Reform Priorities for Pakistan's Energy Sector

Perspectives in the Backdrop of Paris Agreement

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This brief draws from the extensive workshops on the subject led by the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) and the Sustainable Development Policy Institute (SDPI) under the project 'Evidence Based Policies for Sustainable Use of Energy Resources in Asia and the Pacific'. It also draws from an extended study by Dr. Jiang Kejun who was the Team Lead for this project and Ms. Qu Chenfei who supported the energy sector modelling.

NOMENCLATURE

MoPDR	Ministry of Planning, Development and Reform
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
NDCs	Nationally Determined Contributions
CO_2	Carbon Dioxide
GHGs	Greenhouse Gases
LEAP	Long-range Energy Alternatives Planning
IPAC	Integrated Policy Assessment Model for China
SDGs	Sustainable Development Goals
OGRA	Oil and Gas Regulatory Authority
AEDB	Alternative Energy Development Board
NEECA	National Energy Efficiency & Conservation Authority
PEPCO	Pakistan Electric Power Company
WAPDA	Water and Power Development Authority
IPDF	Infrastructure Project Development Facility
MOCC	Ministry of Climate Change

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1 Objectives and Background

This study attempts to provide future energy transition pathways in Pakistan towards 2030, considering determinants such as population growth, economic development and technological progress within the context of CO2 mitigation targets. The methodological framework and all modelling results have been derived from an extended study on 'Power Sector Transition Towards Pakistan's Commitment in Paris Agreement' by Jiang & Chenfei, 2019. Simulations of future energy demand and supply in Pakistan have been conducted with a view to present key policy and technological optional to meet Pakistan's NDC's through an energy sector transition.

1.1 Energy Challenges in Pakistan

Pakistan is a small open economy with Gross Domestic Product now touching USD 321 billion [1]. The agriculture sector makes up 18.9%, while industry and service sectors contribute 20.9% and 60.2%, respectively. The country has the 5^{th} largest population (217,641,492) [2], 10^{th} largest labor market in the world and ranks 67^{th} amongst the global exporters [3]. However, 21% of the population lives under the poverty line [4], facing formidable challenges to meet their energy demands. At least 51 million people in Pakistan or nearly 27% of the population lives without access to electricity [5]. Electricity access varies between urban and rural areas with more than 90% electrified households in urban areas down to only 61% in remote rural area. Pakistan's energy sector is heavily reliant on imported fuels and constitutes a major share in the energy mix of Pakistan. In the energy mix, about 64% of energy comes from fossil fuels (mainly imported oil and gas), 27% hydro, 7% nuclear, while renewable only account for only 2% [6]. Coal is expected to play a relatively more prominent role in the future energy mix. Moreover, transmission losses also account for approximately 30% of total energy supply while exports and bunkers constitute 1.7%. Population growth and economic development has resulted in increased demand for affordable and reliable energy but the reliance on imported fossil fuels puts a heavy burden of the balance of payments while further contributing to climate change.

Expanding infrastructure and upgrading to clean technologies is vital to achieving SDG7 by 2030, which means that investing in solar, wind and thermal power is required to improve energy productivity and efficiency. Figure-1 shows the imports of different fossil fuels in the past years and the share of different energy sources in power generation mix of Pakistan highlighting the historical reliance on fossil fuels.

