for long-term resilience and operational reliability. CHP is the most cost-effective way of using renewable fuels. Currently, 27% of fuels in cogeneration in Europe are renewable, mainly biomass and biogas. Cogen plants in Pakistan are also increasingly integrating renewable fuels. For example, the CHP in Kohinoor Mills is integrating biomass for steam generation.

Integrating large-scale renewables requires operational flexibility to balance supply and demand fluctuations. By enhancing the flexibility of our energy system and increasing renewable penetration, we can overcome market challenges and technical barriers, paving the way for seamless integration of variable renewable generation with existing power systems. Embracing a flexible energy system that efficiently absorbs fluctuations is crucial, and CHP plays a pivotal role in making this a reality.

CHP systems facilitate the efficient connection of electricity, heat, and gas networks enhancing overall energy system resilience in a liberalized Gas and Electricity market (providing ancillary services).

Box 13. Natural Gas CHP Emissions vs Marginal Grid Emissions in California

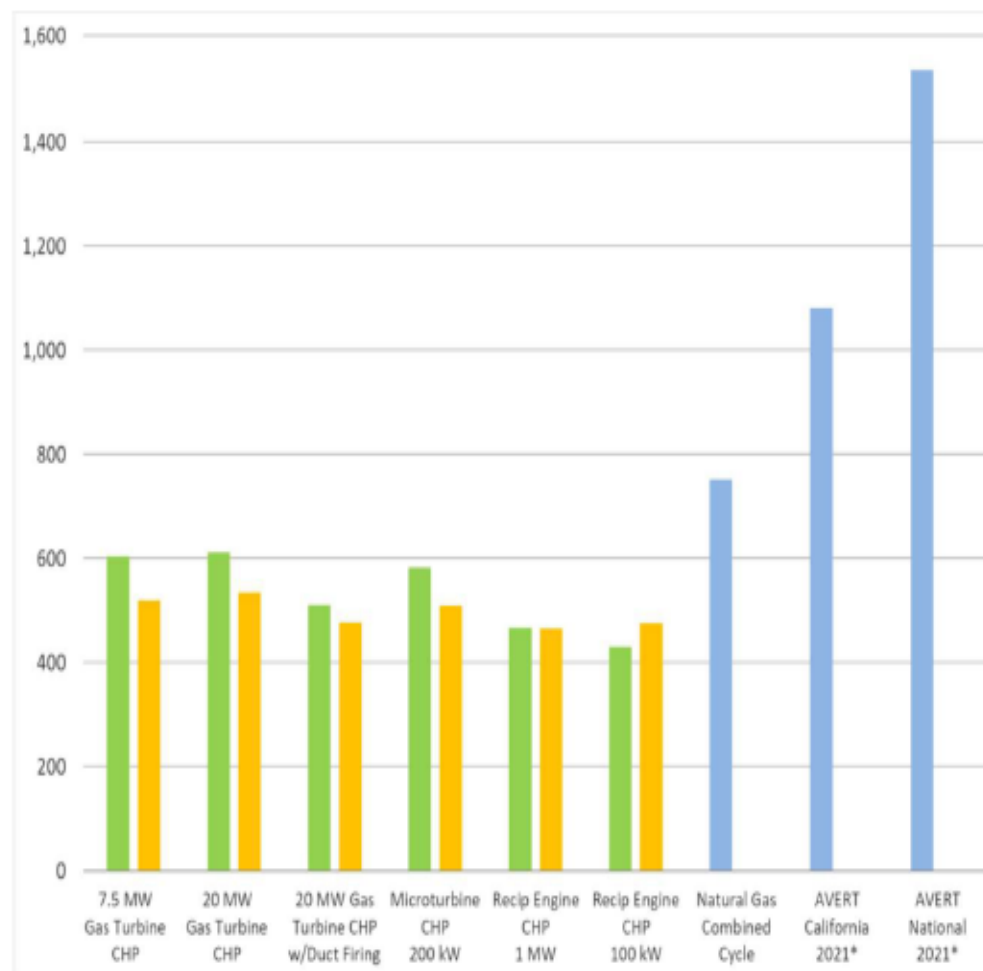
Natural gas CHP displacing natural gas boilers provides emissions savings as long as the marginal grid emissions factor is above 430 to 610 lbs CO₂/MWh.

Natural gas CHP displacing electric boilers provides emissions savings as long as the marginal grid emissions factor is above 475 to 535 lbs CO₂/MWh.

Current marginal grid emissions factors range from 1,081 lbs CO₂/MWh in California to 1,925 lbs CO₂/MWh in the Rocky Mountain regions based on 2021 EPA AVERT data (1,534 national avg).

