INTEGRATED ENERGY PLANNING
FOR SUSTAINABLE DEVELOPMENT

PAKISTAN

ENERGY OUTLOOK REPORT
2021-2030

MINISTRY OF PLANNING, DEVELOPMENT AND SPECIAL INITIATIVES
GOVERNMENT OF PAKISTAN.

Pakistan Energy Outlook Report
(2021–2030)

Integrated Energy Planning for Sustainable Development

Ministry of Planning, Development & Special Initiatives
Government of Pakistan

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INTEGRATED ENERGY PLANNING FOR SUSTAINABLE DEVELOPMENT

The Government of Pakistan (GoP) has envisioned an open, competitive private sector-led energy sector providing reliable, least-cost energy supplies to meet the anticipated growth in the energy demand. Integrated Energy Planning (IEP) is an effective and appropriate tool for realizing the government's vision of developing a sustainable, cost-efficient energy sector that best meets the country's strategic and socio-economic needs and rapidly growing demand for energy.

IEP Process

The goal is to develop the tools and build the capacity of GoP to provide a credible analytical platform for assessing and planning an optimal and holistic strategy for the country's energy sector, build the capacity of GoP institutions and relevant stakeholders for analysis-based decision-making. Implementation of IEP will create capability at the government level to support the development of a long-term development strategy and inform medium and short-term planning. It will also provide a viable inter-agency coordination mechanism for identifying, resolving, and preempting anomalies. In addition, a web-accessible, reliable, consolidated, and up-to-date database of key energy sector information will provide more consistent, current, and reliable input for planning, modeling, and assessment. Key energy sector stakeholders can use this database to avoid ad hoc, siloed planning and set targets for detailed subsector planning.

Contribution(s):

- This report was developed by the Energy Planning & Resource Centre, Ministry of Planning, Development & Special Initiatives.
- The authors are Muhammad Saad Moeen, Forecasting Specialist; Farhan Ahmed Memon, Senior Research Associate (Policy); and Nauman Hafeez, Research Associate.
- Data support is provided by Jawad Ali Qadir, Usman Ahmad (Data Management Specialists), and Muhammad Shahid, Research Associate. The data team acknowledges Mr. Shahoor Islam Khattak, Chief (Fuel) for his immense support during the data collection process from relevant stakeholders.
- Special thanks to Mr. Waqas Bin Najib, Member (Energy), Planning Commission; Mr. Inayat Ullah Qureshi, Chief (Energy Finance & Economics)/Project Director (IEP) and Mr. Aftab Ahmad Awan, Deputy Chief (Energy Finance & Economics) for their technical guidance and supervision.
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Message from Member (Energy), Planning Commission

Integrated energy planning plays a critical role in optimizing the supply of different energy sources. Accurate forecasting of consumption and demand is the first step in developing a planning framework to evaluate the policy options available under different scenarios.

This study presents the demand forecast of different energy sources and evaluates various supply options available to meet that demand. A clear picture of demand and supply will help identify the infrastructure gaps and development requirements in the coming years.

Pakistan's dependence on imported energy sources is increasing with depleting natural gas reserves in the country. Growth in demand of petroleum products and natural gas requires development of a robust import, refining, and storage infrastructure, to enable the country in absorbing the supply and pricing shocks. Power plants set up on imported coal has further increased the dependence on imported fuel. Recent increase in the global energy prices has exposed vulnerabilities of country's energy supply value chain.

This study documents the energy outlook of various fuel sources and analyzes the gaps in the infrastructure. Further studies will be required to identify the opportunities to optimize the import, storage, processing, and transmission infrastructure for least cost and sustainable supply of energy. Affordable, reliable, and sustainable energy supply is at the heart of realizing the economic growth targets of the country.

I hope this study will help us develop a robust integrated energy model that supports evaluation of different policy options to minimize the cost of energy and increase the reliability of supply.

Waqas Bin Najib

Member (Energy) at the Planning Commission of Pakistan

Executive Summary

The Energy Planning and Resource Centre (EPRC) is working on the government's vision to develop a sustainable and cost-efficient energy sector that best meets the country's strategic and socio-economic needs. The quarterly reports published by EPRC under IEP are the continuation of these policy steps.

This report presents the Energy Outlook of Pakistan with a retrospective analysis of the country's energy mix including Oil, petroleum oil lubricants (POL) products, Gas including liquified natural gas (LNG), coal, liquified petroleum gas (LPG), and electricity. To forecast the future energy demand through an accurate energy demand model, historical consumption trends of the energy sector and macroeconomic parameters such as gross domestic product (GDP), population, energy prices, and other such key indicators have been considered. The monthly consumption data of such variables used in the model has been acquired by the IEP team from relevant primary stakeholders and created its data repository (IEP Database) from 2006 to 2020. Moreover, considering the IEP strategic and policy objectives, a top-down approach has been used in demand modeling. The report focuses on four key pillars including a retrospective supply and consumption side analysis, forecasting of primary energy demand by 2030, an energy balance for different sectors, and finally a set of recommendations for supply, demand, and logistics management.

An autoregressive integrated moving average (ARIMA) technique with seasonal variation and an exogenous variable is applied for energy demand projections from 2021 to 2030. The demand estimation model captures nonlinear relationships of time-series data sets to obtain the smallest prediction bias in result estimates. The key parameters of the forecast model include economic development, energy prices, population growth, and urbanization in the country. The forecasting methodology is also improved by using dynamic forecasts, which use lagged forecast values of variables instead of just forecasting all at once. The fuel requirement for thermal power generation calculated from 2022 to 2030 was based on the future thermal-based power generation in the country.

Oil & Petroleum Products: Historically, imported and local POL products were the major energy source for the economic sector and power generation in the country. Presently, its use has been reduced to 22 percent of the energy mix which is mainly owing to the government's policy to phase out furnace oil (FO) based power generation in the country. Forecast results show an increase in POL consumption from 17.03 million tonnes in 2020 to 24.15 million tonnes by 2030. On the supply-side, owing to a limited upstream exploration of oil, the production of oil will decrease with an annual compound growth rate (ACGR) of negative 4 percent. For future sustainability in the oil and POL, up-gradation/expansion of the refineries is necessary to reduce the oil and POL imports. A national oil logistics and infrastructure study should be conducted to identify long-term solutions vis-à-vis refining plans and demand growth.

Natural Gas including LNG: For decades, natural gas stood up as the leading energy source to serve sectoral and power generation needs. Currently, natural gas accounts for 40 percent of the energy mix. Due to the continuous depletion of the local gas reserves, the supply gap is filled with imported LNG to meet the rising demand. Forecast results show an increase in the sectoral consumption will reach 1,337 billion cubic feet (CFt) whereas, the share of natural gas in power generation will reduce to half by 2030. On the supply side, upstream gas production in the country has depleted by an ACGR of negative 5 percent. To bridge the gap between demand and supply of gas, expansion of the LNG import infrastructure will be needed to accommodate the import requirement of 1,900 million cubic feet per day (MMCFD) by 2030. Moreover, recommendations like shifting of captive power plants (CPPs) from gas to the national grid, LNG cost optimization and terminal management, import of natural gas from neighboring countries, and construction of a North-South pipeline to transfer the imported LNG from port to up the country have been suggested.

LPG: Compare to historical trends, an increase in the primary supply of LPG in the country has been observed. Significant investment in the LPG supply has helped the domestic and commercial sectors to substitute natural gas. LPG has covered the energy needs in the areas where natural gas supply disruption exists or in the absence of a distribution network. Forecast results depict a 50 percent increase in the LPG demand within the domestic, commercial, and transport sectors. The energy balance for LPG shows the supply side should improve to cater to the growing LPG demand in the country. To serve this purpose, the private sector should enhance its investments in the import and improvement of supply, logistics, and marketing of LPG, particularly in remote areas of the country.

Coal: Coal has been historically used in power generation and industries including brick kiln and cement industries. Currently, Pakistan has abundant coal reserves to meet the future coal needs of the country. Advancement in coal use technologies has replaced a fair share of oil and gas in the industrial sector. Forecast results portray that coal-based power generation will double the consumption of coal in the country by 2030. Moreover, the boom in the construction sector will directly incline industrial coal consumption as cement industries consume coal as a primary source of energy. To meet the growing coal demand locally in a sustainable way, Thar coal can be used as a substitute for imported coal in the future as mining expansion is already underway to reach 30 million tonnes per annum (mtpa). Substitution of coal will have a positive impact on the price of coal and foreign exchange savings. For smooth and uninterrupted supply, railway tracks can be developed to adopt rail as the primary mode of coal transportation.

Electricity: The rising electricity demand in the country is met by expensive and unsustainable thermal power generation. Over the years, the electricity demand has increased due to the expansion of the national grid, advancements in domestic heating/cooling technologies, and the development of the industrial sector. Forecast results show the demand will keep on increasing by 2030 in all sectors including transportation due to the National Electric Vehicle Policy supporting more electric vehicles (EVs) on the roads in Pakistan. The need for a better energy mix replacing thermal power in the country with hydro and renewable energy is also suggested. Indicative Generation Capacity Expansion Plan (IGCEP) is a well indicative and informative document for generation expansion planning and it has improved supply-side planning. Whereas, its demand-side must be improved with the consultation of sectoral experts, academia, and relevant stakeholders.

1. Introduction

Globally, energy is regarded as one of the core elements of social well-being and an essential component of sustainable development. Balanced energy supply and demand are vital considerations for any country when it comes to providing clean, sustainable, and affordable energy to consumers. For decades, Pakistan's primary energy supply[a] mix has remained dominated by indigenous and imported fossils fuels. More than three fourth portion of the overall energy mix consisted of gas and oil to meet energy demand. Natural gas remained one of the major contributors to the primary energy supply, but due to the fast-depleting pace of indigenous natural gas reserves dependence on imported LNG and oil is increasing, which increases pressure on foreign exchange reserves. The country may face challenges in the near future, like scarcity of indigenous resources, rising imported fuel prices, and future supply chain disorder.

In recent years, to mitigate impending challenges and with the advent of modern and non-fossil fuel-based energy trends, the country has taken noticeable steps to alter the energy supply mix by shuffling decades-consistent fuels with an increasing share of local coal, non-fossil fuels, and renewable electricity generation. As a result, the share of oil and gas dropped to less than two-thirds of the total country's primary energy mix during the last 15 years (see Figure 1).

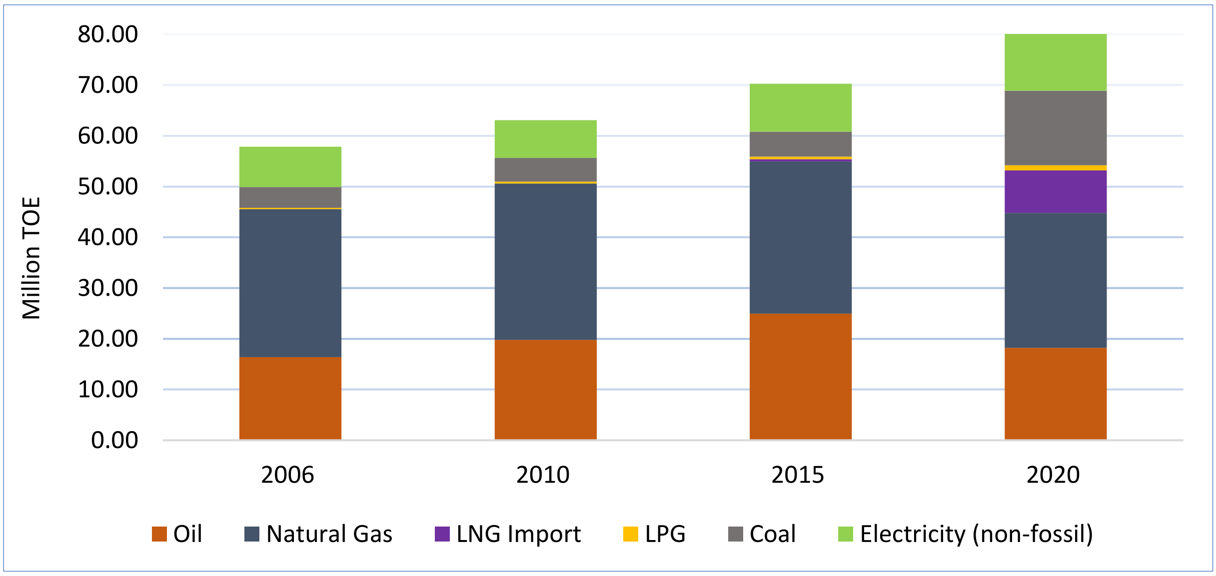

Figure 1. Pakistan's Primary Energy Supply by Source (Source: Energy Year Book (EYB) [2006–2020])

[a] Primary energy supply is an energy form found in nature that has not been subjected to any conversion or transformation process.

A major portion of the primary energy supply (PES) from 2006 to 2020 was consumed by various economic sectors and power generation, while the rest of the shares were consumed by energy transformation[b] and losses (see Figure 2). Energy transformation remains consistent throughout the 15 years and mainly consisted of auxiliary consumption by the energy sector, transformation consumption by gas processing plants, oil refineries, transmission and distribution losses.

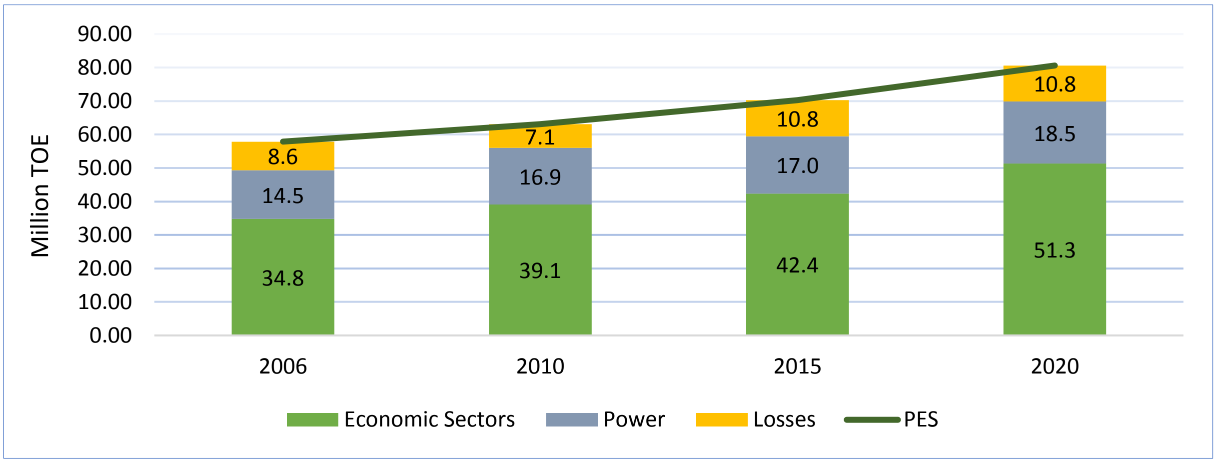

Figure 2. Pakistan's Energy Balance (Source: EYB and IEP Database [2006–2020])

In the case of final energy consumption[c] by the economic sectors, statistics show that the industrial sector is consuming the highest proportion of energy (although its share has declined over the period studied), followed by the transportation and the domestic sectors. Commercial, agriculture, and other/government sectors consume the least amount of energy (see Figure 3).

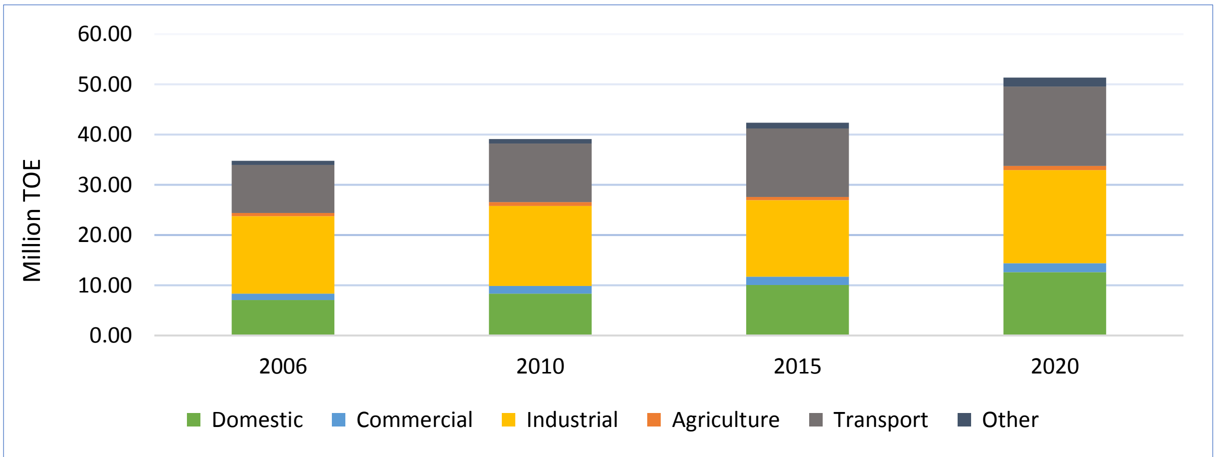

Figure 3. Pakistan's Final Energy Consumption by Sector (Source: IEP Database [2006–2020])

[b] Energy transformation involves processes that convert energy from one type (e.g., kinetic, gravitational potential, chemical energy) to another.
[c] Final energy consumption is the total energy consumed by end users, such as households and industrial, commercial, agriculture sectors, etc.