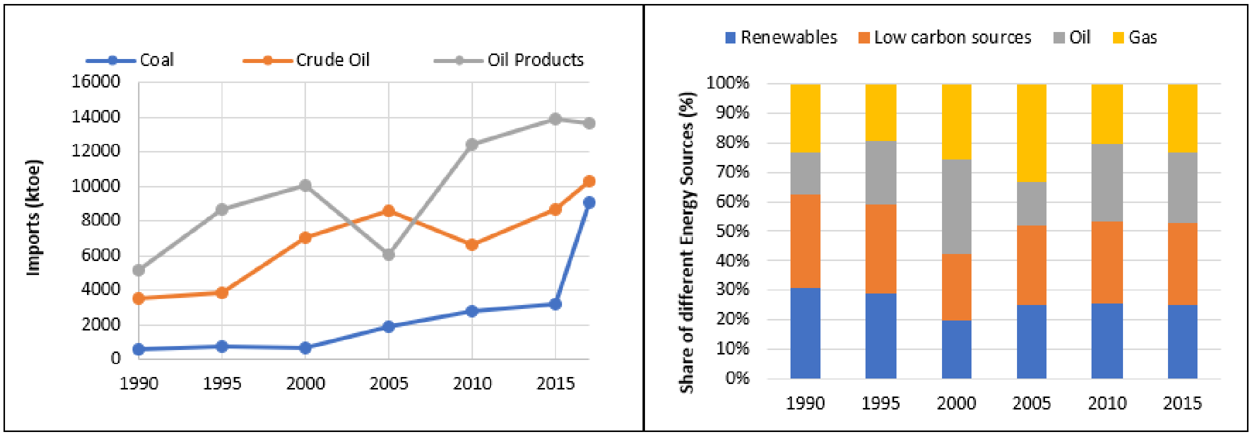

Figure 1 Imports of Different fuels in Energy mix of Pakistan and the Share of Different Energy Sources in Power Generation Mix of Pakistan [7]

Currently, Pakistan is an energy deficient country facing severe power shortages which is one of the major factors preventing the country from achieving its economic potential. According to recent estimates, Pakistan will run out of domestic natural gas within the next 15 years, owing to the huge gap (2.5 billion cubic feet) between demand and supply that costs around 2% of the country's national income. At the same time, energy demand is expected to increase 8-fold by 2030 and 20-fold by 2050 in Pakistan [8]. In addition, fragmented institutional and governance structure of the authoritative bodies, have separate terms and conditions to deal with energy issues in the country. There is an absence of a cohesive body to coordinate between the six relevant Ministries and 42 agencies working in the development of energy sector. Moreover, the regulatory authorities lack resource capacity to govern the entities, creating disharmony in energy prices [9]. This along with inconsistency on maintaining untargeted subsides and lack of accountability on power theft has led to face many challenges in Pakistan's energy sector. The major challenges include:

- Overreliance on oil imports and unbalanced energy mix shows lack of integrated policy and cohesion among relevant sectors and Ministries. The previously followed policies for Renewable policy, Power Policy, Petroleum policy etc.[1], show lack of integration in numerous energy plans and inefficiencies in utilizing planning models being used around the world such as ENPEP, BALANCE, LEAP, MARKAL/TIMES [10], [11].
- Transmission and distribution losses - Pakistan ranks 14 out of 131 countries in power losses. This can be attributed to technical inefficiencies as well as non-payment of bills, theft and governance related issues. It is estimated that "T&D loss of one percent incurs deficit of one billion over national treasury", and PESCO and SEPCO have reported transmission and distribution losses of 34.8% and 27.5% respectively [12].
- The poor fuel efficiency of power plants has translated to a higher cost of generation than the notified cost by Government of Pakistan (GOP), leaving a gap which is then recovered through

[1] See the appendix for Energy, power and climate policies.

subsidization.

- The rise in electricity price by the Independent Power Producers (IPPs) can be attributed to agreements to raise the price of power to favor oil in Pakistan's energy mix. Due to absence of international bidding procedures, untargeted timings of plants commissioning, their location and inappropriate choice of FO for IPPs power plant. The location of IPPs being far from load centers and northern areas of Pakistan laid severe strain on country's physical infrastructure, including the electricity transmission system.
- Pakistan adopted the incremental block tariff (IBT) strategy i.e. providing subsidies on electricity tariff to increase the poor consumer's capacity, but this does create an imbalance between the price paid per unit and per unit cost of supply [13]. Consequently, the Government ends up paying subsidies for electric power consumer resulting in a circular debt. [12].
- In 2013, government subsidies for electricity reached 1.3 billion USD. However, this did not recover the costs of generation, transmission and distribution. This creates a budget gap that curtails public investment in primary infrastructure, essential for economic development of the country. Lack of economic coordination between provinces and the lucrative exploration and production (E&P) policy that does not even consider renewables only attracts a weak pitch from the investor side. The concerns mainly revolve around the role of the State in energy governance reforms, higher capital cost of alternative resources like hydro, regulations on controlling export, prices and supply quotas, and lack of favorable environment for clean energy projects. This poor creditworthiness of electric utilities, with inefficient ways and policies to recover transmission and distribution losses, allocation of subsidies, lack or incompetency of technical staff, and inefficiency in collecting taxes have lingered on the energy crisis in Pakistan.