Source: Hedman (2022)

Net CHP Emissions Factor, lbs CO₂/MWh (based on 100% Thermal Utilization)



Box 14. Emissions in Three G3520H Engines in Kohinoor Textile Mills Ltd.

Parameters	Units	PEQS	Reading 1	Reading 2	Reading 3	Results
O2	%	NGVS	11.37	11.29	11.23	11.3
CO2	%	NGVS	8.21	8.13	8.15	8.16
CO2	mg/Nm3	800	245.77	248.07	246.92	246.92
NO	mg/Nm3	NGVS	259.78	286.05	307.82	284.55
NO2	mg/Nm3	NGVS	61.93	53.97	52.01	55.97
NOx	mg/Nm3	400	321.71	340.02	359.83	340.52
Sox	mg/Nm3	1700	BDL	BDL	BDL	BDL
Smoke	%	40	0	0	0	0
Temperature	C	-	266.1	266	265.9	266
Particulate Matter	mg/Nm3	NGVS	35.6			

Parameters	Units	PEQS	Reading 1	Reading 2	Reading 3	Results
O2	%	NGVS	11.18	11.17	11.16	11.17
CO2	%	NGVS	8.95	8.94	8.92	8.94
CO2	mg/Nm3	800	367.67	366.52	365.37	366.52
NO	mg/Nm3	NGVS	272.35	198.62	320.39	263.79
NO2	mg/Nm3	NGVS	77.61	69.65	67.69	71.65
NOx	mg/Nm3	400	349.96	268.27	388.08	335.44
Sox	mg/Nm3	1700	BDL	BDL	BDL	BDL
Smoke	%	40	0	0	0	0
Temperature	C	-	276.4	276.3	276.2	276.3
Particulate Matter	mg/Nm3	NGVS	24.5			

Parameters	Units	PEQS	Reading 1	Reading 2	Reading 3	Results
O2	%	NGVS	11.53	11.49	11.47	11.5
CO2	%	NGVS	8	8.03	8.04	8.02
CO2	mg/Nm3	800	240.02	238.87	237.72	238.87
NO	mg/Nm3	NGVS	287.56	336.83	336.83	320.41
NO2	mg/Nm3	NGVS	69.69	61.73	59.77	63.73
NOx	mg/Nm3	400	357.25	398.56	396.6	384.14
Sox	mg/Nm3	1700	BDL	BDL	BDL	BDL
Smoke	%	40	0	0	0	0
Temperature	C	-	280.7	280.7	280.6	280.7
Particulate Matter	mg/Nm3	NGVS	14.5			

PEQS: Punjab Environment Quality Standard
BDL: Below Detection Limit

6.5. Global Experience

In the European Union, combined heat and power (CHP) systems are absolute game-changers for boosting energy efficiency and sustainability. Together, these systems produce a whopping 356 terawatt-hours (TWh) of energy annually, which is equivalent to the power consumption of 23 million homes.

This incredible production underscores the vital role of cogeneration in meeting Europe's energy needs. It emphasizes its significance in the continent's journey towards a more integrated, efficient, and eco-friendly energy infrastructure. This perfectly aligns with the ambitious goals of the EU Green Deal, which is all about paving the way for a greener, more sustainable future for Europe.

Cogeneration currently represents 27% of thermal electricity generation in Europe. It has a strong manufacturing base in the EU. CHP systems in Europe typically convert more than 75% of primary energy into useful power and heat, significantly reducing energy losses. Denmark, the Netherlands, and Finland are the world's most intensive cogeneration economies in the world²⁵.

CHP is the backbone of many microgrids, and used in 67% of continuously operating microgrids in the U.S.

6.6. Cogeneration Plants in Pakistan - an Industrial Process – Courts' Rulings

Lahore High Court Decision (January 12, 2018) in a writ Petition No. 3973/2016 and other consolidated petitions

- Cogeneration facilities used by industrial consumers should be classified as industrial users, not captive power producers. The Court ruled that producing electricity as a by-product of the manufacturing process (via steam generation) qualifies as an industrial activity and should not be subjected to the higher captive power producer tariff.
- The Court set aside the OGRA notification dated August 23, 2013, and ruled that these consumers should continue to pay the lower industrial tariff. Additionally, the Court set aside OGRA's clarification letter dated July 11, 2014, which had instructed gas companies to charge a higher captive power rate to cogeneration plants.

Sindh High Court Decision (2017 PLD Sindh 733)

- The Court ruled that the captive power tariff should not be applied to industrial consumers using natural gas for cogeneration if the electricity generated is primarily

²⁵ Source: COGEN Europe, July 2024

for self-consumption as part of an industrial process, reinforcing the Lahore High Court's Ruling.