Historically, thermal power generation has been mainly dominated by FO, followed by natural gas and diesel; however, the government added coal-based and LNG-based power generation in recent years and decided to retire FO-based power generation in the country (see Figure 4).

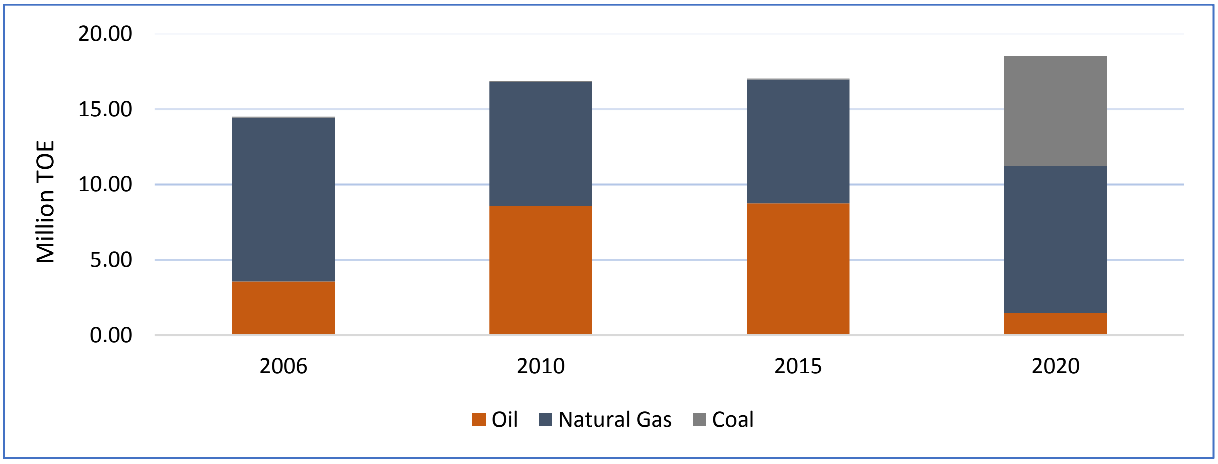

Figure 4. Primary Energy Supply for Thermal Power Generation (Source: IEP Database [2006–2020])

1.1 Energy Demand Models

Energy demand models are developed to analyze the growing energy needs around the world. In developing countries, energy demand models have been rapidly adopted to map the growing need for energy due to modernization in the industrial sector, increasing use of domestic appliances, and urbanization. Modeling energy systems in developing economies remains a challenge because many existing models are geared toward developed countries and do not consider the informal economy, supply charges, inadequate performance of the energy sector utilities, economic fluctuations, and electrification.[1] Pakistan must adopt these models to manage its future energy needs. Energy demand models can be categorized as long-term and short-term demand models (see Figure 5).

Short-term energy demand models use optimization tools to analyze daily-to-weekly energy demands. This type of planning includes operational plans to improve the operational strategies of system operators like the National Transmission and Dispatch Company (NTDC), Central Power Purchasing Agency (Guarantee) (CPPA-G), and distribution companies (DISCOs) in the power sector and gas supply utilities along with operational oversight by the Ministry of Energy (Petroleum Division and Power Division). Short-term planning uses parameters like metering data, weather forecast, time of use pricing, and random fluctuations in the system. The overall objective of short-term planning is to improve the delivery of supplies in the energy system.

Long-term planning spans from years to decades. It is carried out using two different approaches: the bottom-up and top-down approaches. The bottom-up approach includes system and network expansion planning such as the provision of electricity to unelectrified areas and the upgrading of the transmission and dispatch system. The major stakeholders using the bottom-up approach are NTDC, CPPA-G, and the Ministry of Energy (Petroleum Division and Power Division). This type of planning works in accordance with network infrastructure requirements, energy supplies, metering data, etc. The bottom-up approach aids in ensuring the adequacy and availability of the energy supply.

The top-down approach is part of the IEP conducted under long-term energy demand modeling. Top-down energy demand modeling serves as an umbrella for mapping the future energy demands of the country. It includes energy modeling by using macroeconomic parameters such as GDP, population, energy prices, and other key indicators. It provides an analysis of sector-wise energy demand or cross-sectoral effects in the energy sector. As an integrated energy model, IEP is currently being carried out by the EPRC, under the Energy Wing of the Planning Commission's IEP project. The EPRC targets strategic and policy objectives in energy demand modeling. Such long-term policy assessments by EPRC will help steer the country's energy planning toward sustainability and reliability.

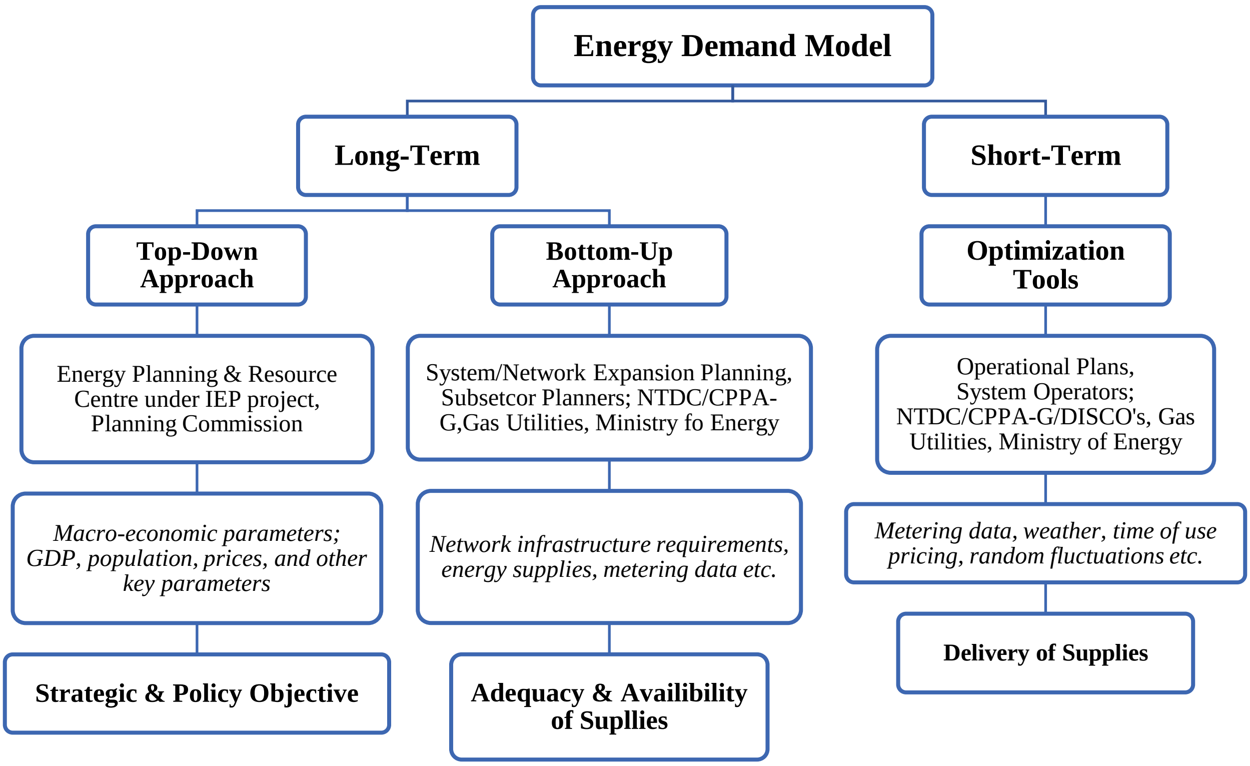

Figure 5. Energy Demand Model Approaches

1.2 Scope of the Study

This report addresses various challenges regarding energy demand forecasting and modeling to achieve a robust and reliable energy forecast in the country. This report is a continuation of a previous effort by the EPRC to develop an accurate and reliable forecasting model. Using models to accurately forecast future energy consumption trends—especially when nonlinear relationships exist—is an important issue to be addressed by the forecasting process. Monthly data needs to be used when performing an energy demand forecast for seasonal projections. EPRC has developed a monthly database and an improved estimation model to forecast the future demand-side energy needs of the country. The core objectives of this study are:

- To perform a retrospective supply and consumption-side analysis of oil and petroleum products, natural gas including LNG, LPG, coal, and electricity.
- To forecast the primary energy demand until 2030 to provide a view window to the future energy needs of the country in the fuel and electricity.
- To determine an energy balance for oil and petroleum, oil and lubricants (POL) products, natural gas, LNG, LPG, coal, and electricity to establish a base for future recommendations.
- To provide a set of recommendations for oil supply, demand, and logistics, improvements in the LNG terminal facilities, port facilities for imported coal, and LPG supply management.

2. Energy Forecasting Framework

Energy demand is driven by the use of various energy sources and appliances (for example, different options can be used for cooking, transport, or heating). Hence, energy demand is mainly dependent on energy services and on the choice of appliances that use energy differently. Primary energy demand in a country also has a causal relationship with GDP, fuel and electricity prices, population and urbanization in the country, inflation, and other key economic parameters.[2]

Energy demand forecasting becomes a core component of energy planning, design strategy, and recommendations for the best energy policies. To mitigate the risks and challenges, robust energy demand forecasting is crucial for identifying alternatives and managing energy resources to achieve a sustainable energy balance. Further, well-estimated energy demand should help achieve sustainable economic development.

The long-term energy forecast (2021–2030) described in this report was developed for energy consumption trends by economic sectors (i.e., domestic, commercial, industrial, agriculture, transportation, and other government) and fossil fuel requirements for power generation. The factors considered for the projections summarized in this report were economic development, energy prices, population growth, and urbanization. The energy demand model considered the monthly consumption consisting of the historical trend (2006–2020) of final energy consumption by various economic sectors as an endogenous variable for the forecasting process. For detailed input data, please see Annexures I and II.

2.1 Assumptions

Assumptions concerning variation in energy prices, population, and urbanization growth were also considered to develop the model framework. GDP is a major contributing factor in energy planning and demand assessment. The real GDP growth and its forecast were based on the three key economic sectors: agriculture, industry, and services. The annual GDP growth rate is directly proportional to the rise in energy demand because it causes a significant change in the energy consumption trends (see Table 1).

Table 1. Assumptions Underlying the Primary Energy Forecast

Underlying Assumptions	
Energy Consumption	• Previous energy consumption has a direct link to future energy demand.
Total and sector-specific GDP (Agriculture, industrial, and services) at constant prices	• Energy intensity is correspondent to GDP, which implies that higher real GDP for sector and GDP per capita correspond to an increase in energy consumption for various economic sectors.
Energy Prices	• The percentage change in energy demand also depends upon energy prices, implying that higher real prices decrease energy consumption.
Population & Urbanization	• Population and urbanization are also controlling factors for energy demand, the estimation model also considered these factors in the model.

Among the underlying assumptions, the most critical was the substantial uncertainties in the future that can create risk for the long-term trends, seasonal and short-term variations, and volatility in the price of fuels. For instance, the COVID-19 pandemic had the direct and indirect effects of unanticipated demand-side shocks and short-term fluctuations on various sectors and agents in the economy.[3] Likewise, international crude oil prices can directly or indirectly affect fuel and electricity prices in Pakistan. Therefore, underlying assumptions are considered for each economic sector and energy source. The projected total and sectoral GDP (agriculture, industry, and services), population, and urbanization from 2021 to 2030 are shown in Figures 6 and 7.

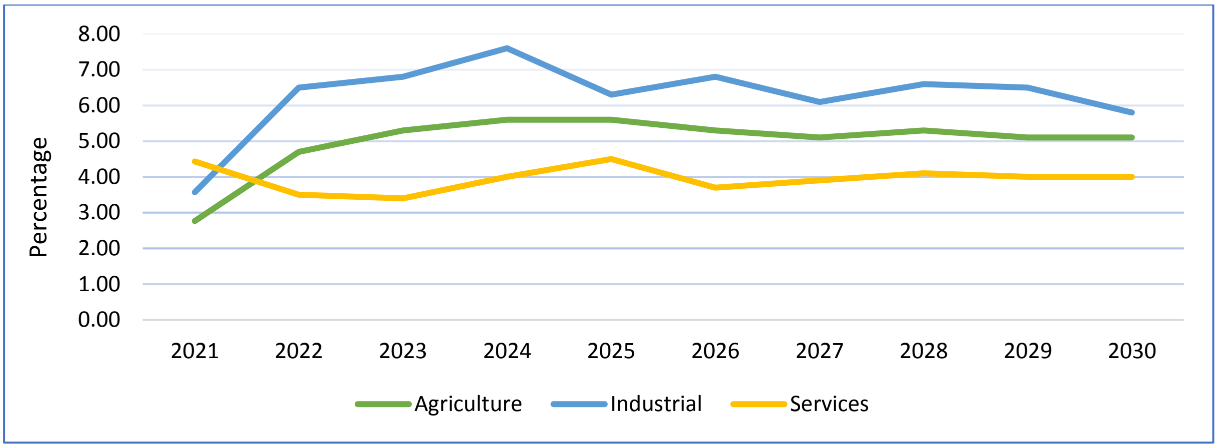

Figure 6. Projected GDP by Economic Sector (2021–2030) (Source: IGCEP 2021)

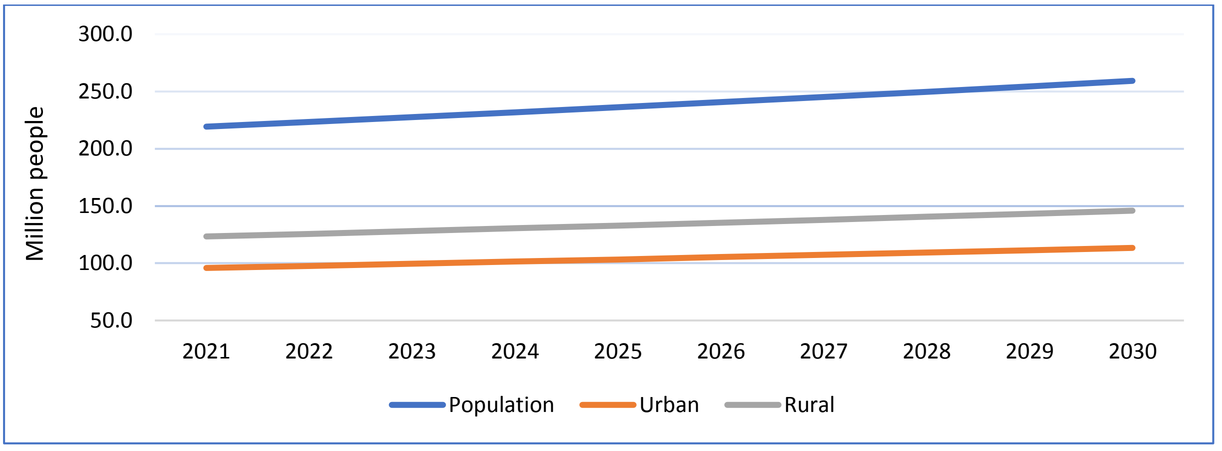

Figure 7. Projected Population by Category (2021–2030) (Source: International Monetary Fund: 2021–2026, trend analysis: 2027–2030)

International crude oil prices are linked to domestic energy sector prices; therefore, the projected trend in energy prices is based on future crude oil prices (see Figure 8).

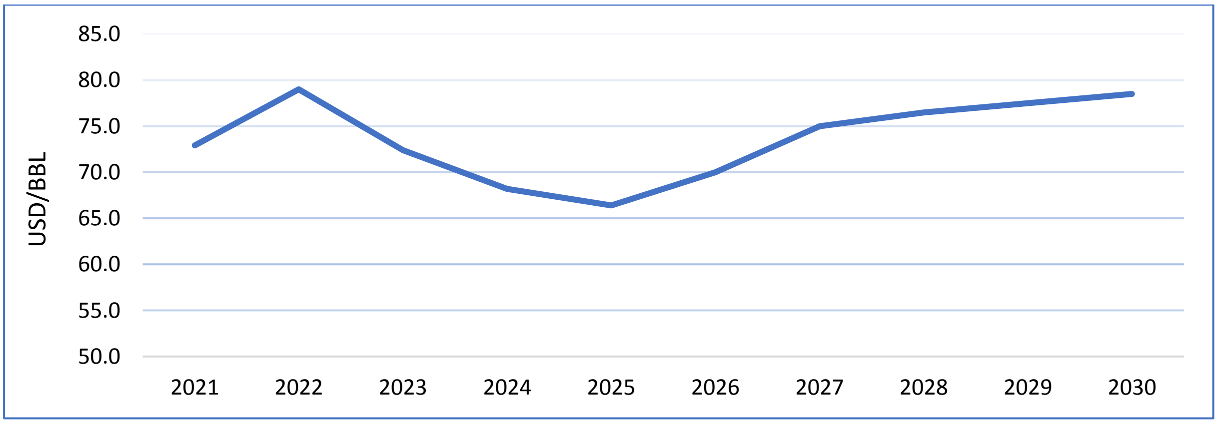

Figure 8. Crude Oil Prices (2022–2030) (Source: Long-Term Forecast, Energy Information Administration)

2.2 Estimation Model

The selection of a forecasting model is mostly based on data availability, the objectives of the tool, and the planning exercise. The formation of monthly consumption data has been developed based on input from all key energy sector stakeholders to determine the future primary energy demand for Pakistan. This study uses the Auto-Regressive Integrated Moving Average (ARIMA) technique to estimate the future primary energy demand of Pakistan. The existing energy demand model is mainly based on multiple regressions with a time-series data set; however, ordinary least-squares estimate only consider linear relationships, which may not be suitable for time-series data.[4] All methods exhibit a prediction error, but suitable models must yield the smallest mean absolute error, as well as the smallest prediction bias. The least-squares regressions are not resistant to outliers. Therefore, reliance on an autoregressive model, such as ARIMA, for the smallest prediction bias in the resulting estimates is required.