1.2 Pakistan in the Paris Agreement

Although Pakistan's Greenhouse Gas (GHG) emissions are one of the lowest in the world it ranks among the top 10 countries most affected by climate change according to the long-term Climate Risk Index (CRI). The country suffers from extreme climatic events such as recurrent floods, desertification, glacial melt, and droughts that have resulted in irreversible damages to human societies and the economy. As per the updated GHG Inventory, the total emission of GHGs in Pakistan in the year 2012 were estimated at 369 $GtCO_2eq$, which equals to about 0.8% of the global GHG emissions. On a per capita basis, Pakistan with 2.06 Gt per capita GHG emissions stands at 135th place in the world ranking of the countries. The major contributing sectors of GHG are the energy industries, emissions from biomass, land use changes and forestry, industrial processes, transport, burning of crops, and poor waste disposal systems. Given the future economic growth and associated growth in the energy sector, the peak of emissions in Pakistan is expected to take place much beyond the year 2030. Table-1 provides the emissions by sectors in Pakistan's INDC.

Table 1 Sector Wise Projection of Emissions (MT CO2-equivalent) [14]

Sectors	1994	2015	2030
Energy	85.8	185.97	898
Industrial Processes	13.29	21.58	130

Agriculture	71.63	174.56	457
Land use and forestry	6.52	10.39	29
Waste	4.45	12.29	89
Total	181.7	405.07	1603

Source: Pakistan's Intended Nationally Determined Contribution (Pak-INDC)

Hence, the country is in the midst of a serious energy crisis accompanied with unprecedented impacts of climate change (CC), jeopardizing the whole economy of Pakistan. In the Internationally Determined Contributions (INDC), it is assumed that the GHG emissions of Pakistan in 2030 will be 1603 MT CO_2-equivalent, from 405 MtCO_2-equivalent in 2015. Among this 405 Mt CO_2-equivalent, energy sector constitutes approximately 186 Mt. Industrial, Transport, Residential, Commercial, Power plants, and Agriculture sector provides 41.2%, 20.2%, 13.4%, 2.6%, 15.2%, and 7% of share respectively. Pakistan being a signatory to the Paris Agreement has identified an ambitious and realistic mitigation target which provides an opportunity to showcase Pakistan's mitigation actions and adaptation priorities for climate change. The country's Nationally Determined Contributions (NDC) has set targets for mitigation in "Energy supply side: 37% GHG emissions reduction from BAU in 2030, equal to 35 Mt CO_2 GHG reduction in 2030; Demand side: 22% GHG emission reduction from BAU in 2030, equal to 50 Mt CO_2 GHG reduction in 2030". To meet the projected demand, the country needs substantial energy efficient technologies along with an increase in the share of renewable energy in utilities. The country is poised to shift towards an increased reliance upon its indigenous coal reserves to fuel its development in the 2010-2050-time frame[2] which would significantly increase the projected GHG emissions. There are technologies that can capture CO2 emissions at the source of generation and have been assessed in the model by decreasing energy emissions per unit of consumption. Still, a rapid increase in coal use will increase in resultant GHG emissions. Pakistan will need huge financing to adapt and mitigate the impacts of climate change. International financing institutions and agencies such as the Green Climate fund (GCF) and Global Environment Facility (GEF) can help address this gap by channeling funds through impactful and bankable projects. A study estimates that mitigation to climate change require USD 8 Billion with a potential of reducing emissions by 18% and 40% with a possible shift to cleaner energy technologies. The adaptation cost was estimated to be between US $ 6 billion to US $ 14 billion per year in 2010-2050 timeframe to avoid bearing significant residual damage costs caused by climate change (ibid).

In pursuit of this, Pakistan has pledged to make considerable efforts to fight climate change, recognized in the efforts made at the local level and the National Development Plans including Long-Range Plans, Annual Budgets, Public Sector Development Programme (PSDP) and Economic Survey of Pakistan. The Framework for implementation of the National Climate Change Policy for the period 2014-2030 serves to integrate climate-friendly policies into our national and economic planning. The "Vision 2025" of Pakistan also recognizes climate change as one of priority actions in keeping the imperatives of UN Sustainable development Goals (SDGs). Climate Finance Unit (CFU) has been established to secure a larger-scale and a more sustained implementation of Pakistan's climate change policy and its implementation framework, NDCs, and GEF/GCF programs. The Prime Minister of Pakistan has launched the "Clean Green Pakistan

Movement" to support and facilitate initiatives, measures, and reforms in all the sectors with a vision to promote environment friendly developments in the country.