Supreme Court of Pakistan Decision (May 10, 2019)

- Following the decisions of the Lahore and Sindh High Courts, SNGPL appealed to the Supreme Court of Pakistan. In Civil Appeals No. 159-L to 214-L of 2018 (SNGPL vs. Bulleh Shah Packaging Pvt. Ltd. and others), the Supreme Court upheld the judgments of the lower courts.
- The Court ruled that consumers who use natural gas for industrial purposes and have in-house electricity generation facilities for self-consumption fall under the category of industrial consumers. These consumers should be charged the industrial tariff unless they qualify as a Captive Power Plant as defined by the National Electric Power Regulatory Authority (NEPRA) regulations.
- The Supreme Court's decision emphasized that merely generating electricity for self-consumption does not transform an industrial consumer into a Captive Power Plant. The Court dismissed SNGPL's appeal and affirmed the petitioner's entitlement to the lower industrial tariff.

Peshawar High Court Directive (Writ Petition No. 1157/2019)

- The Peshawar High Court directed OGRA on April 9, 2019, to review the case and decide within one month. The Court instructed OGRA to consider the petitioners' case under Section 13 of the OGRA Ordinance, 2002, and Rule 4 of the Natural Gas Tariff Rules, 2002.
- OGRA was also directed to refrain from applying the enhanced captive power tariff during the review period. This directive was based on the precedent the Lahore and Sindh High Courts set.

OGRA's Final Decision

- In compliance with the directives of the Peshawar High Court and the rulings from the Lahore High Court, Sindh High Court, and Supreme Court of Pakistan, OGRA conducted a hearing on February 6, 2020. During the hearing, representatives from both SNGPL and the petitioners presented their cases. OGRA issued its final decision on July 6, 2020, which is reproduced below:

“In view of the above facts of the case and after hearing the petitioners, respondents and perusal of record specifically the cited judgments of Honorable Courts, the Authority observes that the consumers who are having supply of natural gas for industrial use and having in-house electricity generation facility for self-consumption fall in the category of industrial consumers and are subject to the corresponding tariff until aforesaid facility is Captive Power Plant as per NEPRA Regulations. Therefore, the Authority hereby directs SNGPL to charge/adjust the amount from the petitioners in accordance with the yardstick laid down by the August Supreme Court of Pakistan under intimation to Authority”.

With their impressive technical and operational efficiency and the backing of court rulings, cogeneration plants undeniably fall into the category of industrial processes rather than captive power plants.

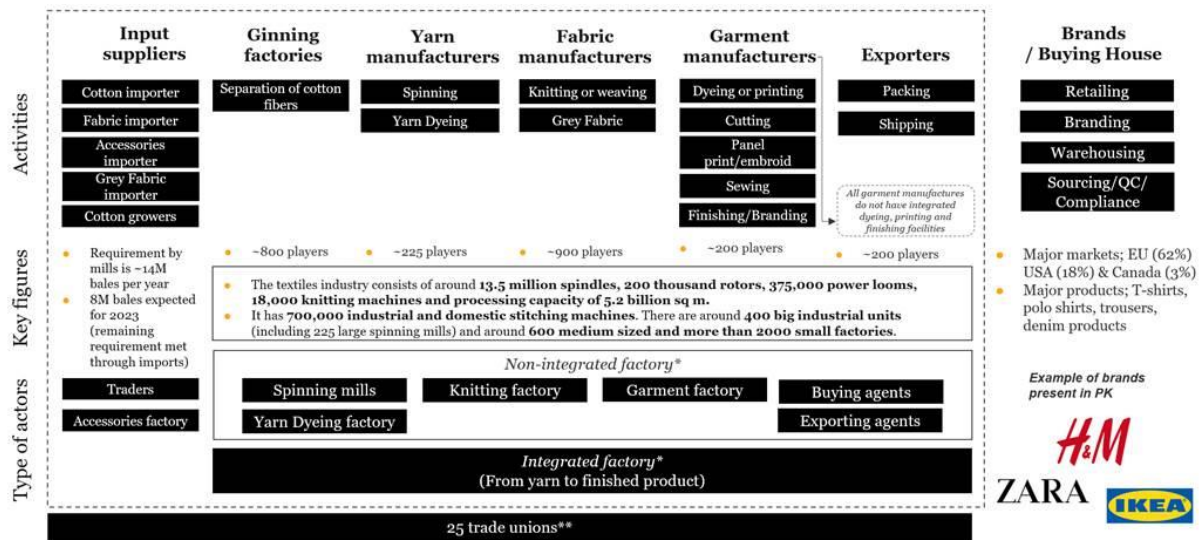
Chapter 7.

ENERGY AND INDUSTRY: MARKET DYNAMICS

As energy costs increase, industries reliant on intensive energy use face significant financial strain, ultimately driving some out of business and fragmenting vital value chains. The textile industry in Pakistan is a prime example of this phenomenon.