For this study, the forecasting method is applied for the time-series data for energy sources (oil, natural gas, coal, LPG, and electricity) used for the domestic, commercial, industrial, agriculture, transportation, and other/government economic sectors. The forecasting methodology is also improved by using dynamic forecasts, which use the lagged forecast values of variables instead of just forecasting all variables at once to see what a year-ahead model looks like compared to the data.

An ARIMA model has three potential components (defined as ARIMA [p,d,q]), where p is the number of autoregressive terms, q is the number of moving average terms, and d is the number of nonseasonal differences needed for the stationarity of data.[5] The ARIMA model can be used when the time series is stationary.[6] In this study, seasonal components are also included in the model; therefore, the ARIMA model is used with the seasonal autoregressive integrated moving average (SARIMA) model. The SARIMA model for seasonal patterns is defined as SARIMA (p,d,q) multiplied by (P, D, Q). The model also demonstrates a connection between the final energy consumption and GDP growth, energy prices, population, and urbanization; therefore, the estimation strategy is based on the seasonal autoregressive integrated moving average with exogenous variable (SARIMAX) model:

$$FED_t = C + \sum_{i=1}^{p} \beta_i \, FED_{t-i} + \sum_{j=1}^{q} \theta_j \, \epsilon_{t-j} + \sum_{k=1}^{r} \phi_k GDP_k + \sum_{k=1}^{r} \psi_k Energy\ Prices_k + \sum_{k=1}^{r} \psi_k Z_k + \epsilon_t$$

where:

FED_t = final energy consumption by category,
FED_{t-i} = lag values of final energy consumption by category,
GDP_k = GDP by sector (agriculture, industrial, services, transportation, other),
$Energy\ Prices_k$ = energy prices by energy source for each category,
Z_k = vector for control regressors, such as population and urbanization factors,
ϵ_{t-j} = moving average window for factors error terms,
C = constant,
$\beta_i, \phi_k, \psi_k, \psi_k$ and θ_j = parameter coefficients.

The different SARIMAs (p,d,q) multiplied by (P, D, Q) of the models are applied to each energy source for the best fit model ranging from 1 to 3. Selection of suitable parameters and estimation of future load forecasts is best for certain steps, which are elaborated in the flow diagram below (see Figure 9). For details about model validation, please see Annexure II.

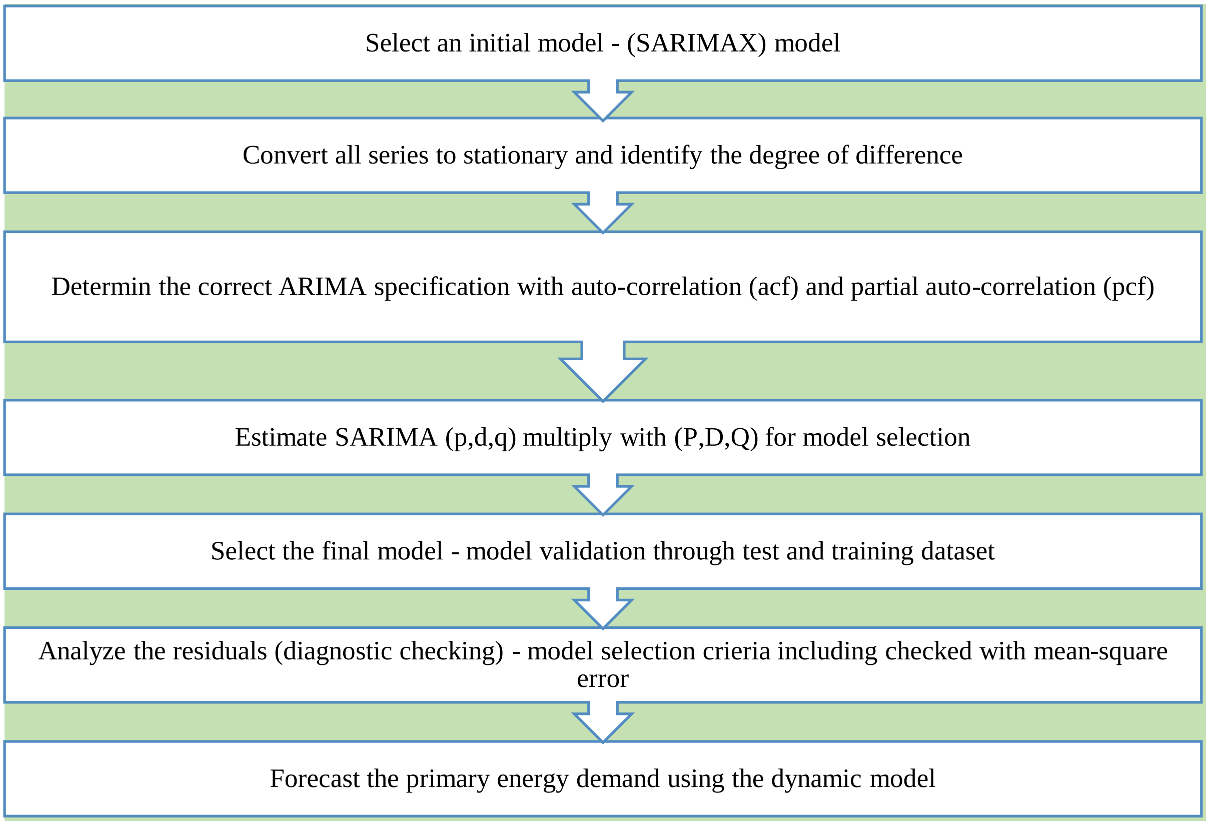

Figure 9. ARIMA Model Steps for the Forecast of Primary Energy Demand

2.3 Fossil Fuels for Thermal Power Generation

Future electricity generation and installed capacity in the country from 2021 to 2030 have been considered based on the approved IGCEP-2021[7] and the K-Electric (KE) Generation Expansion Plan.[8] The fuel requirement for thermal power generation calculated from 2022 to 2030 was based on the future thermal-based power generation in the country.

3. Outlook for Oil and Petroleum Products

This chapter discusses the outlook for oil and POL products including an overview of historical supply and consumption trends in the country. The forecasting results (2021-2030) sheds light on the future demand trends for oil and POL products. It also includes the upstream crude oil production and oil refining capacity expansion/up-gradation in the country. Moreover, an energy balance for oil and POL products has been presented followed by a comparison of local vs imported POL products and oil infrastructure and logistics. The chapter finally concludes with a set of recommendations to improve the sustainability of oil and POL products in Pakistan.

3.1 Primary Supply – A Historical Overview

Historically, POL products have been a major source of energy for the economic sector and power generation companies, thereby covering a major portion of the energy mix. Currently, the use of POL products is reduced to 22 percent of the energy mix from the highest ever value of 35 percent in the year 2006. The country's primary energy demand for oil (crude and POL products) is met through imports; less than one-fourth of the demand is met by local supplies. This fostered dependency on expensive imported oil put considerable strain on Pakistan's economy by increasing import bills (see Table 2).

Table 2. Primary Energy Supply for POL Products (Tonnes)

Supply	2006	2010	2015	2020
Indigenous crude processed	2,839,085	2,976,660	3,884,022	3,101,679
Imported crude processed	8,511,595	6,890,993	8,257,484	6,977,760
Total crude processed	**11,350,680**	**9,867,653**	**12,141,506**	**10,079,439**
Import of POL products	6,009,401	11,178,100	13,347,000	7,539,358
Primary supply	**17,360,081**	**21,045,753**	**25,488,506**	**17,618,797**

(Source: EYB [2006–2020])

3.2 Historical Consumption

Pakistan, in line with the rest of the world, has largely been dependent on the consumption of POL products by the transportation sector. The two highly consumed POL products—namely motor spirit and high-speed diesel (HSD)—are the primary energy providers for the transportation sector. As a general trend, HSD, FO, and kerosene oil were used as alternative fuels by the industrial sector. However, because of the significant transportation cost associated with the oil supply and difficult handling needs, consumption of POL products has shown a fluctuating trend within the industrial sector (see Figure 10).

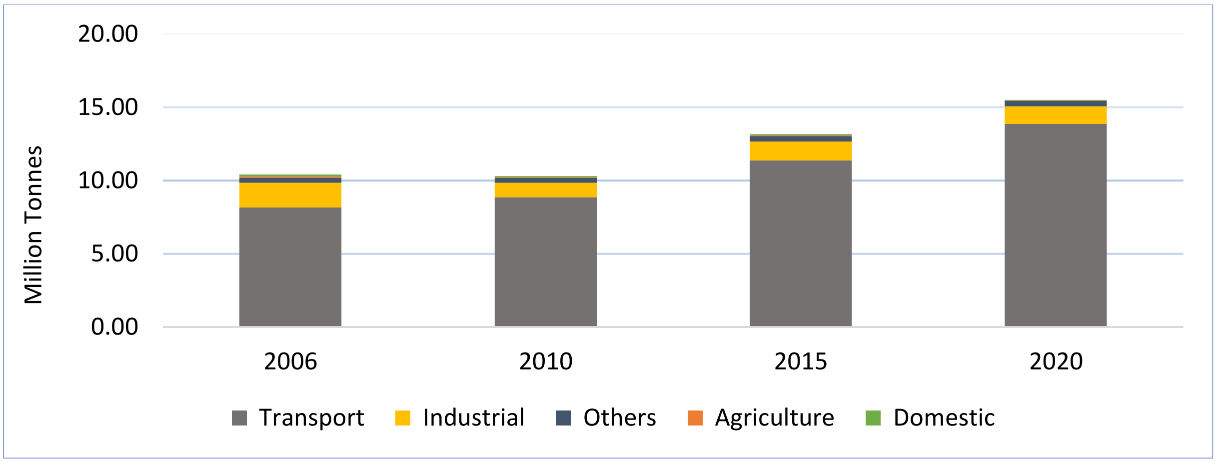

Figure 10. POL Product Consumption by the Economic Sector (Source: IEP Database [2006–2020])

Historically, thermal power generation has been dominated mainly by FO-based power plants. Intending to find a more environmentally friendly solution, the GoP in recent years decided to reduce FO consumption in the power sector by adding other energy sources. This exercise has resulted in a sharp decline in oil consumption from 2015 to 2020 in the power generation sector. The major change occurred because FO-based power generation in the country was retired (see Figure 11).

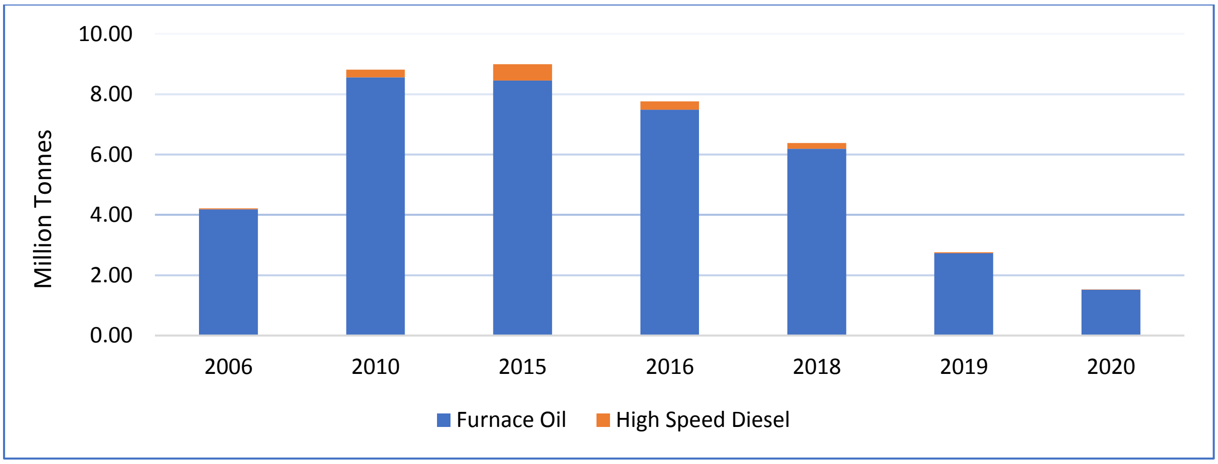

Figure 11. POL Consumption Pattern for Power Generation (Source: IEP Database [2006–2020])

Seasonal Pattern for Consumption of POL Products. Transportation is the most oil-consuming sector; its significant variance of monthly oil consumption affects total oil consumption as well. The change that can be observed in the summer months may be due to vacations and holidays (see Figure 12).

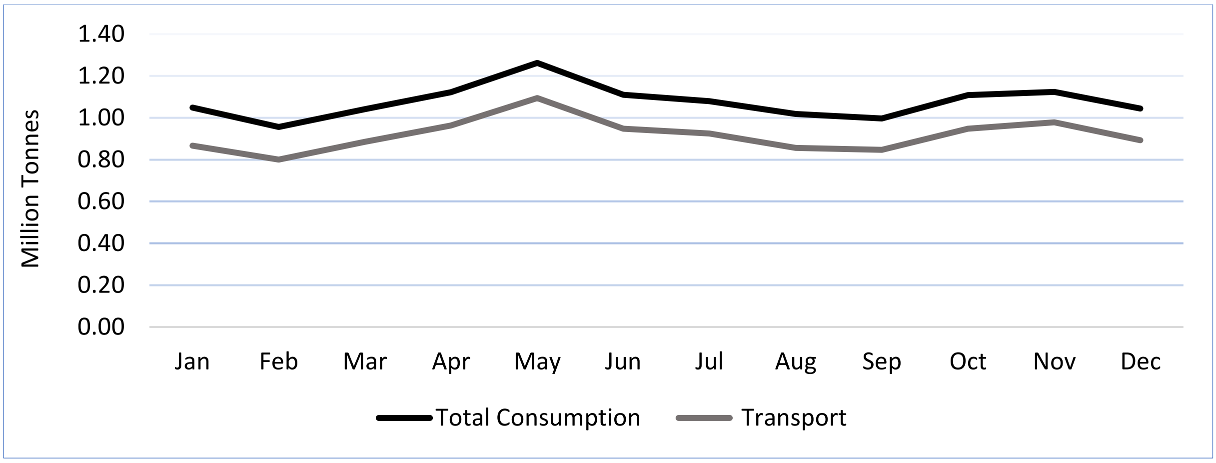

Figure 12. Seasonal Pattern for Consumption of POL Products (Source: IEP Database [2006–2020] and the author's calculation based on the average from 2006–2020)

3.3 Forecasting Results (2021–2030)

The forecasting results are produced based on the historical baseline trends of the oil supply and consumption in the country. Similar to the historical trends, oil and POL products will constitute the major part of the energy mix for serving the sectoral demand. Because transport is a major sector in oil and POL products consumption, its demand will be met by local production and imports. The demand for the transport sector, coupled with the recent industrial growth, demographic changes, and economic progress, will increase the overall consumption from 17.03 million tonnes in 2020 to 24.15 million tonnes by 2030. The demand for motor spirit and HSD is expected to reach a level of 20.8 million by 2030, compared to 13.86 million tonnes in 2020. Based on the recent government policy, the 33 percent share of FO in power generation will be phased out by 2030 (see Figure 13).

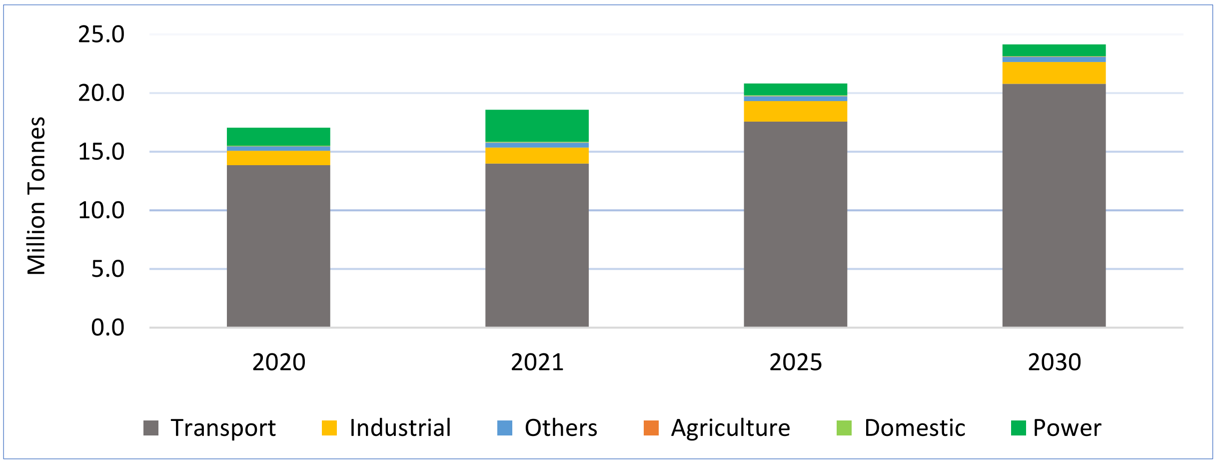

Figure 13. Energy Forecast for Petroleum Products (Source: IEP Database [2006–2020] and the author's calculations)

3.4 Upstream Oil (Crude Oil Production)

During the last 5 years, the production of oil has sharply declined in the upstream oil sector. Historical trends show a decline in the local oil production from 94,493 BBL/day in 2015 to 76,739 BBL/day in 2020, until and unless any major oil sources are discovered.