1.3 Pakistan's International Agreements:

Energy supplies of Pakistan in the model are highly based on its international agreements like CPEC, CASA-1000, and other gas pipeline projects. These projects are discussed below:

- **China Pakistan Economic Corridor (CPEC):** In context of energy projects, CPEC aims to strengthen the cooperation in thermal fuels, power grids, hydropower, coal gasification, and renewable power generation. Establishing oil refineries along the route of CPEC is also under consideration. Hydropower will be promoted through river planning and other preparatory work. High voltage class grids will also be constructed to fulfil the demand of electricity. It was expected that over 10,400 MW of energy generation capacity will be brought online by 2018. Apart from this, CPEC holds high future prospects for Pakistan's energy outlook.
- **Central Asia-South Asia power project:** CASA-1000 is a $1.16 billion project that is to be completed in 2020. It will allow an export of surplus hydro-electricity from Kyrgyzstan and Tajikistan to Afghanistan and Pakistan. The electricity export is valued at 1300 MW during summer from hydro-power. 300 MW is allotted to Afghanistan while 1000 MW is reserved for Pakistan. Apart from electricity supply, the project also includes construction of HVDC converter stations.
- **Pakistan-Iran Gas Pipeline Project:** Also known as peace pipeline, it is a $7 Billion project which is considered as an energy lifeline project for Pakistan. Both financially and geographically, it is considered as the most viable option for fulfilling energy needs of the country and is considered sustainable in terms of sufficient gas reserves. The maximum capacity of the pipeline is to be 55 billion cubic meters of natural gas per year however bilateral agreements have stipulated that it will only carry 8.7 billion cubic meters of gas per year.
- **Turkmenistan-Afghanistan-Pakistan Gas pipeline project:** Trans-Afghanistan pipeline project is our second most important project for the import of natural gas. This was developed with some involvement of the Asian Development Bank (ADB). This pipeline will work at a pressure of 10,000 kPa and is expected to be 1814 km long and 56 inch in diameter. From a total of 33 Billion cubic meters, 5 Billion will be supplied to Afghanistan whereas 14 Billion will be supplied to both Pakistan and India.
- **Pakistan-Qatar Long-term LNG contract:**

  In 2016, Pakistan and Qatar signed a multi-billion dollar deal for Liquified Natural Gas (LNG) import in Pakistan for coming 15 years. Qatar has now emerged as a front-runner for providing a long-term supply of LNG to meet Pakistan's domestic requirements. Qatar's agreement promises an export of 3.75 million tons of LNG each year to Pakistan. Pakistan is also looking for a long-term plan for a 2nd LNG terminal that will receive about 600 mmcfd of natural gas per day.
- **Pakistan's Commitment to the 2030 Agenda for Sustainable Development**

  Under the 2030 Agenda for Sustainable Development, Pakistan's commitment to the Sustainable Development Goals (SDGs) and in particular Goal 7 to ensure access to affordable, reliable, sustainable and modern energy for all is well aligned with Pakistan Vision 2025 and the Power Policy 2015.

2 Dynamics of Energy transition- Scenario based modeling.

2.1 Methodological framework

The methodological framework and all modelling results have been derived from an extended study on 'Power Sector Transition Towards Pakistan's Commitment in Paris Agreement' by Jiang & Chenfei, 2019.
The study uses Long-range Energy Alternatives Planning (LEAP) System model (IPAC-LEAP) to quantify the energy and emission scenarios for Pakistan. LEAP [15] is not a model of a particular energy system, but rather a tool that can be used to create models of different energy systems while supporting a wide range of different modeling methodologies. On the demand side, these range from bottom-up end-use accounting techniques to top-down macroeconomic modeling [16]. The major part of LEAP used in the model consists of five major parts: energy supply and demand, energy conversion, biomass resources, environmental impact assessment, and cost analysis [mainly in context of GDP]. Some key variables that the model considers are GDP (and growth), value added by sectors, population (and growth), urbanization rate, number and size of households, output of key energy intensive products, transport demand, traffic volume, vehicle fleet, building floor space in service sector, new technology development, cost, and efficiency. The output from LEAP model includes:

- Energy demand: primary energy, final energy, final energy by sectors
- Energy supply: power generation by technologies, heat supply, coke making
- CO_2 emission, air pollutant emissions

Figure-2 shows the model structure adopted in LEAP for modeling. The model consists of 5 major demand sectors and major energy supplies. The model works on the basis of demand-supply equilibrium where the supplies will be used based on their demand in different sectors. Since, environmental emissions are an index of energy generation so environmental emissions are linked with every technology consuming energy. Although emissions from sectors other than energy are described in the report the model mainly discusses energy related emissions without taking into consideration the emissions generated from other sectors in detail.