7.1. Overview of the Textile Value Chain

Figure 24. Overview of Pakistan's Textile Value Chain



Source: Business Sweden

The textile value chain encompasses multiple stages of production, from raw material to the final stages of manufacturing garments and home textiles. The key stages include:

- **Raw Material Production/Procurement:** Cotton and synthetic fibers are the primary raw materials used for textile manufacturing.
- **Spinning:** Conversion of raw materials into yarn.
- **Weaving/kitting:** Yarn is transformed into fabric.
- **Processing:** Fabric undergoes treatments like dyeing and printing.
- **Garmenting and Made-ups Manufacturing:** The process of fabric is turned into final products such as garments or home textiles.

Energy intensity varies across different segments of the value chain, with processes becoming less energy-intensive from upstream to downstream:

Figure 25. Energy as a Share of Conversion Costs across the Textile Value Chain



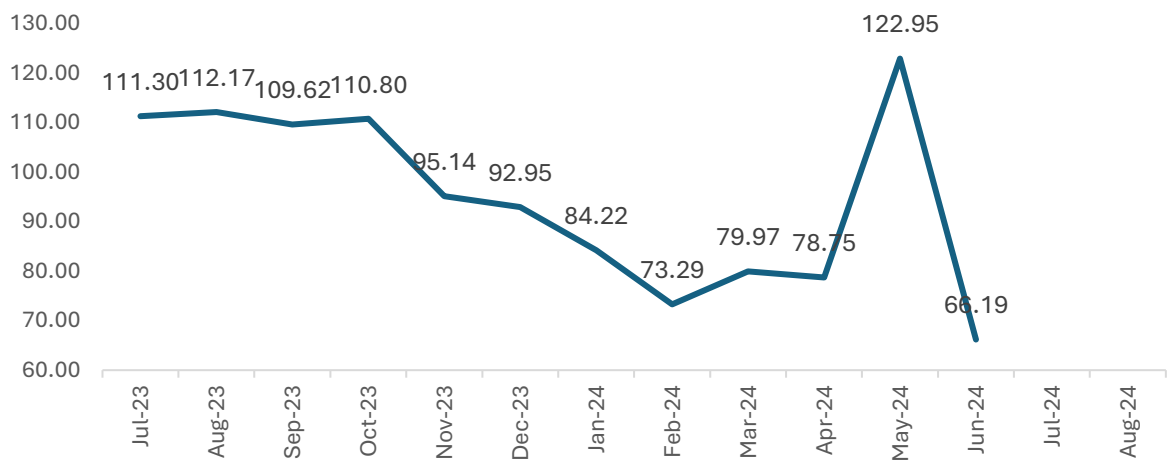
Source: Ghezri Pakistan Textile Sector Benchmarking Study

7.2. Rising Energy Costs and Shifting Market Dynamics

Energy costs have increased dramatically in recent years, threatening the competitiveness of Pakistan’s textile industry. Upstream segments like spinning and weaving that are particularly energy-intensive and reliant on an affordable and stable supply of energy have been particularly affected.

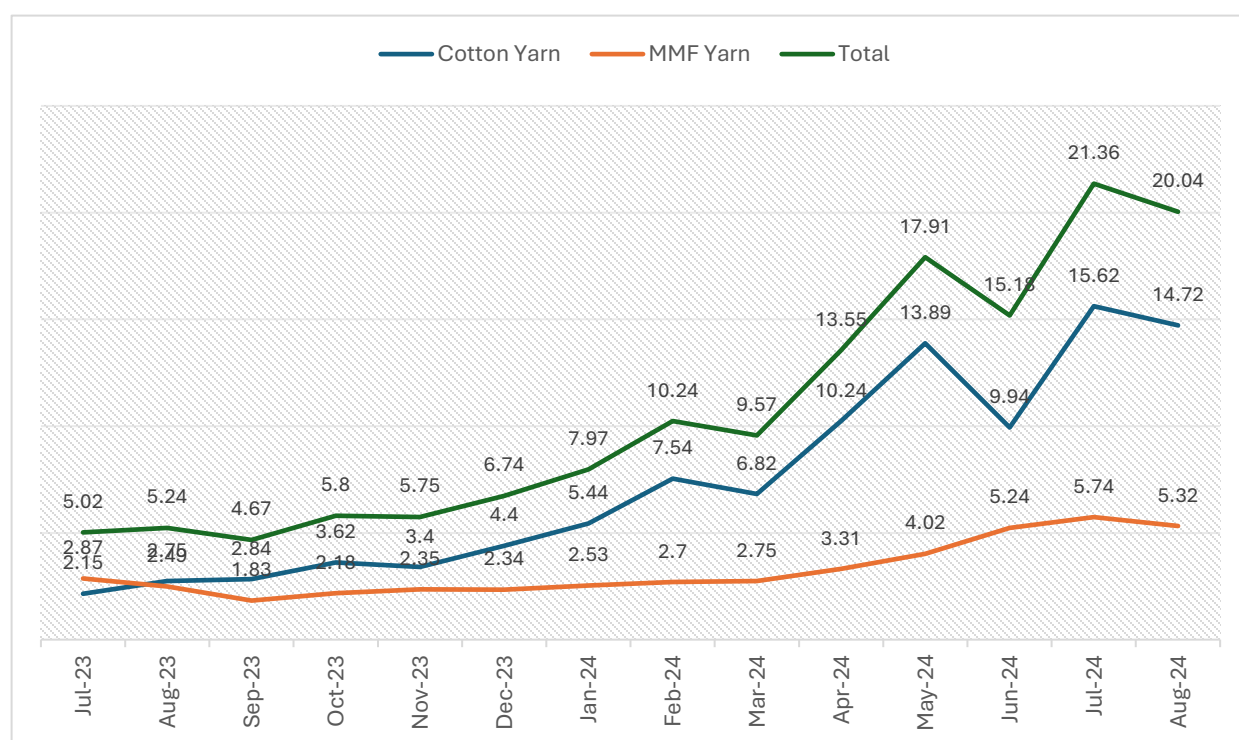
As a result, spinning mills have become financially unviable, leading to widespread closures and a subsequent increase in imports of energy-intensive intermediate inputs. Cotton yarn imports, for instance, surged by 626% between July 2023 and July 2024, as domestic production was down by over 40%.