The ACGR of crude oil production is negative 4 percent. With a similar trend, the future projections show a further decline in oil production from 62,663 BBL/day by 2025 to 51,029 BBL/day by 2030 (see Figure 14).

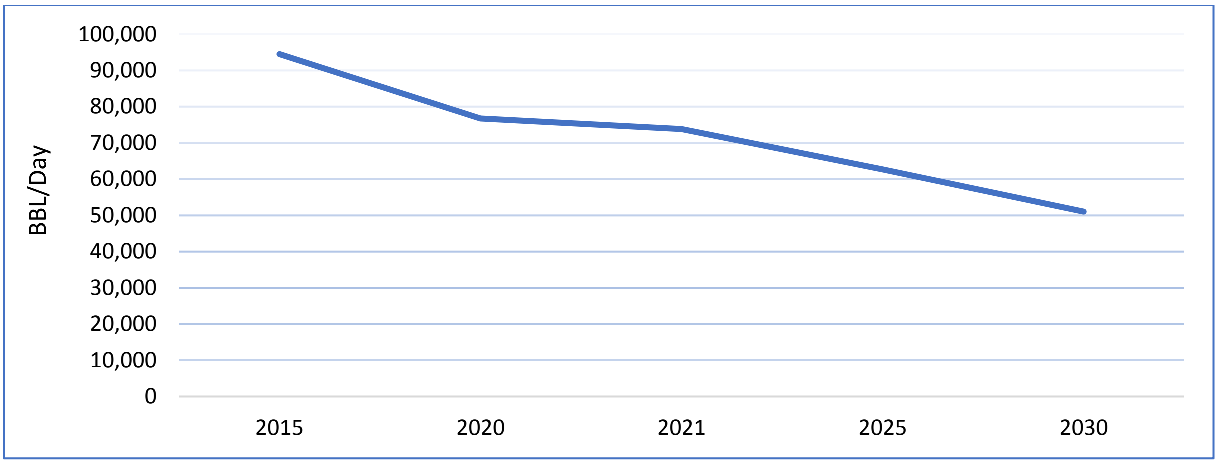

Figure 14. Crude Oil Production for 2015 to 2030 (Source: EYB [2015–2020] and the author's calculation)

3.5 Oil Refining Capacity Expansion and Upgrading

Oil demand in the country is driven by two sectors—the economic sector and the power sector. The power sector demands major contributions from FO, which is already in the process of being phased out by 2030. The oil consumption analysis shows that economic sector demand is largely concentrated on transportation fuels including motor spirit and HSD (70 percent of the economic sector demand).

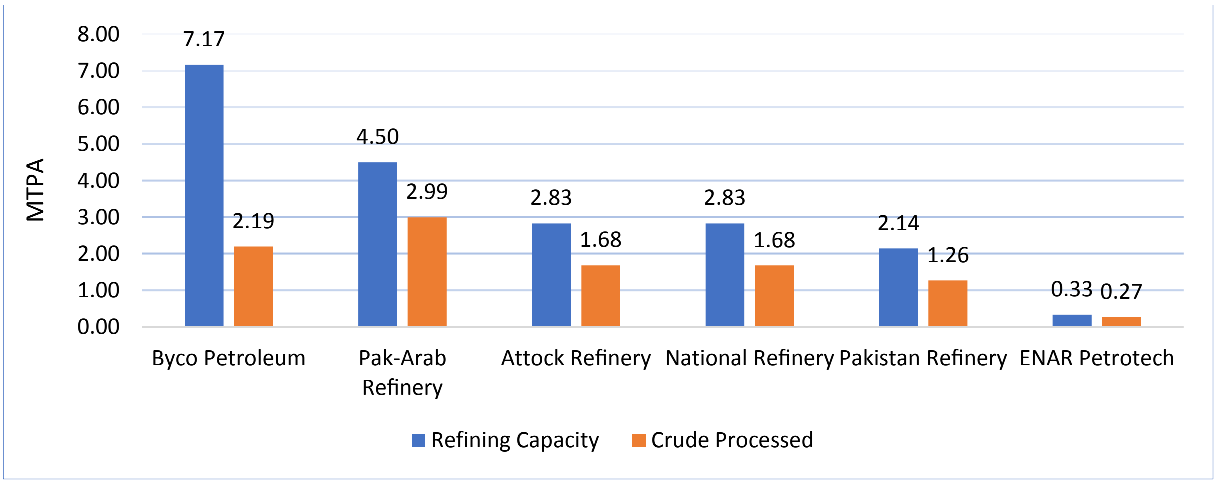

Figure 15. Local Refining Capacity and Crude Oil Processed, 2020 (Source: EYB 2020)

The current oil demand in the country is 17 mtpa. Imports (crude oil and refined products) meet 82 percent of the total demand. The existing oil-refining capacity stands at 19.4 mtpa. On the other hand, the current crude processing capacity in the country stands at 10.08 mtpa, which is roughly half of the total refining capacity. Individual refinery analysis shows Byco Petroleum is using only 31 percent of its refining capacity. This underutilization has significantly reduced the overall crude processing in the country (see Figure15).

Byco Refinery has announced plans to upgrade its old hydro skimming process to a deep conversion refinery, which will enable it to produce more diesel and gasoline by 2024.[9] With the Byco upgrade, the operational refining capacity will increase from 10.08 mtpa to 13.98 mtpa by 2024

With the implementation of the Refinery Policy of Pakistan 2021, the government intends to double the country's refining capacity, according to the available demand forecasts. The anticipated upgrade of the refineries in Pakistan will increase the production of motor spirit and HSD. Owing to reduced future consumption of FO, refineries will use processes like deep conversion to maximize motor spirit and HSD, thereby shifting the production of FO to products that are more compliant with Euro Standards (see Table 3).

Table 3. Oil Refining Capacity (Tonnes)

Oil Refining	2020	2021	2025	2030
Attock Refinery	1,682,628	1,682,628	1,682,628	1,682,628
Byco Petroleum Pakistan	2,193,258	2,193,258	6,094,500	6,094,500
ENAR Petrotech	267,688	267,688	267,688	267,688
National Refinery	1,676,532	1,676,532	1,676,532	1,676,532
Pak-Arab Refinery	2,994,908	2,994,908	2,994,908	2,994,908
Pakistan Refinery	1,264,425	1,264,425	1,264,425	1,264,425
Crude Oil Processed	**10,079,439**	**10,079,439**	**13,980,681**	**13,980,681**
Local Crude	***3,101,679***	***2,889,721***	***2,451,889***	***1,996,673***
Imported Crude	***6,977,760***	***7,189,718***	***11,528,792***	***11,984,008***
Total Crude Processed	**10,079,439**	**10,079,439**	**13,980,681**	**13,980,681**

(Source: EYB 2020 and the author's calculations)

3.6 Energy Balance for Oil and POL Products

Owing to a limited upstream exploration of oil, Pakistan is expected to keep importing the major share of oil in the coming years. However, considering the planned expansion of its refining capacity, the country's demand for imported POL products will decline by 20 percent whereas imported crude oil demand will surpass 60 percent by 2030. Consequently, the country will import more crude oil than it will import POL products (see Table 4).

Table 4. Future Primary Energy Supply for POL Products (Tonnes)

Supply	2020	2021	2025	2030
Indigenous crude processed	**3,101,679**	**2,889,721**	**2,451,889**	**1,996,673**
Imported crude processed	6,977,760	7,189,718	11,528,792	11,984,008
HSD import	2,484,442	2,799,501	2,251,053	3,353,537
Motor spirit import	4,839,745	5,453,487	4,385,098	6,532,761
Import of other POL products	215,171	242,457	194,958	290,441
Total oil & POL import	**14,517,118**	**15,685,164**	**18,359,901**	**22,160,748**
Primary supply	**17,618,797**	**18,574,885**	**20,811,790**	**24,157,420**

(Source: EYB 2020 and the author's calculations)

3.7 Local vs Imported POL Products

Despite the planned expansion of local refining capacity, local crude oil processing has been estimated to diminish by more than 30 percent by 2030 compared to 2020; whereas the import of crude oil has been estimated to increase by more than 60 percent by 2030. As a result, the share of local POL products processed through local refineries will be boosted enormously, while the share of imported POL products will diminish significantly by 2025. However, imported POL will again increase by up to 10.18 million tonnes in 2030 because there is no planned expansion of refining capacity over the period (see Figure 16).

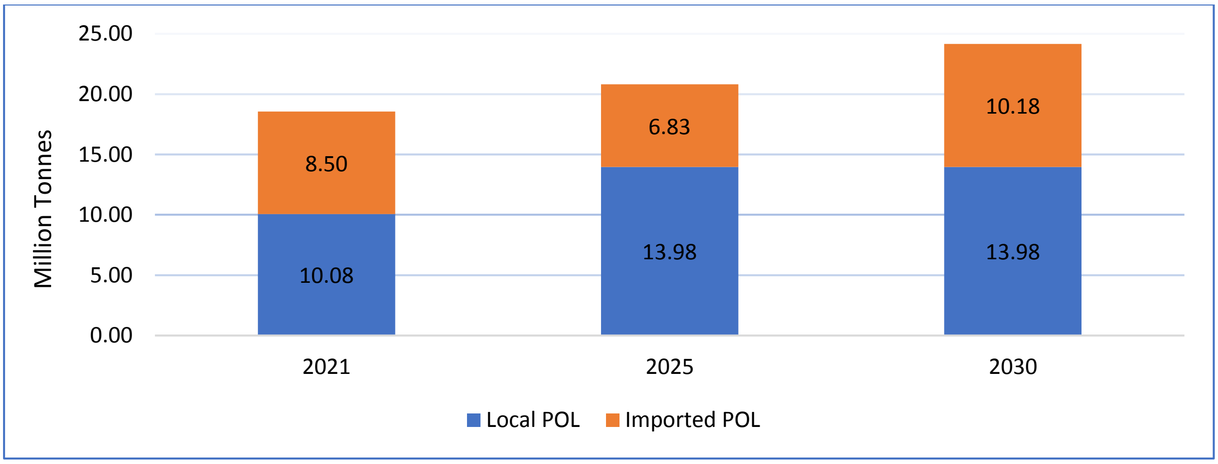

Figure 16. Local vs Imported POL Products (Source: IEP Database [2006–2020] and the author's calculations)

3.8 Oil Infrastructure and Logistics

Currently, to manage the oil imports, six operational oil terminals are available in the country. The country has about a 51 mtpa capacity for oil terminals, but the actual operational capacity is about 15 to 18 mtpa for POL and non-POL imports (see Table 5). To meet the future requirement for imported crude oil, imported POL, and non-POL products, non-functional/closed port facilities will need to be restored and additional port facilities will be required by 2030.

Table 5. Oil Port Capacity and Operational Status

Terminal	Location	MTPA	Remarks
Oil Pier-I	Keemari	8	Operational but in dilapidated condition
Oil Pier-II	Keemari	8	Operational
Oil Pier-III	Keemari	8	Closed since 2018
Fauji Oil Terminal & Distribution Co.	Port Qasim	9	Operational
MW1-Liquid Cargo Terminal	Port Qasim	4	Operational
Byco Single Point Mooring	Balochistan	14	Operational and dedicated for Byco Petroleum
Total		**51**	

(Source: Ministry of Energy, Petroleum Division)

The crude oil storage capacity of Pakistan currently stands at 0.88 mtpa (see Table 6). Owing to the increase in the demand for local and imported POL products by 2030, it is imperative to expand the countrywide crude oil storage capacity to meet the rising demand.

Table 6. Crude Oil Storage Capacity in Pakistan

Infrastructure Capacity	Tonnes per annum
Keemari, Karachi	197,000
Korangi, Karachi	305,000
Morgah, Rawalpindi	93,900
PARCO, Mid country refinery	165,000
Hub, Balochistan	128,000
Total	**888,900**

(Source: Ministry of Energy, Petroleum Division)

3.9 Recommendations

- **Upgrade refineries.** To meet the growing demand for POL in the country and to reduce the import of expensive refined POL products, the upgrading/expansion of oil refineries is necessary.
- **Conduct a national oil logistics and infrastructure study.** The country lives on operational stocks, which fall to critically low levels from time to time. A national oil logistics and infrastructure study should be conducted to pinpoint bottlenecks and to identify long-term solutions vis-à-vis refining plans and the growth in demand.
- **Improve and expand oil transportation capabilities.** About 60 percent of oil consumption is in the northern part of the country, and it is currently being served by transportation via road and railways mode. The country has only one white oil pipeline facility with a capacity of 8 mtpa. In addition, the transportation of POL products by road leads to highway congestion. To meet the future oil demand, there is a dire need to expand the pipeline capacity and improve the railway network.

4. Outlook for Natural Gas, Including LNG

This chapter discusses the outlook of natural gas and LNG as energy sources in Pakistan. It gives an overview of the historical primary supply and consumption patterns. The forecasting results (2021-2030) have been discussed to better analyze the future demand trends. The chapter then discusses the upstream natural gas production in the country and the present status of the LNG import infrastructure. Finally, some recommendations have been presented to improve the supply of natural gas and LNG in the country.

4.1 Primary Supply – A Historical Overview

Pakistan has mainly relied on gas as a primary energy source. Natural gas was stood up as the leading energy source to meet the energy demand in different sectors. Ever since, the discovery of the Sui gas field in Balochistan in early 1950, natural gas has been depleting fast. The government has imported LNG over the last 10 years to keep up with the growing demand for gas in different sectors. Natural gas and imported LNG now contribute more than a 40 percent share to the current energy mix of the country. The historical pattern for indigenous gas production and imported LNG as a primary energy supply is reflected in Table 7.

Table 7. Primary Energy Supply for Gas (Million CFt)

Supply	2006	2010	2015	2020
Natural gas production	1,400,026	1,482,847	1,465,760	1,316,635
Imported LNG	-	-	20,192	355,577
Primary supply	**1,400,026**	**1,482,847**	**1,485,952**	**1,672,212**

(Source: EYB [2006–2020])

4.2 Historical Consumption

Past trends show that the industrial sector consumes the most gas. Since the decline in gas reserves, the government has prioritized the domestic sector over industry in recent years. With the substitution of natural gas for cooking and heating, its use significantly increased when replacing kerosene oil in the domestic sector (see Figure 17).

The aggressive demand for Compressed Natural Gas (CNG) in the transportation sector, coupled with declining gas reserves, created a deficiency in natural gas supply to other sectors. Therefore, the GoP reviewed and revised the natural gas allocation policy and consequently, the consumption of CNG declined in the transportation sector. The use of natural gas in the commercial sector continued to increase until the GoP changed its natural gas supply priorities; as a result, LPG started to replace natural gas.

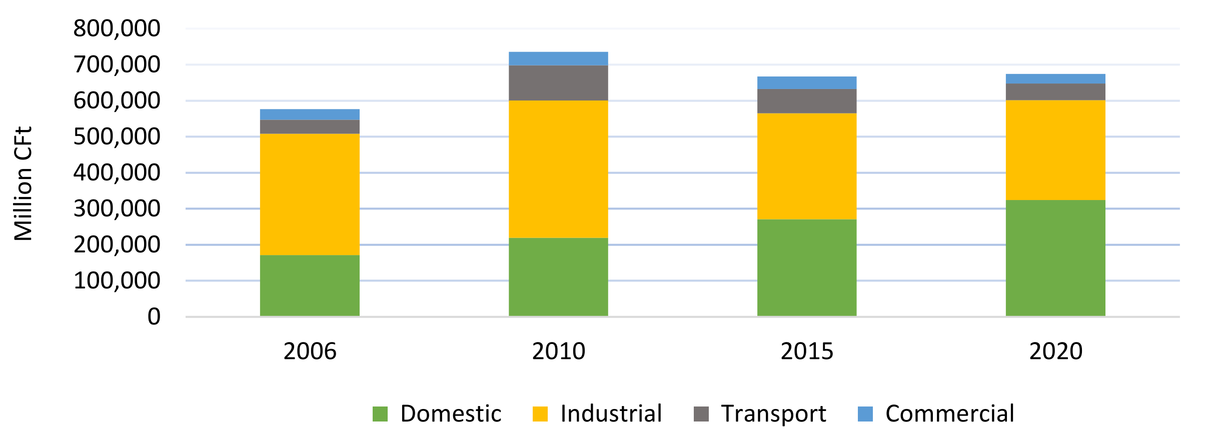

Figure 17. Gas Consumption by Sector (Source: IEP Database [2006–2020])

Historically, gas was the primary source for thermal power generation, but due to the decline in gas reserves in the last decade, its contribution to power generation has declined significantly. However, recently, the government decided to add LNG as a gas resource for power generation (see Figure 18).