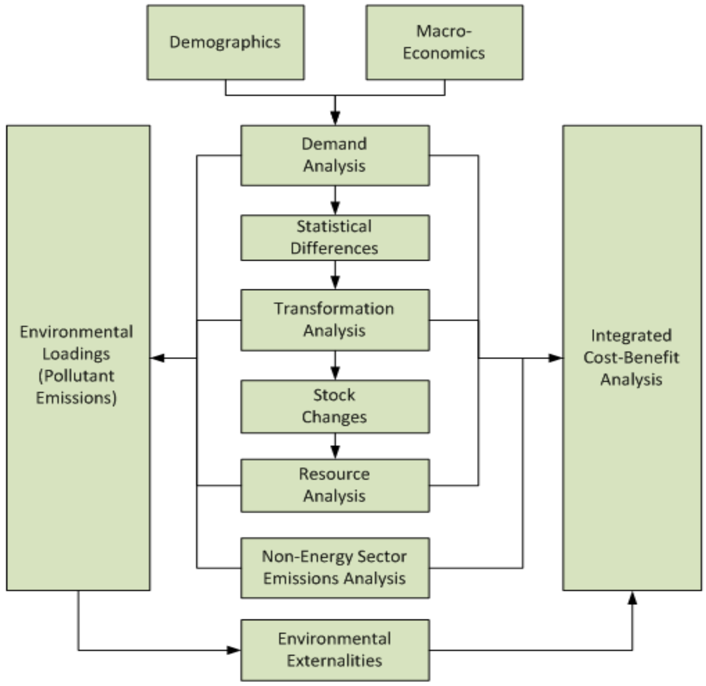

Figure 2 Methodological framework of LEAP [15]

2.2 Scenarios generation

To identify Pakistan's transition towards low carbon energy transition, three scenarios were developed in consultation with Ministry of Planning, Development and Reforms (MoPDR), and the simulations were conducted for both energy demand and supply side.

a) **Baseline Policy Scenario:** This scenario includes energy policies announced by taking account of national development circumstances and targets, energy security consideration, and local energy resource availability. This scenario serves as a conventional energy development future based on current planning. Current ideas for next five-year plan were also included in this scenario, as well as energy efficiency and renewable energy policies, as well as concerns about national energy security.
b) **NDC Scenario:** On top of the baseline/policy scenario, commitment from Pakistan for UNFCCC/Paris Agreement has been analyzed to realize the targets set up in this commitment.
c) **Energy Transition Scenario:** This scenario shows a pathway of energy transition towards low carbon and green future and achieve at the very least the 2℃ targets.

Considering the long life-span of energy infrastructure, 2050 was set as the target year and 2025 as the energy planning year. End-use sectors include industry (20 subsectors), service, urban household, rural household, transport, agriculture, along with more than 200 technologies. The supply sector included power generation, refinery, heat supply, coke making and etc. together with energy resource availability in Pakistan, along with 50 technologies in this sector. Table 2 provides the details of targets considered for scenarios analysis.

Table 2 Summary of the Targets and Scenarios

	Scenarios
GDP	Achieve the GDP growth rate in Vision 2025: 2020-2030 grow at 7%; then decrease 0.1% per year.
Population	The population continued to grow, but the growth rate declined; the population reached 245 million in 2030; and 300 million in 2050.
Per capita GDP	It reached $2400/cap in 2030 and $5800/cap in 2050 (real GDP in 2010$ base)
Urbanization rate	44.8% in 2030; 57.4% in 2050
Economic structure	Before 2035, the proportion of industry in GDP increased rapidly, with the declination of agriculture, reaching 27% by 2025; and then slowed down and the proportion of service industry increased. By 2040, the proportion of industry reaches 30%, the proportion of service industry reaches 63%, and the proportion of agriculture reaches 7%.