Figure 1. Sales of Domestically Manufactured Cotton Yarn, ‘000 tons



Source: Textile Commissioner’s Organization

Figure 26. Import of Cotton and MMF Yarn, '000 tons



Source: PRAL

7.3. The Role of a Broken Export Facilitation Scheme and Perverse Incentives

A distorted tax regime has further exacerbated the challenges facing the textile sector. The Finance Act 2024 withdrew the zero-rating/sales tax exemption on local supplies for export manufacturing under the Export Facilitation Scheme, while imports of the same are allowed duty-free and sales tax-free. This has created perverse incentives for exporters to substitute locally manufactured inputs with imported ones, further contributing to increasing imports of intermediate inputs and deindustrialization of spinning and other upstream segments. Competitors like Bangladesh, on the other hand, offer manufacturers a 10% tax rebate on utilizing locally manufactured inputs for export manufacturing.

7.4. Fragmentation of the Textile Value Chain

The closure of upstream production units has fragmented the textile value chain, forcing downstream manufacturers to increasingly rely on imported inputs. This dependency on imports weakens domestic production and undermines Pakistan's ability to add value to its textile exports. Some of the key consequences include:

- **Increased Import Dependency:** The reliance on imported yarn disrupts the entire textile ecosystem, negatively impacting weavers, knitters, and garment manufacturers.
- **Decline in Domestic Value Addition and Employment:** As imports increase, domestic value addition decreases, adversely affecting the trade balance and limiting opportunities for job creation.
- **Disincentive for Investment:** High energy costs and a tax regime that favors imports over local production discourage investment in energy-efficient technologies.

7.5. Impact of Trade Balance

The lack of an integrated domestic value chain leaves Pakistan's textile sector vulnerable to external shocks, including:

- **Fluctuations in Global Energy and Cotton Prices:** External price volatility can significantly impact production costs.
- **International Trade Policies:** Changes in foreign trade policies, including tariffs or trade facilitation schemes, can affect competitiveness.
- **Disruptions in Global Supply Chains:** Climatic and geopolitical risks further threaten the stability of supply chains, affecting Pakistan's ability to source raw materials or intermediate goods.

7.6. Impact on Employment

The collapse of upstream segments has had severe repercussions for productive employment in Pakistan's economy, not just in the textile sector but also in various associated industries. In 2021, the textile sector employed up to 40% of the industrial labor force, the bulk of which was in small and medium enterprises in the spinning and weaving subsectors. The widespread closure of these units due to rising imports has caused a significant portion of the textile sector workforce to become unemployed.

Moreover, the reliance on imported intermediate input means that fewer jobs are created domestically in the production process. In contrast, a healthy and integrated textile value chain, with local production of intermediate inputs, would create jobs not only in the spinning sector but also in the various downstream industries that rely on locally produced yarn and fabric. The loss of these jobs, combined with the erosion of domestic value addition, creates a vicious cycle where industrial capacity shrinks, economic growth slows, and unemployment rises.

Chapter 8

CONCLUSION

8.1. Industrial Cut-off Point

PKR 31/kWh (US\$ 0.11/ kWh) is the energy-price threshold for the overall manufacturing industry in Pakistan²⁶. It is a critical threshold beyond which the industry can no longer sustain its operations and will be compelled to shut down. Meanwhile, APTMA reports the same threshold value of around 0.125 US\$/kWh for the textile and apparel sector²⁷.