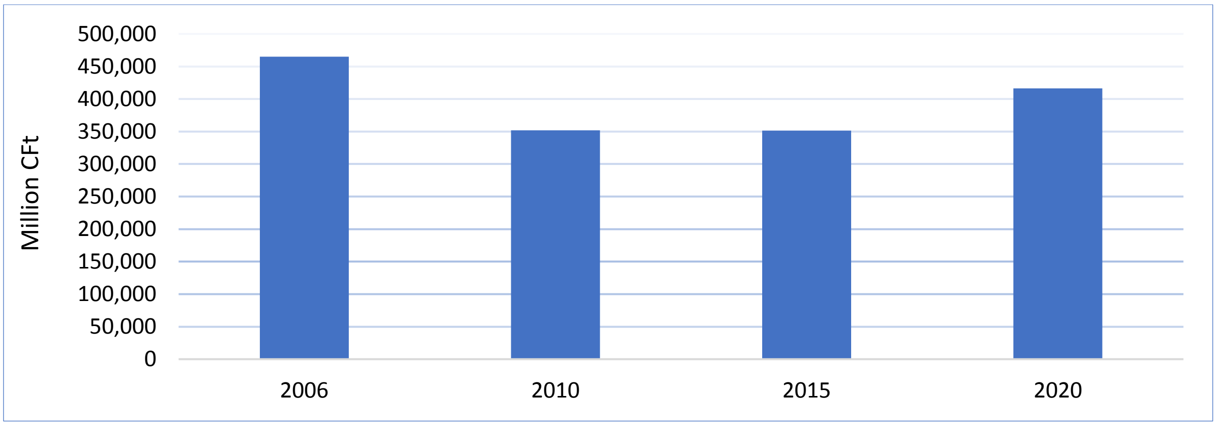

Figure 18. Gas Consumption Including the LNG Pattern for Power Generation (Source: IEP Database [2006–2020])

Gas being a country's leading energy source contributes to its use in almost all sectors, including the fertilizer industry as a feedstock (non-energy) and as a fuel. The use of gas as a non-energy source is increasing due to the increased demand for feedstocks and the increasing use of fertilizer inputs in the agriculture sector (see Table 8).

Table 8. Energy and Non-energy Use of Gas in the Fertilizer Sector (Million CFt)

Source	2006	2010	2015	2020
Fertilizer (as feedstock)	155,259	175,631	170,266	213,176
Fertilizer (as fuel use)	42,918	44,481	59,459	74,589

(Source: IEP Database [2006–2020])

Seasonal Pattern for Consumption of Natural Gas. Because the domestic sector mostly consumes gas, its demand during the winter months (November–February) increases sharply for space and water heating; it also surges in terms of month-wise total gas consumption. During the summer months, gas consumption in the domestic sector remains sluggish and shifts to the industrial sector for effective utilization of available resources (see Figure 19).

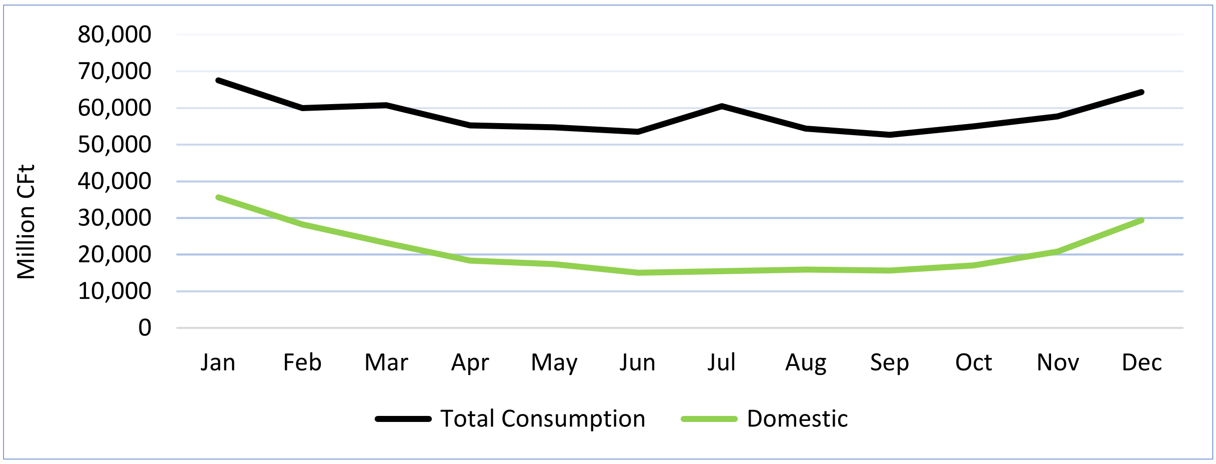

Figure 19. Seasonal Pattern for Consumption of Natural Gas (Source: IEP Database [2006–2020] and the author's calculation based on the average consumption from 2006–2020)

4.3 Forecasting Results (2021–2030)

Similar to past trends, forecasting indicates that domestic use will be the top-consuming sector based on population and urban growth. Because natural gas production is on the decline, more imported LNG will be required in the near future to meet the demand of the domestic sector.

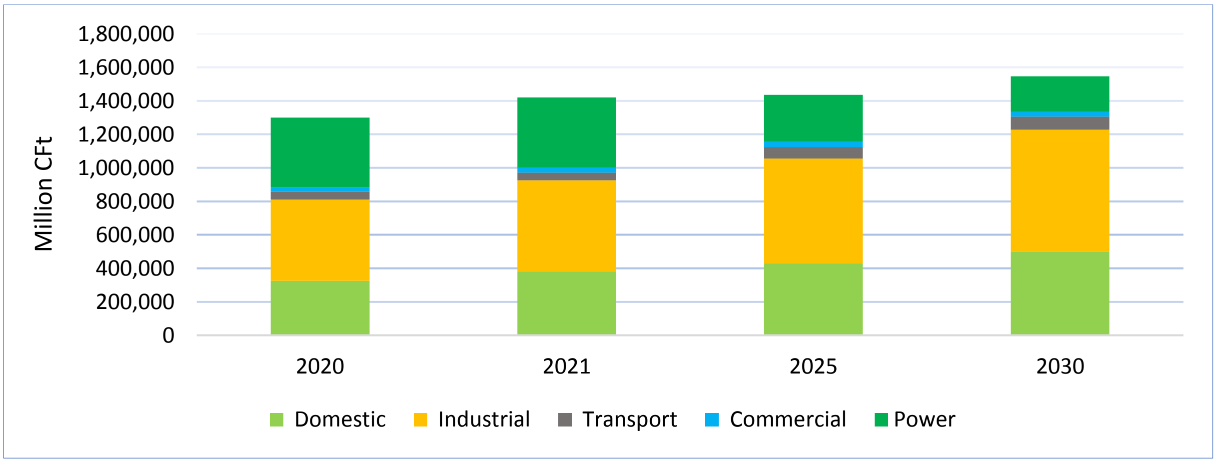

Figure 20. Energy Forecast for Natural Gas (Source: IEP Database [2006–2020] and the author's calculations)

Based on industrial growth and the government's policy tilt toward promoting overall exports, the industrial share along with fertilizers (feedstocks) may increase sharply in the future and it will constitute the highest share of gas consumption.

Previously, the gas consumption for power generation remained around 400 billion CFt per annum, however, due to depletion in reserves, its share will come down to 200 billion CFt per annum by 2030 (see Figure 20).

4.4 Upstream Gas (Natural Gas Production)

During the past 5 years, natural gas production kept depleting at the rate of negative 5 percent ACGR. Natural gas production has declined from 4,016 MMCFD in 2015 to 3,689 MMCFD in 2020. Assuming this trend continues, the future projections show a further decline in gas production from 2,819 MMCFD by 2025 to 2,181 by 2030 (see Figure 21).

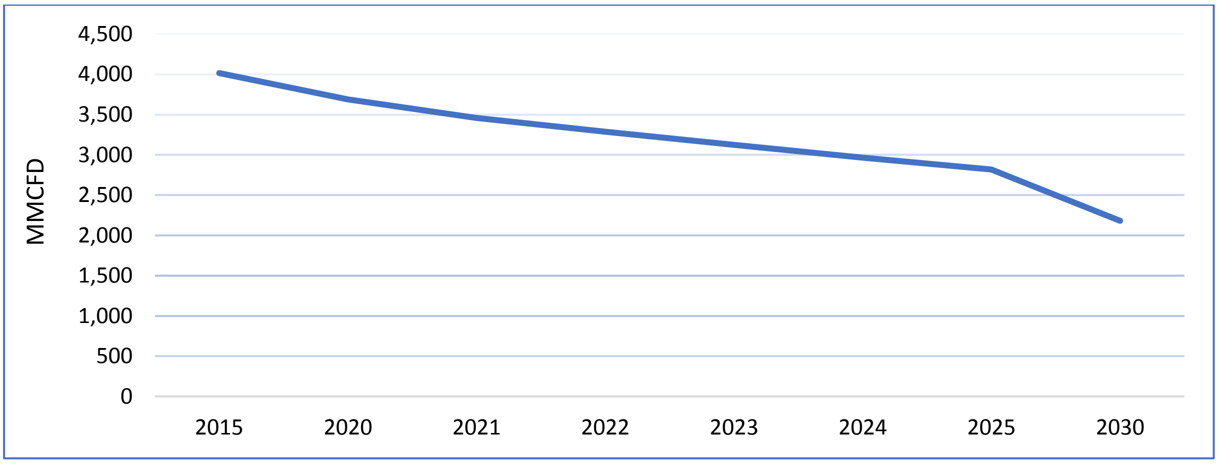

Figure 21. Natural Gas Production (Source: EYB [2015–2020] and the author's calculation)

4.5 Energy Balance for Natural Gas

The fast depletion of local natural gas resources is affecting the energy balance for natural gas in the country. It is estimated that natural gas demand in the country will increase from 3,563 MMCFD in 2020 to 4,237 MMCFD by 2030. Net supply will reduce to 2,102 MMCFD by 2025 and to 1,627 MMCFD by 2030. The decline in gas production is a serious issue that requires serious planning effort to meet the future demand in the sector. To make up for gas shortages, importation of LNG will be required to meet the future demand (see Table 9).

Table 9. Future Primary Energy Supply for Gas (Million CFt)

Supply	2020	2021	2025	2030
Net Supply	982,089	942,156	767,392	593,793
Imported LNG	318,241	477,776	669,670	952,680
Primary supply	**1,300,330**	**1,419,931**	**1,437,062**	**1,546,473**

(Source: EYB 2020 and author's calculations)

4.6 LNG Import

The LNG shortages are expected to remain throughout the year (after a few years) and unless significant new gas reserves are exploited or gas importation options are implemented, as planned, the shortages will worsen over time. Seasonal consumption variation in winter will be seen in the future as well, and to mitigate the winter hike challenge LNG importation will vary with seasonal variation in the gas consumption.

To meet the demand shortfall, almost three times more LNG will need to be acquired by 2030 compared to current importation quantities in the country. Currently, only two LNG terminals exist to manage the imports and they have a total capacity of about 1,200–1,400 MMCFD. Therefore, because of the sharp projected increase in LNG imports, the country will need additional LNG terminals to meet the import requirement of 1,900 MMCFD by 2030 (see Figure 22).

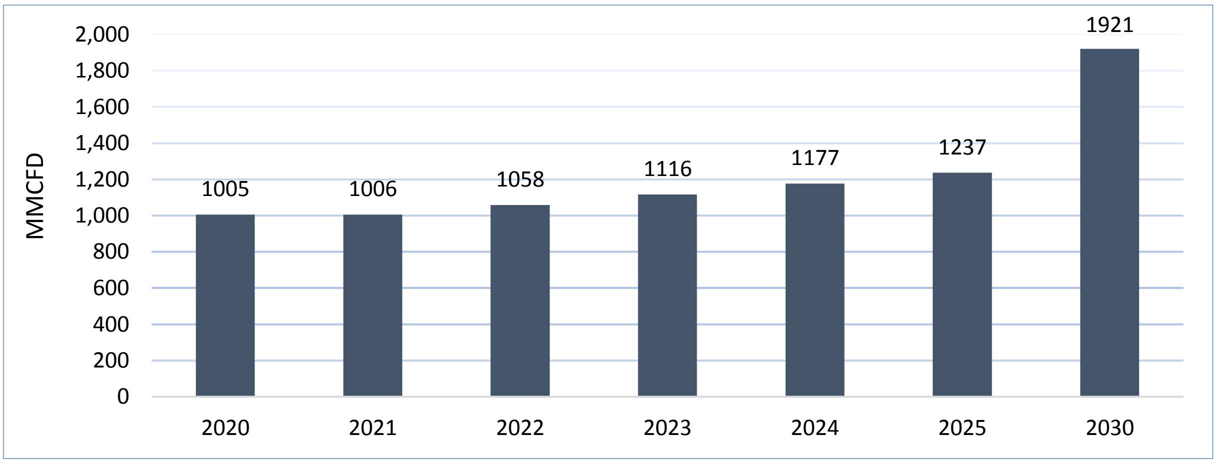

Figure 22. LNG Import 2020–2030 (Source: EYB, 2020 and the author's calculations based on the peak demand for natural gas)

4.7 Recommendations

- **Manage the growing demand.** About 1,211 gas-based CPPs are operational and consume 415 MMCFD of gas, including LNG. There is a dire need to provide electricity to CPPs from the national grid, which is currently producing electricity from natural gas. This will ease the burden on gas supply toward the domestic sector and will help manage the growing demand for natural gas. To manage the growing demand, the grid connectivity and reliability have to be improved.

- **Optimize LNG costs.** LNG may be provided at its imported cost, which is still a cheaper substitute for natural gas than LPG. Its availability needs to be ensured within the domestic sector to meet growing demand in the future. The GoP has to resolve the issue with provinces in accordance with Article 151 of the constitution.

- **Improve and expand the number of LNG terminals.** Currently, there are only two LNG terminals with a combined capacity of about 1,200–1,400 MMCFD to manage current imports. Given the projected sharp increase in LNG imports, the country will need additional LNG terminals to meet the import requirement of 1,921 MMCFD by 2030.

- **Import gas from neighboring countries.** It is also important to concentrate on importing gas from neighboring countries such as Tajikistan, Iran, Russia, etc. Pakistan had already backed out of a joint gas pipeline deal with Iran due to the threat of U.S. sanctions. Pakistan needs to expedite the Turkmenistan-Afghanistan-Pakistan-India Gas Pipeline Project. In addition, there is a need to explore other options for imported gas pipeline projects to meet the country's demand by 2030.
- **Construct a north-south gas pipeline.** Because the major load requirement of gas is from the north part of the country, especially during the winter, there is a need to construct a north-south pipeline to transfer the imported LNG from the southern port to the country up north.

5. Outlook for LPG

This chapter discusses the outlook of LPG in Pakistan. a brief overview of the historical supply and consumption trends of LPG has been presented. The forecasting results (2021-2030) depict the demand side scenario for LPG in the country. The energy balance of the LPG sector has been calculated to study the increasing national demand. Finally, substantial recommendations have been presented to meet the future LPG demands.

5.1 Primary Supply – A Historical Overview

Currently, there are 11 LPG producers with 216 marketing companies. In addition, significant investment has been made in the LPG supply and distribution infrastructure. Due to growing pressure from different sectors, the production of LPG and its importation has witnessed significant growth. Apart from supplying the country's domestic needs, it is important to meet the country's other growing demands (see Table 10).

Table 10. Primary Energy Supply for LPG (Tonnes)

Supply	2006	2010	2015	2020
Field	344,875	298,457	276,891	603,510
Refineries	212,974	186,658	191,664	158,400
Local production	**557,849**	**485,115**	**468,555**	**761,910**
Import	24,779	67,721	145,634	344,639
Primary supply	**582,628**	**552,837**	**614,189**	**1,106,549**

(Source: EYB [2006–2020])

5.2 Historical Consumption

LPG represents a substitute for natural gas that is consumed primarily in the domestic sector for cooking and heating purposes. The use of natural gas in the commercial sector increased until natural gas supply priorities were changed by the government; as a result, LPG started to replace natural gas because of the ease of portability that it offers to consumers and its competitive pricing compared to natural gas. As a result, an increase in LPG consumption has been observed in the domestic and commercial sectors since 2015.

Spikes in LPG use by the commercial and domestic sectors have also been witnessed due to natural gas supply and distribution disruptions. Hence, LPG has become the second most used cooking fuel in both rural and urban households. Surprisingly, LPG consumption in other economic sectors (commercial transport such as auto-rickshaws, etc.) has increased aggressively from minimal to becoming the third most highly consumed fuel (see Figure 23).