Any move to cut off the gas supply to industrial consumers will not push them to the grid but force them to shut down their factories and exit the sector, as was the case with those who did not have self-generation capacity.

APTMA (2024) estimates suggest that reducing power tariffs to 9 cents/kWh (competitiveness threshold) could substantially increase power consumption within the textile sector, potentially adding up to 1,530 MW/annum. This change can generate an additional \$1.06 billion in power sector revenue, around \$9 billion/annum in additional exports, and over \$513 million in government revenue through various channels. These potential revenue increases could significantly strengthen Pakistan's economic growth.

Furthermore, the lower power tariffs would prompt an automatic shift from gas-based self-generation to the grid, freeing up domestic gas-based resources and reducing the LNG import bill. To achieve change, the electricity tariff design must be revamped, and a competitive market cultivated. These steps are crucial and cannot be overlooked.

8.2. To Conclude

Industrial in-house power generation facilities form a distributed generation system that produces energy close to the point of use. **These plants are fuel efficient and reduce the losses incurred during long-distance transmission from centralized power facilities. Cutting gas to these units will not just harm industry but will result in financial losses for the gas companies already grappling with massive sector deficit.**

The power sector is not just ready to absorb the increased industrial demand. It involves enormous investments and time. Even if the power sector manages, the grid tariff is not competitive for the industry.

²⁶ Author's estimate using macro data for the whole manufacturing sector.

²⁷ <https://aptma.org.pk/rising-energy-tariffs-sinking-economy/>

In-house power generation facilities, particularly those operating cogeneration technology, are closely aligned with the industrial process and should not be treated separately. Moreover, these plants offer a level of adaptability that is unparalleled in the energy sector. They provide flexibility to integrate gas engines with other power generation or storage technologies, making them an incredibly versatile and efficient energy solution.

Industrial self-generation plants generate electricity and heat for industrial processes but face disproportionately high gas tariffs compared to other sectors, including industry (process). The current tariff structure has forced them to use less efficient and environmentally harmful energy sources.

Reducing these tariffs is imperative to incentivize the adoption of energy-efficient systems, ultimately contributing to enhanced energy security, environmental sustainability and economic growth.

The departure of industrial self-generation facilities from gas utilities' networks is poised to shake up the gas distribution landscape and cast a shadow over gas companies' profitability.

Unlocking the full potential of Pakistan's natural gas resources is being held back by inefficiencies in gas allocation, pricing, and its monopolistic market structure. **It's time for a shift towards economically driven policies, market liberalization, and fair pricing models to pave the way for the country's more efficient and sustainable energy future.**

8.3. Way Forward

Deregulate Gas Tariffs and Gas Allocation Policy

- Revise tariff design - market-based (marginal cost) pricing, no more political considerations. There is no justification for continuing this distortionary cross-subsidy. Removing the cross-subsidy burden would allow gas to be diverted into more productive sectors, optimizing its use for economic growth and reducing the financial strain on gas distribution companies.
- Gas allocation should be based on its economic value, not political considerations. Let the market forces determine its allocation.

Unbundle Gas Utilities

- To ensure competition in the downstream sector, it is crucial to first divide these monopolies vertically and horizontally.
- Gas distribution companies should focus on commercialization and margin-based systems to conduct their business effectively.
- Shift residential gas consumers to grid, starting point will be no new gas connections.
- No gas allocation to downstream utilities, but only through open access.

Implement WACOG

- Comparable rates for E&P companies are crucial. If imported RLNG is bought at US\$13 per MMBtu, local companies must be offered competitive rates to incentivize domestic E&P and reduce reliance on imported LNG, enhancing energy security.

Develop Gas Storage Facilities

- Gas storage facilities are essential for buffering against price volatility and ensuring a stable supply.

Third Party Access in the Upstream

- Allow the third party access to local gas fields and the LNG import business
- Cost components of RLNG value chain need to be optimized (such as high port charges, duty, taxes, margins etc.)

Classify Cogeneration Plants as Industry (Process)

- It is essential to recognize the high efficiency of cogeneration plants and reclassify them as industry (process) consumers instead of CPPs. Accordingly, align their tariff structure with that of industrial process gas.

Energy Audits of CPPs

- Energy audits are crucial for motivating industries to maintain high efficiency levels. If the efficiency level is below the specified target, an industry must be given a target of not more than six months to upgrade.

Implement CTBCM

- The electricity cost through a B2B contract equal to or less than 9 cents/kWh would encourage industries to move away from gas-fired self-generation without compromising competitiveness.
- Cutting off gas supply to industries and transitioning industrial CPPs to electricity (not from the grid) will be feasible five years after the wholesale market has been fully developed. Industries have made significant investments in in-house generation facilities and should be given sufficient time to recoup those investments.
- It's crucial to remember that subsidies/ cross-subsidies are part of the state's socioeconomic or political obligations; system inefficiencies and stranded costs are the outcome of years of mismanagement and wrong decisions. These factors must not burden the consumers in the B2B market.

References

Annex A1. Impact of Electricity Tariffs on Firms

We analyzed the impact of total energy cost on firms' profitability, revenues/sales, exports, investment, and employment using the methodology explained in PIDE (2021) and Malik et al. (2023). We used a sample of 129 industrial units (2018 to 2023) in six major exporting sectors (textile and clothing, food and beverages, chemical, electronics, cement, and other manufacturing units, including automobiles) in Pakistan. We estimated the impact on all firms and textiles separately.

To gauge the impact, we utilized the cost-minimization approach. Through this method, we derived the elasticities of investment, employment, and total sales revenue. Subsequently, we evaluated the influence of energy costs on export revenue. These estimations were carried out using panel data econometric tools and techniques. The results are illustrated in the table below.

Table A1. Impact of Energy Costs on Firms

	All Firms	Textile
	Elasticity	
Investment	-0.098	-0.121
Total Sales Revenue	-0.065	-0.044
Exports Revenue	-0.128	-0.117
Employment¹	-195	-595.4

Source: Author's estimation based on firm level data from 2018-2023

Note: Standard Errors in Parenthesis, *** p<0.01, ** p<0.05, * p<0.1

¹ Semi-elasticity

- With a 1% increase in energy tariffs, investment will decline by 0.098% in exporting firms, and total sales revenue will go down by 0.065% for all firms, exports revenue by 0.13%, and a firm will be forced to lay off its workers.
- The maximum labor unemployed will be in the textile sector. With a 1% increase in energy costs (tariffs), a textile firm (on average) will lay 6 employees.

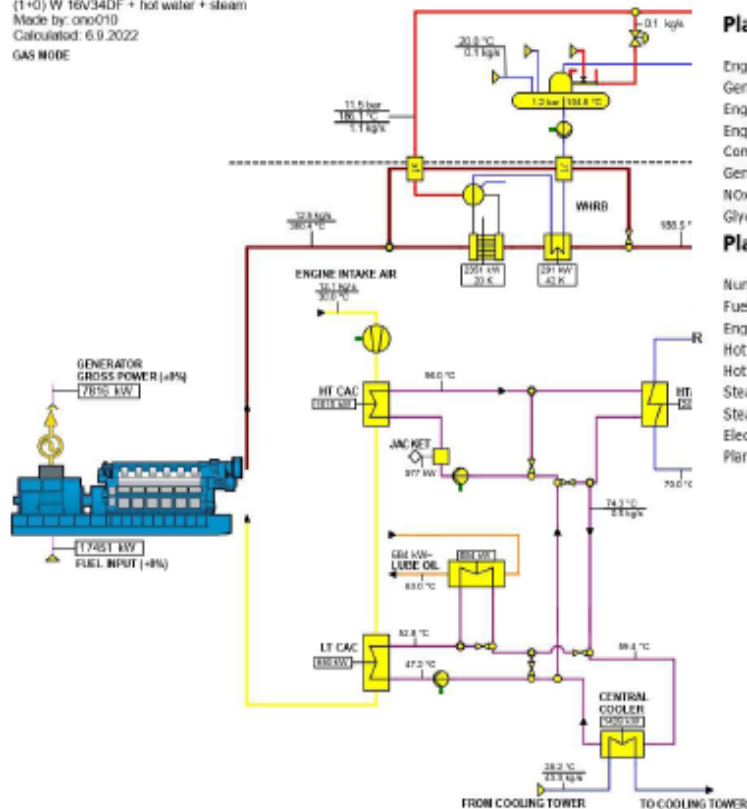
Annex A2. Export Receipts from Captive Gas Consumers in FY2022

Export Range	No. of Companies	No. of Connections	Average Consumption (MMCFD)	Exports (US\$)
US\$ > 100 million	34	108	65.65	7,512,570,980
US\$ > 10 million	137	208	98.63	5,339,105,937
US\$ > 1 million	97	120	27.14	434,848,028
US\$ > 0.1 million	54	58	9.79	23,645,089
US\$ < 0.1 million	27	29	2.55	1,201,436
Grand Total	349	523	203.77	13,311,371,470

Source: Ministry of Commerce

Annex A3. Cogeneration – Interloop Extension

Project: Interloop EXT 2
(1+0) W 16V34DF + hot water + steam
Made by: ono010
Calculated: 6.9.2022
GAS MODE