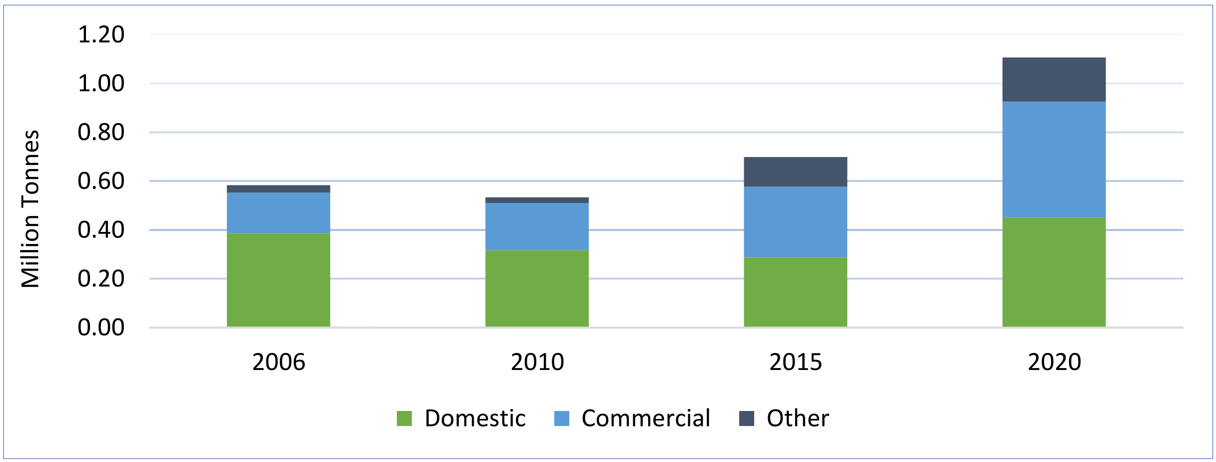

Figure 23. LPG Consumption by Sector (Source: IEP Database [2006–2020])

Seasonal Pattern for Consumption of LPG. Similar to natural gas, LPG has a monthly consumption variance. Due to decreased demand during the summer months, the price of LPG cylinders also declines—making it ideal for other sectors (autos, rickshaws) to use as a cheap primary fuel (see Figure 24).

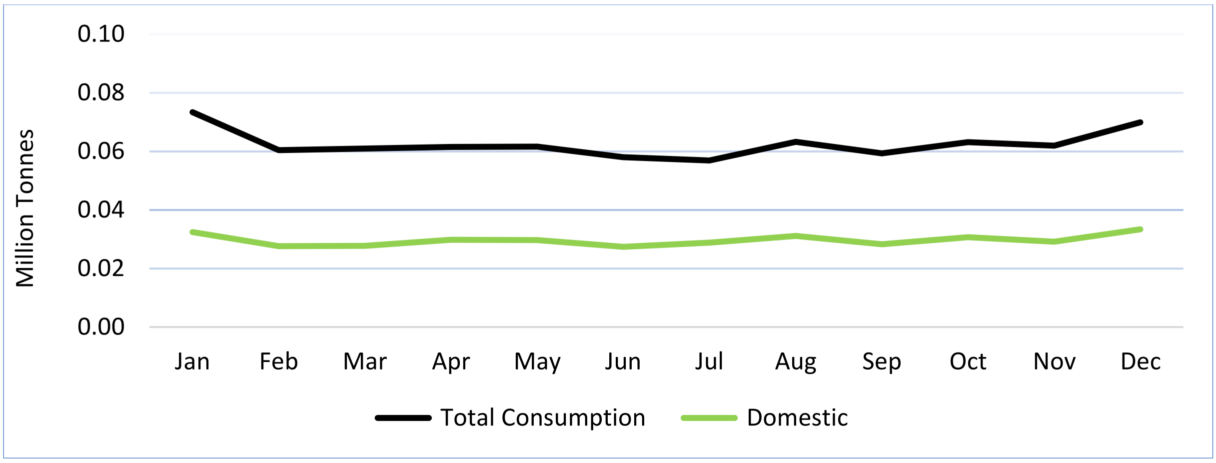

Figure 24. Seasonal Pattern for Consumption of LPG (Source: IEP Database, [2006–2020] and the author's calculation based on the average from 2006–2020)

5.3 Forecasting Results (2021–2030)

Despite an increase in the price of LPG, the consumption of LPG is predicted to increase within the domestic, commercial, and transport (2–3 wheelers transport) sectors. The LPG demand will increase by 50 percent to 1.68 million tonnes by 2030 compared to 1.10 million tonnes in 2020. Based on its ease of portability and comparative price relative to that of natural gas, the commercial sector is also preferring LPG, thereby becoming the largest LPG consumer of the sectors (see Figure 25).

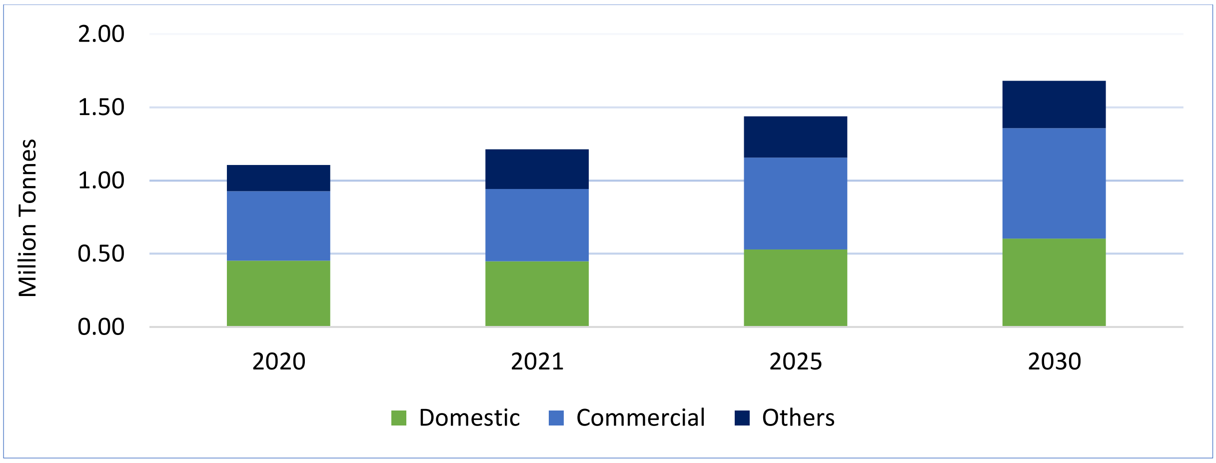

Figure 25. Energy Forecast for LPG (Source: IEP Database [2006–2020] and the author's calculations)

5.4 Energy Balance for LPG

The future primary energy supply for LPG, as presented in Table 11, indicates that the local share of gas through fields and refineries will decline because of depleting oil and gas reserves. LPG supply channels should be improved by LPG marketing companies managing outlets better, especially in remote areas. To meet future demand, Pakistan also needs to import LPG to balance its future consumption needs. Currently, major imports of LPG come from Iran through the Taftan border land route and the Arabian Sea.

Table 11. Future Primary Energy Supply for LPG (Tonnes)

Supply	2020	2021	2025	2030
Field	603,510	573,335	466,985	361,344
Refineries	158,400	152,475	130,909	108,189
Local supply	761,910	725,809	597,894	469,533
Import	344,160	487,844	839,671	1,211,268
Primary supply	**1,106,070**	**1,213,653**	**1,437,565**	**1,680,801**

(Source: EYB 2020 and author's calculations)

5.5 Recommendations

To provide sustainability in LPG supply, private sector-led LPG importing companies should import LPG based on competitive prices to meet the future LPG demand in the country. The government on the other hand should provide flexible and favorable terms to encourage the private sector to import sustainable and least-cost LPG to the country. Moreover, within the country, the LPG supply logistics should be improved by using private sector LPG marketing companies to meet the gradually rising domestic demand.

6. Outlook for Coal

This chapter discusses the outlook of coal in Pakistan. It sheds light on the historical supply and consumption trends of coal in the country. The forecasting results (2021-2030) show the change in the expected demand for coal in different economic sectors in Pakistan. The energy balance of coal analyses the future consumption of coal in power generation. The chapter concludes with an option to substitute imported coal with local coal and a set of recommendations for the management of the coal supply in the country.

6.1 Primary Supply – A Historical Overview

Pakistan has abundant coal resources, found in all provinces, that are still untapped and underutilized. The largest reserves are in the Thar Desert of Sindh, which has 7,025 million tonnes of measured reserves. Coal is the cheapest source of energy that can be used as fuel for power generation and industrial use, such as the brick-kiln and cement industry. A country with a plentiful reserve can provide a hedge against international fuel price volatility. With the advancement of the Thar coal project, domestic coal is contributing a considerable share to the country's current energy mix relative to past practices (see Table 12).

Table 12. Primary Energy Supply for Coal (Tonnes)

Supply	2006	2010	2015	2020
Thar Coal	-	-	-	3,669,968
Non-Thar Coal	4,871,159	3,480,674	3,711,561	5,065,122
Local coal	**4,871,159**	**3,480,674**	**3,711,561**	**8,735,090**
Import	2,842,829	4,657,829	5,003,806	16,421,787
Primary supply	**7,713,988**	**8,138,503**	**8,715,367**	**25,156,877**

(Source: EYB [2006–2020])

6.2 Historical Consumption

Coal mining enhancement, the advancement of coal-burning technologies (that enabled the extraction of more heat due to the high carbon content present in coal), and the use of coal by-products by various industries (e.g., brick-kiln and cement), gradually increased the consumption of coal and replaced a fair portion of oil and natural gas consumption in the industrial sector. In past years, the major share was consumed by the brick-kiln and cement industry, followed by the Pakistan steel mill (see Figure 26).

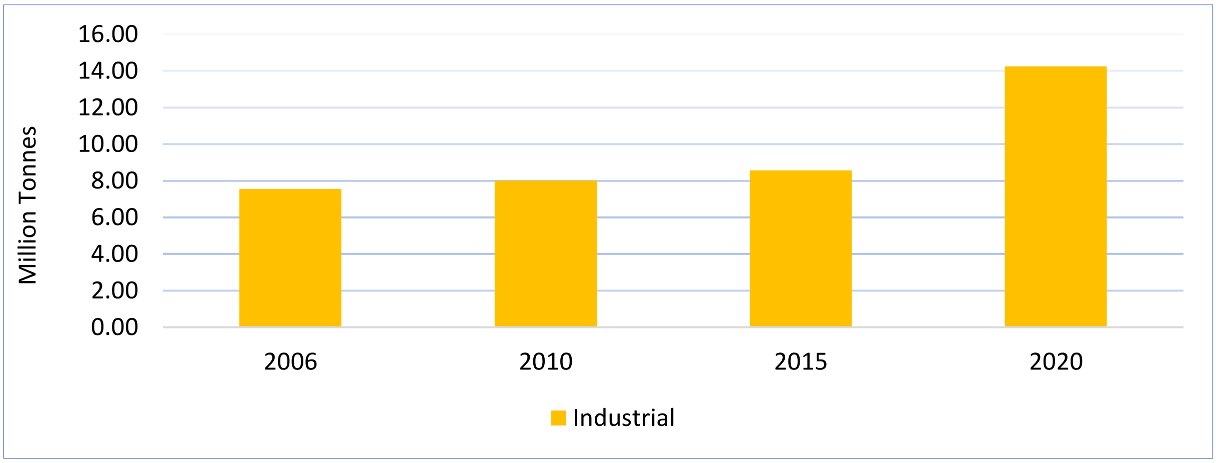

Figure 26. Coal Consumption by Industrial Sector (Source: IEP Database [2006–2020])

The government decided to use coal for thermal power generation because it is the cheapest source of energy. An aggressive spike can be observed in the current coal consumption for thermal power generation compared to the last one and a half decades. Currently, almost 70 percent of imported coal and 30 percent of domestic coal is being used for thermal power generation (see Figure 27).

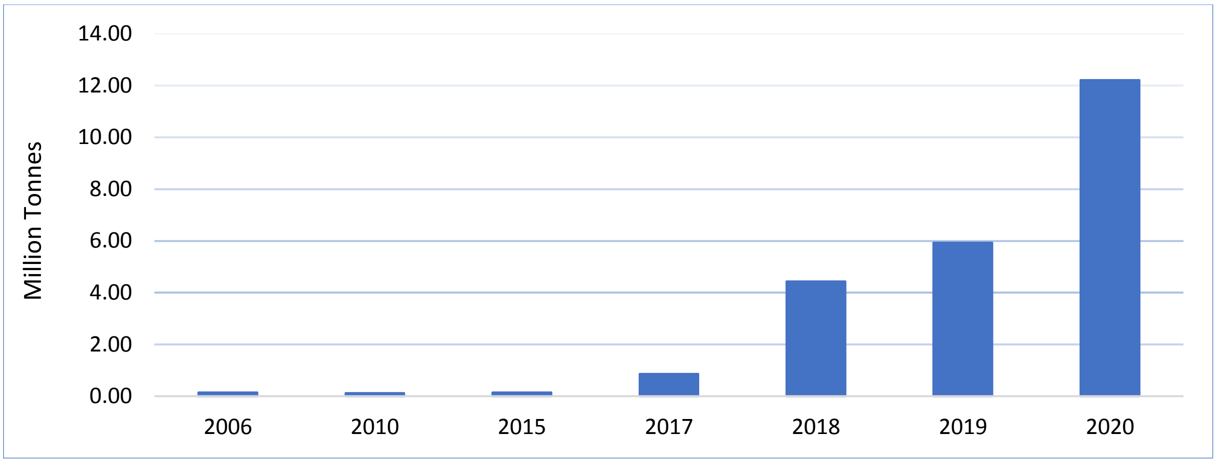

Figure 27. Coal Consumption Pattern for Power Generation (Source: IEP Database [2006–2020])

6.3 Forecasting Results (2021–2030)

Considering the government preferences for using local coal resources, the demand for coal in power generation and the industrial sector will almost double by 2030. From 2021 to 2030, coal will become the country's second-largest primary energy source to serve the overall energy demand. The use of coal will increase to 50 million tonnes in 2030, as compared to 26 million tonnes in 2020 (see Figure 28).

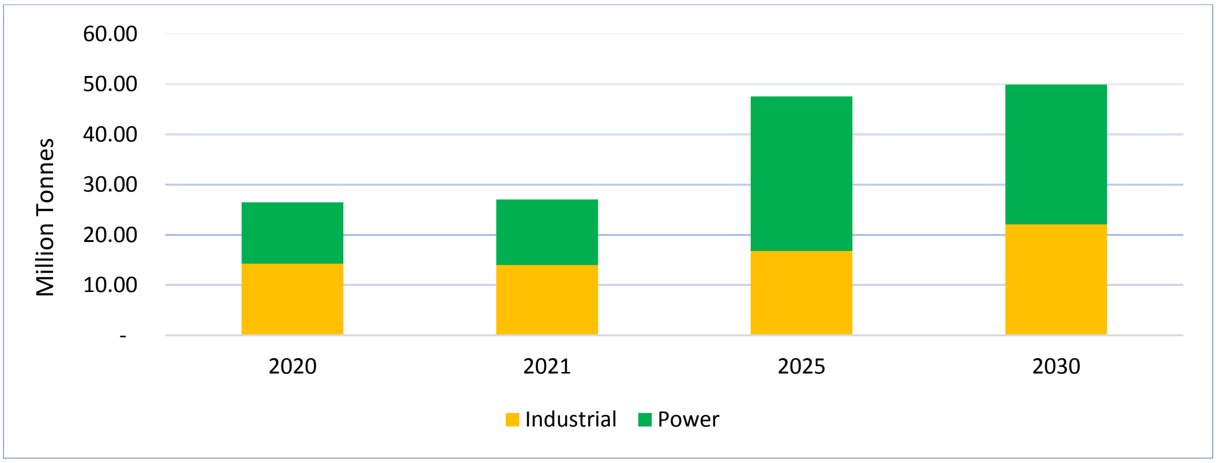

Figure 28. Energy Forecast for Coal (Source: IEP Database [2006–2020] and the author's calculations)

Due to the government's incentives for the construction sector, the consumption of cement has increased, which has triggered more consumption of coal by industries in recent years. Along with these developments, the government has also issued No Objection Certificates to construct five more new cement plants to enhance the production of cement. Coal demand is projected to increase by 50 percent in both the cement and brick kilns industries by 2030 compared to 2020.

For sustainable and cheap electricity supply, the government decided to shift the major share of thermal power generation toward coal. Therefore, more than 70 percent of thermal power generation will be produced by coal-based power plants (45 percent local coal and 25 percent imported coal) in 2030.

6.4 Energy Balance for Coal

The effects of the government's decision will be quite visible in the power and industrial sectors (given the increased number of cement and brick kiln operation in the country) as massive supplies

The government's decision to promote the use of indigenous coal has led to a substantial increase in the production and supply of coal. The increase in coal supply will be reflected in the future through massive demands for coal within the power and industrial (cement and brick kilns) sectors by 2030. Moreover, imported coal supplies for the industrial sector will also increase steadily. However, the share of coal will see a declining trend in power generation after 2025 (see Table 13).