Plant details based on PerfPro 2022.1

Engine:	W 16V34DF	Ambient temperature:	30.0 °C
Generator voltage:	11.0 kV	Altitude:	190 m.a.s.l.
Engine Speed:	750 rpm	Relative humidity:	60 %
Engine Load:	60%	Engine intake air temperature:	30 °C
Compression ratio:	12.0	Minimum methane number:	80
Gen cos fi:	0.8	Heat tolerance:	± 10 %
NOx:	162 ppmv at 15% O2	Fuel tolerance:	+ 0 %
Glycol mass fraction:	0.000		

Plant performance

Number of engines:	1 Engine	1 Engines
Fuel power, engine:	11436 kW	11436 kW
Engine generator GROSS power (±0%):	4690 kW	4690 kW
Hot water power to consumer:	1353 kW	1353 kW
Hot water mass flow to consumer:	58 t/h	58 t/h
Steam power to consumer:	1981 kW	1981 kW
Steam mass flow to consumer:	2.9 t/h	2.9 t/h
Electrical efficiency, gross:	41.0 %	
Plant GROSS efficiency:	70.2 %	

60%
Load
70%
Utilization

Plant details based on PerfPro 2022.1

Engine:	W 16V34DF	Ambient temperature:	30.0 °C
Generator voltage:	11.0 kV	Altitude:	190 m.a.s.l.
Engine Speed:	750 rpm	Relative humidity:	60 %
Engine Load:	100%	Engine intake air temperature:	30 °C
Compression ratio:	12.0	Minimum methane number:	80
Gen cos fi:	0.8	Heat tolerance:	± 10 %
NOx:	180 ppmv at 15% O2	Fuel tolerance:	+ 0 %
Glycol mass fraction:	0.000		

Plant performance

Number of engines:	1 Engine	1 Engines
Fuel power, engine:	17451 kW	17451 kW
Engine generator GROSS power (±0%):	7816 kW	7816 kW
Hot water power to consumer:	2476 kW	2476 kW
Hot water mass flow to consumer:	106 t/h	106 t/h
Steam power to consumer:	2485 kW	2485 kW
Steam mass flow to consumer:	3.7 t/h	3.7 t/h
Electrical efficiency, gross:	44.8 %	
Plant GROSS efficiency:	73.2 %	

100%
Load
73.2%
Utilization

Annex A4. Summary of Reciprocating Engine Attributes for CHP Applications

Attribute	Description of Reciprocating Engine Attribute
Size Range	Reciprocating engines for CHP are available in sizes from 1 kW to 10 MW. Multiple engines can be combined to deliver higher capacities. Most reciprocating engine CHP systems are below 5 MW.
Thermal Output	Thermal energy can be recovered from engine exhaust, cooling water, lubricating oil, and intercooler/aftercooler fluid. The recovered thermal energy can be used to produce hot water or steam (<125 psi). With an absorption chiller, thermal energy can be used to produce chilled water or chilled thermal fluid.
Start-Up	Reciprocating engines start quickly and typically reach full power within 3-5 minutes. ¹ Some new engines can reach full capacity in under 1 minute. ²
Part-Load Operation	Reciprocating engines maintain efficient operation at part-load and are well suited for both baseload and load following applications. The minimum part-load operation for CHP reciprocating engines is typically near 25% of full-load. ³
Fuel	CHP reciprocating engine installations operate on a range of fuels, including natural gas, biogas (e.g., digester gas and landfill gas), RNG, and hydrogen. Natural gas is currently the most common fuel used in reciprocating engine CHP applications.
Reliability	Reciprocating engines are a mature technology and are highly reliable. The minimum availability ⁴ of reciprocating engines in the Department of Energy's (DOE) Packaged CHP eCatalog is 92%, but it can be higher in practice.
Other	Reciprocating engines have relatively low installed costs and are widely used in CHP applications. Reciprocating engines operate on typical natural gas delivery pressures with no additional gas compression required.

1 Power-Gen International, 2017, Mid-Sized New Generation: Reciprocating Internal Combustion Engines or Combustion Turbine? [Link](#)

2 Jenbacher, 2019, INNIO Launches Fast-Start 3-Megawatt Natural Gas Generator Solution for Data Centers. [Link](#)

3 Power-Gen International, 2017, Mid-Sized New Generation: Reciprocating Internal Combustion Engines or Combustion Turbine? [Link](#)

4 Availability is the percentage of time a reciprocating engine is running or available to run. Availability less than 100% reflects downtime for scheduled maintenance and unplanned outages.

5 Department of Energy (DOE) Combined Heat and Power Installation Database, June 2022, [Link](#)

Source: U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. 'Effective Electric CHP CO2 Emissions Calculation.' DOE/EE-2764. August 2023