Table 13. Future Primary Energy Supply for Coal (Tonnes)

Supply	2020	2021	2025	2030
Industrial – Non-Thar Coal	5,160,590	5,577,725	6,691,943	8,811,995
Power – Thar Coal	3,574,500	3,612,925	21,155,492	20,245,766
Local Coal	**8,735,090**	**9,190,651**	**27,847,435**	**29,057,761**
Industrial	7,777,615	8,406,287	10,085,544	13,280,711
Power	8,644,172	9,445,548	9,645,709	7,605,256
Import	**16,421,787**	**17,851,835**	**19,731,253**	**20,885,967**
Primary supply	**25,156,877**	**27,042,485**	**47,578,688**	**49,943,728**

(Source: EYB 2020 and the author's calculations)

6.5 Coal Substitution

The GoP has intended to harness the untapped potential of local coal to increase its share in the primary energy mix. Effort can be made to substitute the use of imported coal with Thar coal in the country. Local coal has a low heating value (2,800 kcal/kg) and high moisture and ash contents compared to imported coal that has a calorific value of 5,505 kcal/kg. The local coal requirement in terms of quantity of supply will be two times higher than imported coal, which may have cost implications; but as the mining capacity increases, the local coal price will also decrease.

By 2030, the imported coal requirement is expected to be 20.8 million tonnes, including 7.6 mtpa for power and 13.28 mtpa for the industrial sector. The GoP may substitute 20 percent imported coal for power generation and 30 percent imported coal for the industrial sector. Thus, the aggregated outcome of coal substitution will ultimately decrease the imported coal requirement by up to 15.38 mtpa by 2030. The additional requirement for local coal could be met by Thar coal reserves for power substitution and non-Thar coal sources for the industrial sector, which will also decrease the local coal prices (see Table 14).

Table 14. Imported Coal Substitution with Local Coal by 2030 (Tonnes)

Coal Demand	Imported Coal	Thar Coal	Non-Thar
Demand for coal (2030)	20,885,967	20,245,766	8,811,995
Industrial (30 % substitution)	*-3,984,213*		*7,848,902*
Power (20 % substitution)	*-1,521,051*	*2,996,471*	
Demand after substitution	**15,380,703**	**23,242,238**	**16,660,897**

(Source: Author's own calculation.)

- **Impact on Coal Tariff.** With the planned coal mine expansion, the coal price will come down for power plants to around $30/tonnes by 2022 or 2023. Additional demand for coal substitution for power generation can further decrease the price by around $4/tonnes down to the floor price of $26/tonners (see Figure 29).

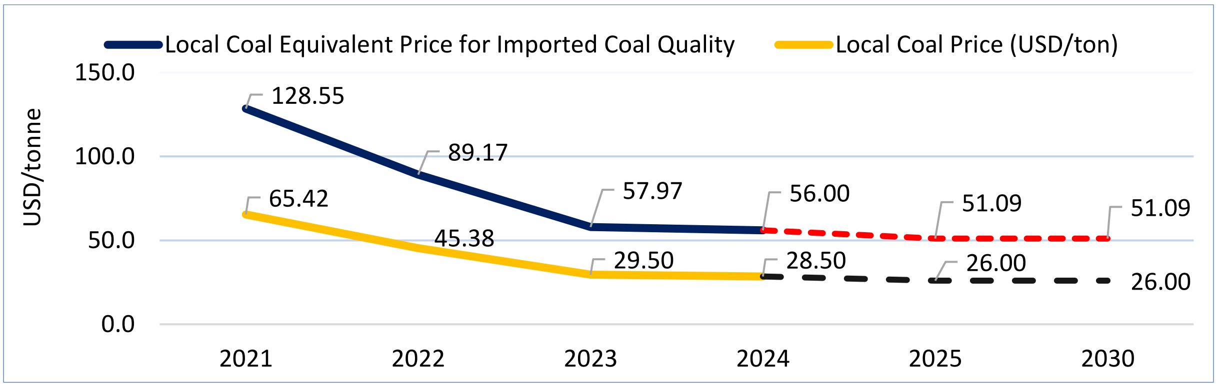

Figure 29. Local Coal Price (Source: NEPRA, NTDC, Sindh Sino & SECMC)

- **Foreign Exchange Savings.** With a 20 percent substitution by 2030, about 3 mtpa of local coal will be used by coal-based power plants instead of importing coal for power generation. As a result, approximately USD 81 million will be saved as foreign exchange savings (see Figure 30).

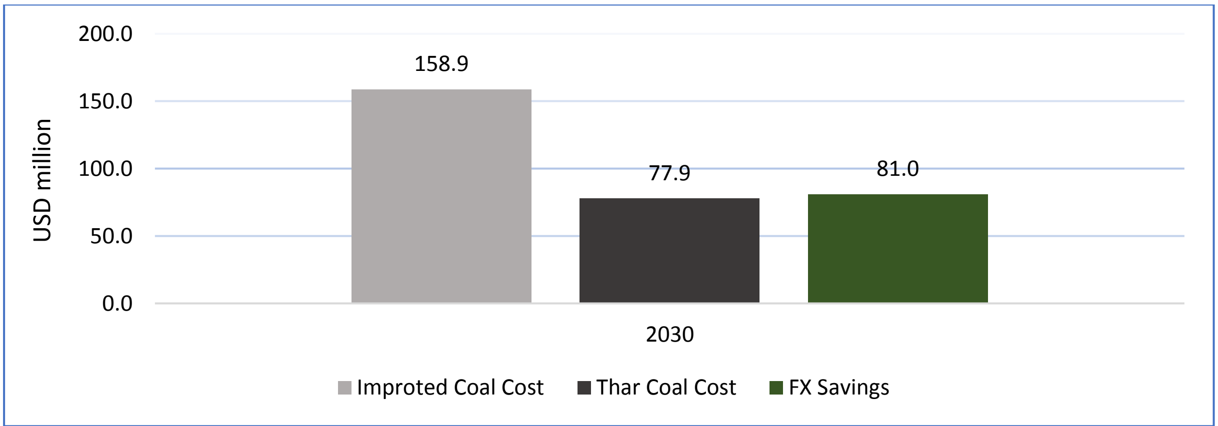

Figure 30. Foreign Exchange Savings (Source: Richard Bay Imported Coal Prices and the author's calculation)

6.6 Recommendations

- **Mining expansion.** With the planned mining expansion, the price of coal is expected to come down for power generation by 2030. Therefore, additional demand for coal and the substitution with imported coal can further decrease the prices of local coal. Considering the production of 30 mtpa of coal from Thar, no expansion in the mining blocks is required.
- **Develop a new rail link.** A rail link of 105 kilometers to connect Thar mines with the new Chorr station on the Hyderabad-Mirpurkhas should be developed so that rail can be adopted as a primary mode of transportation.

7. Outlook for Electricity

This chapter discusses the outlook of electricity in Pakistan. It gives a brief overview of the historical power generation and consumption trends in the country. The forecasting results (2021-2030) shows the electricity demand in all economic sectors including transportation. An analysis of future installed capacity (2021-2030) and energy mix for power generation (2021-2030) have been given. Finally, the chapter closes with recommendations to improve the supply of electricity in the country.

7.1 Power Generation – A Historical Overview

Due to the sharp spike in electricity demand, both state-owned power generation companies and independent power producers are aggressively engaged in producing electricity. Pakistan's electricity generation mix relies heavily upon unsustainable thermal generation. The country's electricity installed capacity (Mega Watts (MW)) and power generation (Giga Watt Hour (GWh)) historic patterns are shown in Figures 31 and 32, respectively.

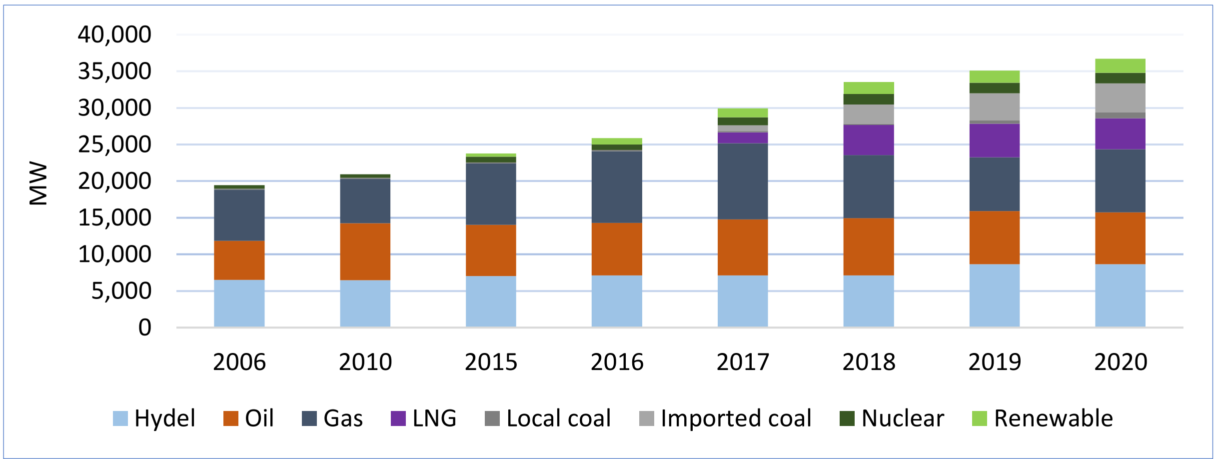

Figure 31. The Country's Installed Capacity (Source: EYB [2006–2020])

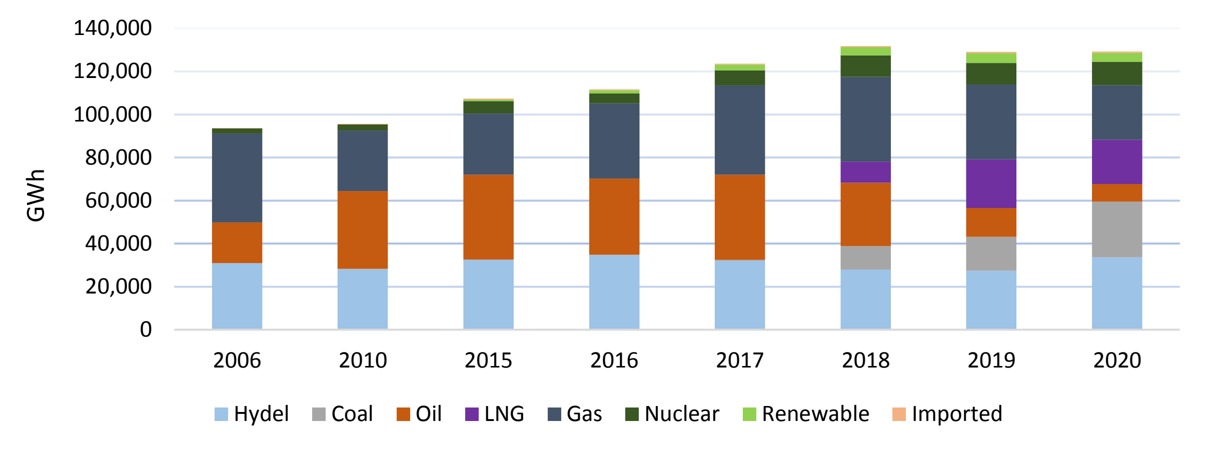

Figure 32.The Country's Power Generation (Source: EYB [2006–2020])

7.2 Historical Consumption

Electricity consumption in the domestic sector increased from 2006 to 2020 because of increased rural electrification, rapid urbanization, and the increasing use of electricity as an efficient alternative fuel for domestic heating/cooling and cooking.

Likewise, due to the enormous use of electricity in the commercial sector (lighting, heating, cooling, commercial cooking, small-scale production, etc.) and the lack of suitable alternate fuels, the consumption of electricity increased during the period of review (see Figure 33).

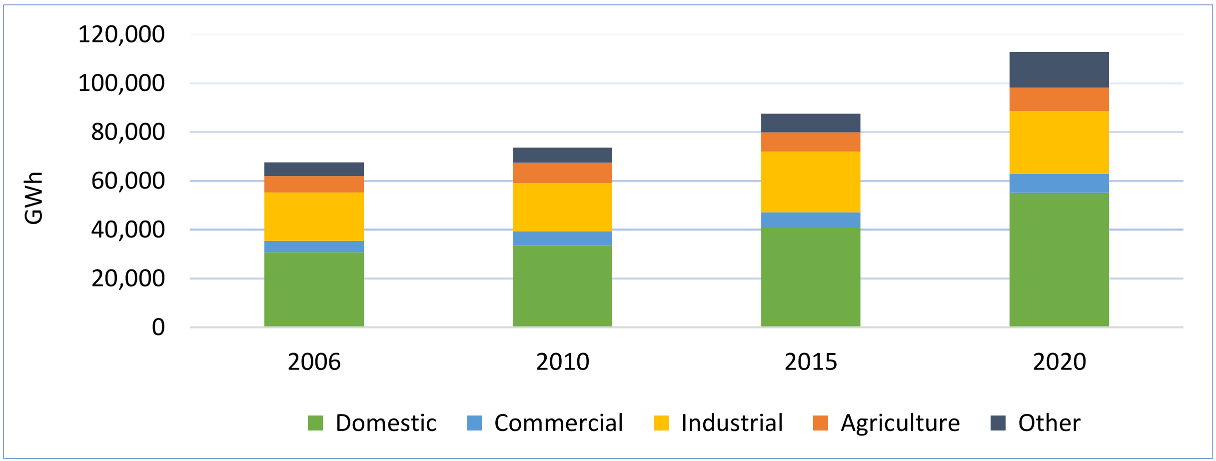

Figure 33. Electricity Consumption by Sector (Source: IEP Database [2006–2020])

The use of electricity in the agriculture sector increased because of multiple government-sponsored initiatives (such as the provision of subsidized electric motors, pumps, etc.) and the advancement of electricity-based agricultural equipment to encourage farmers to adopt modern farming practices. As a result, electricity has replaced a significant portion of POL consumption in the agricultural sector. Electricity consumption in other economic sectors, like governmental entities, institutes, etc., also significantly increased from 2006 to 2020.

Seasonal Pattern for Consumption of Electricity. Higher temperatures and changing climate effects drive an increase in electric appliance usage for cooling and raise the electricity demand within the domestic sector in the summer season (April–September), eventually increasing total consumption demand (see Figure 34).

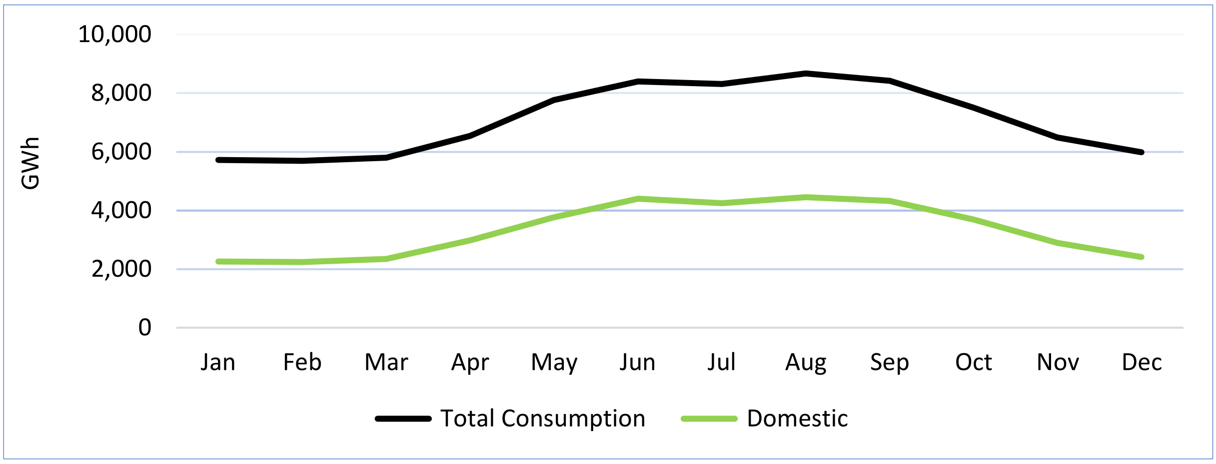

Figure 34. Seasonal Pattern of Consumption of Electricity (Source: IEP Database [2006–2020] and the author's calculation based on the average from 2006–2020)

7.3 Forecasting Results (2021–2030)

Economic growth, increased urbanization and population, and ever-improving lifestyles of the citizens drive the increased future consumption of electricity in all economic sectors. If business proceeds as usual, domestic demand will be boosted to more than 75,000 GWh—almost half of total electricity consumption —in 2030, followed by industrial, agriculture, commercial, and other sector demands. With the inclusion of electric vehicles in the transport sector, consumption of electricity by the transport sector will be more than 6,000 GWh by 2030 (see Figure 35).

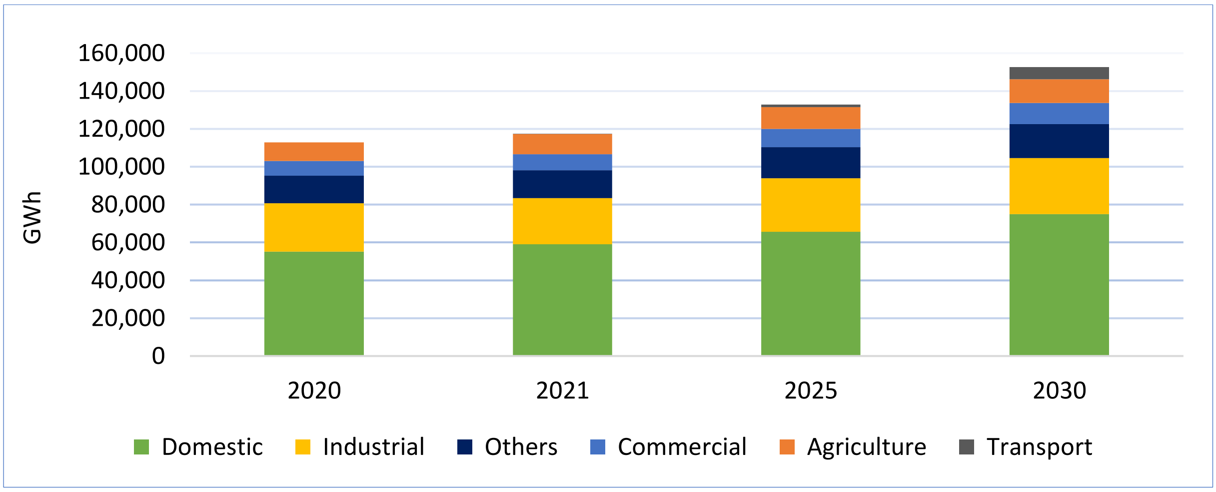

Figure 35. Energy Forecast for Electricity (Source: IEP Database [2006–2020] and the author's calculations)

7.4 Future Installed Capacity (2021–2030)

Future electricity generation and installed capacity in the country has been considered based on approved IGCEP-2021[10] and the KE Generation Expansion Plan[11] (see Figure 36).

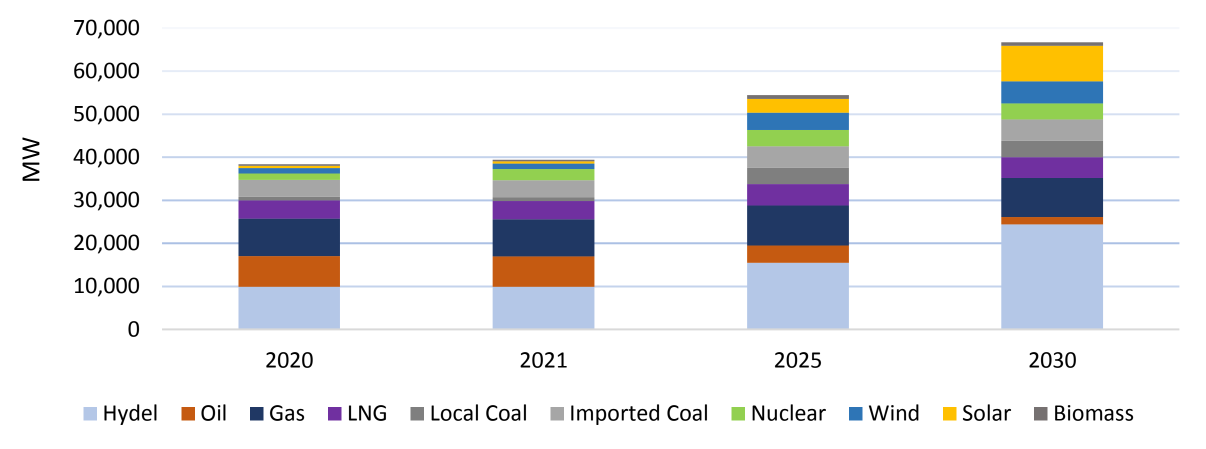

Figure 36. Energy Mix for Power Generation (2021–2030) (Source: SOIR 2020-21 and IGCEP & KE Plan 2022–2030)

7.5 Energy Mix for Power Generation (2021–2030)

Due to the recent shuffling of the energy mix, future power generation will be made more environmentally friendly by adding more hydro and non-hydro renewable sources and reducing the use of fossils fuels. As an outcome, by 2030 more than 50 percent of electricity will be generated by hydro and non-hydro renewable-based power plants and only 31 percent by burning fossil fuels (see Table 15).

Table 15. Future Energy Mix for Power Generation (GWh)

Supply	2020	2021	2025	2030
Hydel	38,699	38,801	51,098	94,649
Coal	26,085	28,619	51,686	42,046
Oil	8,315	9,122	3,884	3,884
LNG	20,726	22,740	17,761	15,453
Gas	25,700	28,196	14,188	9,076
Nuclear	9,898	11,090	24,877	24,910
Renewable	4,305	4,522	22,635	36,721
Imported	514	498	3,168	3,436
Primary supply	**134,242**	**143,589**	**189,298**	**230,176**

(Source: SOIR 2020-21 and IGCEP & KE Plan 2022–2030)

7.6 Recommendations

- **Continuity of IGCEP for Future Generation and Expansion Planning.** Future electricity generation and installed capacity planned by the NTDC and KE are considered to be enough to meet the country's overall electricity demand by 2030. The IGCEP is an informative and useful document for generation expansion planning and has improved supply-side planning. Therefore, IGCEP should continue for power generation and expansion planning in the country.
- **Upgrade the Demand Estimation Model.** The demand side forecast in IGCEP needs to be upgraded in consultation with the sectoral experts, academia, and relevant stakeholders while forecasting and analyzing different socio-economic, environmental, and technological factors for prioritizing different energy sources (fuels) and plants for energy generation planned for 2030.

Annexure I: IEP Database

The IEP team has acquired monthly consumption data from relevant primary stakeholders and created its data repository (IEP Database). The IEP Database consists of monthly consumption data for each of the energy sources, including oil, LNG, LPG, coal, and electricity, by the economic sectors (domestic, commercial, agriculture, industry, others) from 2006 to 2020 (see Table A-I).

Table A-I. IEP Database

Input Data	Data Source(s)
Oil	Directorate General (Oil), Ministry of Energy, (Petroleum Division) retrieved from The Oil Companies Advisory Council
Gas Incl. LNG	Directorate General (Gas), M/o Energy, (Petroleum Division) retrieved from (Sui Northern Gas Pipelines Limited (SNGPL), Sui Southern Gas Company Limited (SSGCL), Mari Petroleum, Oil and Gas Development Company Limited (OGDCL), Pakistan Petroleum Limited (PPL), KDT)
LPG	Oil and Gas Regularity Authority (OGRA)
Coal (indigenous and imported)	Pakistan Bureau of Statistics (PBS)
Electricity (Central Power Purchasing Agency)	Power Information Technology Company, Ministry of Energy (Power Division)
Electricity (KE)	K-Electric

Annexure II: Input Data and Data Sources

The input data that were collected included sector-specific GDP (agriculture, industry, and services), fuel and electricity prices by economic sector, population, and urbanization data.

Table A-II. Input Data and Data Sources

Sr. No	Input Data	Data Sources
Historical Data		
1	Energy consumption by sector	IEP Database
2	Total and sector-specific GDP (agriculture, industrial, and services) at constant prices	Economic Survey of Pakistan, Finance Division, GoP
3	Prices of petroleum products, LPG, natural gas, coal, and electricity by the economic sector	Pakistan EYB by Hydrocarbon Development Institute of Pakistan, Ministry of Energy (Petroleum Division), Pakistan State Oil, Oil and Gas Regularity Authority, National Transmission and Despatch Company, and KE
4	Population (urban, rural, and total)	Economic Survey of Pakistan, Finance Division, GoP
Projected Data		
5	Total and sector-wise GDP (agriculture, industrial, and services)	The GDP projections from 2022 to 2030 have been provided by the Finance Division (Economic Adviser Wing) for Indicative Generation Capacity Expansion Plan https://nepra.org.pk/licensing/Licences/LAT-01%20IGCEP%2024-09-2021%2037702-29.pdf (accessed December 20, 2021)
6	Population growth	International Monetary Fund https://www.imf.org/en/Publications/WEO/Issues/2021/10/12/world-economic-outlook-october-2021 (accessed December 20, 2021)
7	Crude oil prices	Energy Information Administration https://knoema.com/infographics/yxptpab/crude-oil-price-forecast-2021-2022-and-long-term-to-2050 (accessed December 20, 2021)

Annexure III: Model Validation

Using the ex-post approach[12], retrospective forecast analyses were performed for 2016 to 2020 to check the validity of the model and prediction bias. For these analyses, data from 2006 to 2015 were used as a training set and data from 2016 to 2020 were considered the test set. The results from the retrospective forecast for oil, natural gas, LPG, and electricity are shown in the figures below.

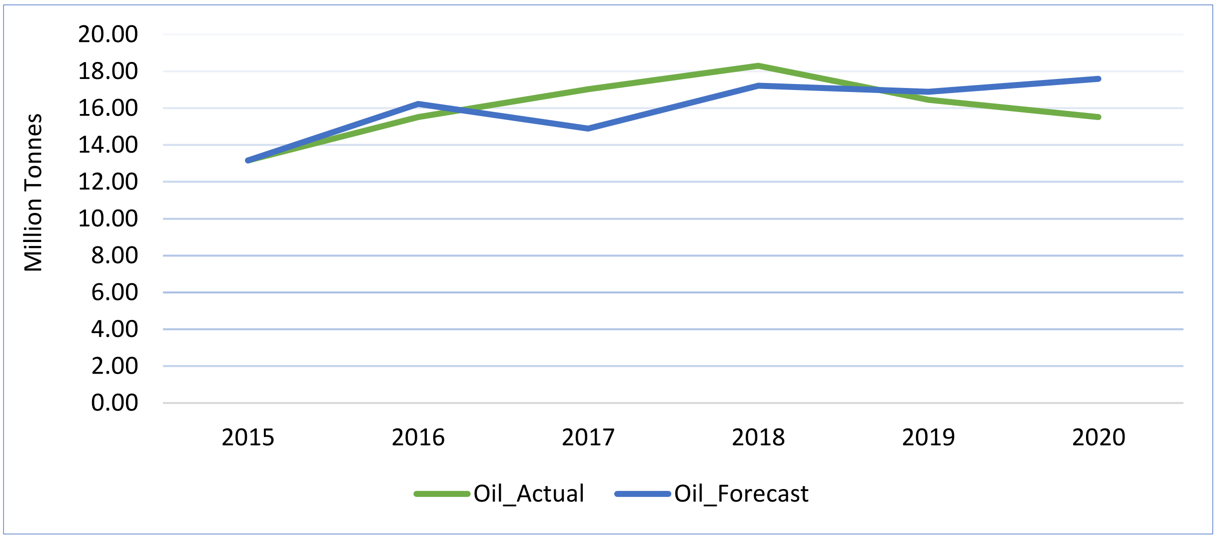

Figure A-III-1. Retrospective Forecast for Oil and POL Consumption (2015–2020) (Source: IEP Database [2015–2020] and the author's calculations)

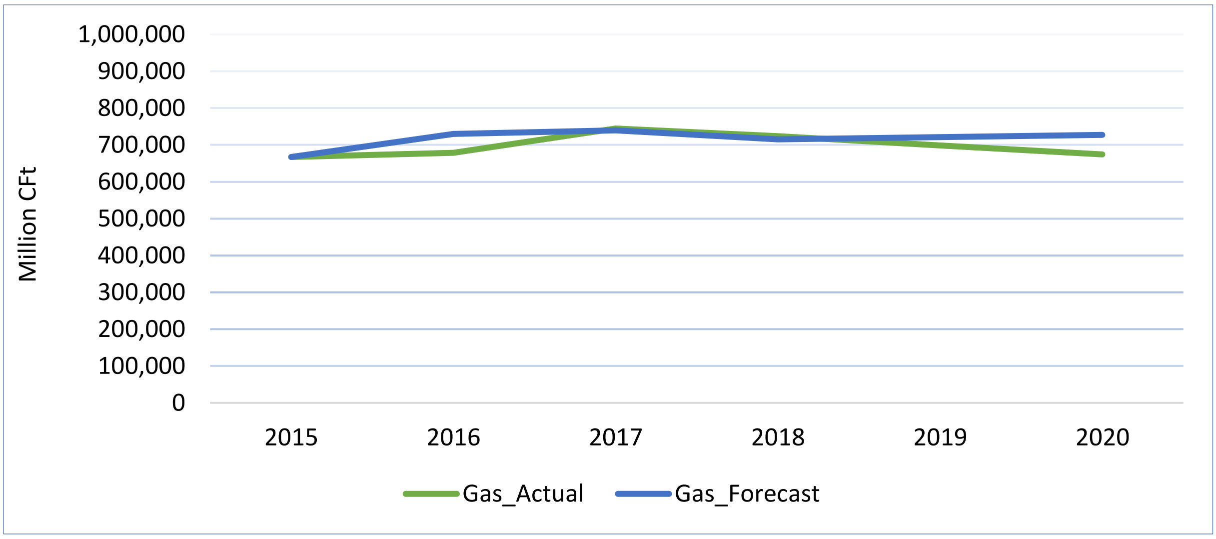

Figure A-III-2. Retrospective Forecast for Gas Consumption (2015–2020) (Source: IEP Database [2015–2020] and the author's calculations)

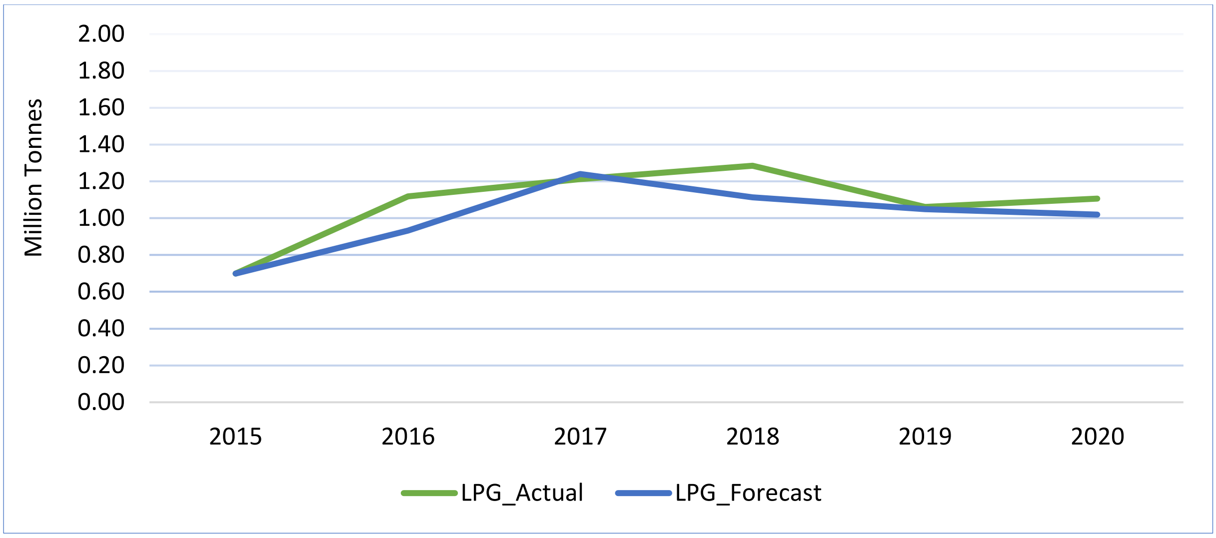

Figure A-III-3. Retrospective Forecast for LPG Consumption (2015–2020) (Source: IEP Database [2015–2020] and the author's calculations)

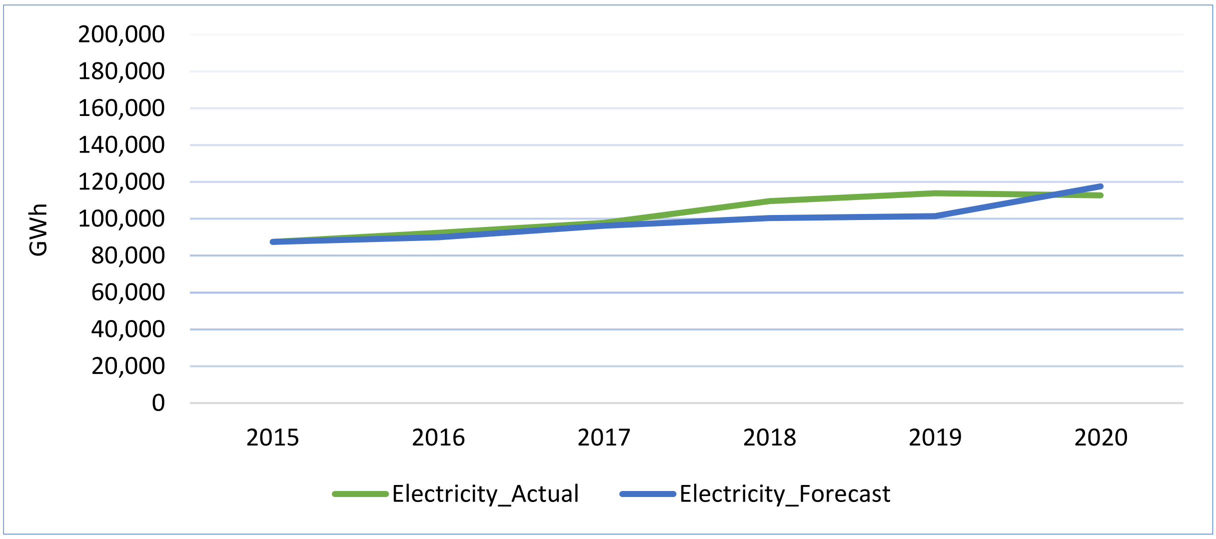

Figure A-III-4. Retrospective Forecast for Electricity Consumption (2015–2020) (Source: IEP Database [2015–2020] and the author's calculations)

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