3 Energy Transition Projections

3.1 Socio-economic transitions

The results of the model identified major transitions in socio-economic indicators (tables 3, 4):

- The draft of the 12th five-year plan targeted GDP to grow by 6.2% in 2018-19 with 3.8% contribution from agriculture, 7.6% from industry and 6.5% from services. The industry sector is assumed to be the primary engine of economic growth in Pakistan, a sign of economic structural reform [17].
- With the historic population data from Pakistan Bureau of statistic and predicted future population growth by UNDP [18] as shown below, Pakistan's population will reach 320 million in 2050.
- As per the target in Vision 2025, the household income (as GNI per capita) will reach upper-middle income level, with a GNI/capita of at least $3896 (current USD) (2018 threshold) using the Atlas method. However, this means GNI/cap needs to grow approximately 11% annually to reach the goal—an unrealistic assumption following the current trend. Hence, In LEAP-Pakistan model, an annual growth rate of 5.5% for GNI/capita (also GDP/capita) was used towards 2030.

Table 3 GDP Scenarios

	Sector share in GDP (%, constant price)			**Real GDP (million $ 2010 base)**	**Real GDP growth rate (compared to former year)**	**Population Growth rate (compared to former year)**
Year	Agriculture	Industry	Service			
2015	19.84	20.9	59.26	215933		
2020	17	21.5	61.5	295060	7.00%	1.80%
2025	12	24	64	413837	7.00%	1.70%

2030	10	26.5	63.5	580428	7.00%	1.50%
2035	8	29	63	795237	6.50%	1.30%
2040	7	29	64	1064206	6.00%	1.20%
2050	5	26	69	1775148	5.00%	0.90%

Table 4 Population Scenarios

Year	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2050**
Population (million people)	189.87	209.30	227.71	245.30	261.67	277.75	306.81
Population Growth rate		1.80%	1.70%	1.50%	1.30%	1.20%	0.90%
Urbanization rate (%)	38.8	40.9	42.6	44.8	47.4	50.5	57.4
GNI/cap-urban (current $)	1803	2376	3207	4142	5210	6317	8863
GNI/capita-rural (current $)	1194	1494	1843	2380	2994	3738	5574

Figure-3 to figure-5 provides the scenarios of socio-economic indicators that would be the major determinants of energy transition pathways of Pakistan.

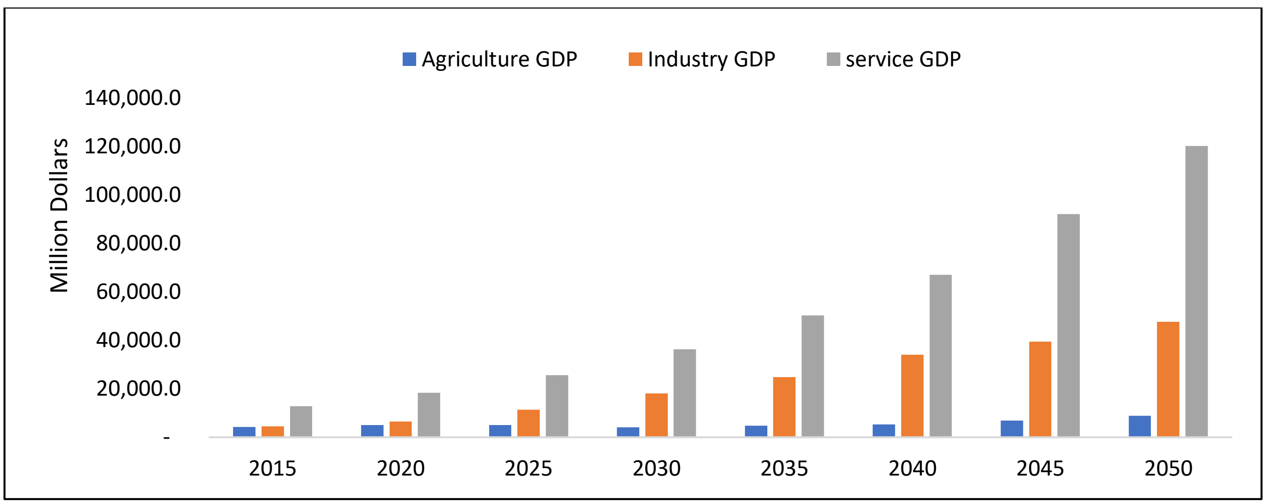

Figure 3 GDP by Sub-sectors

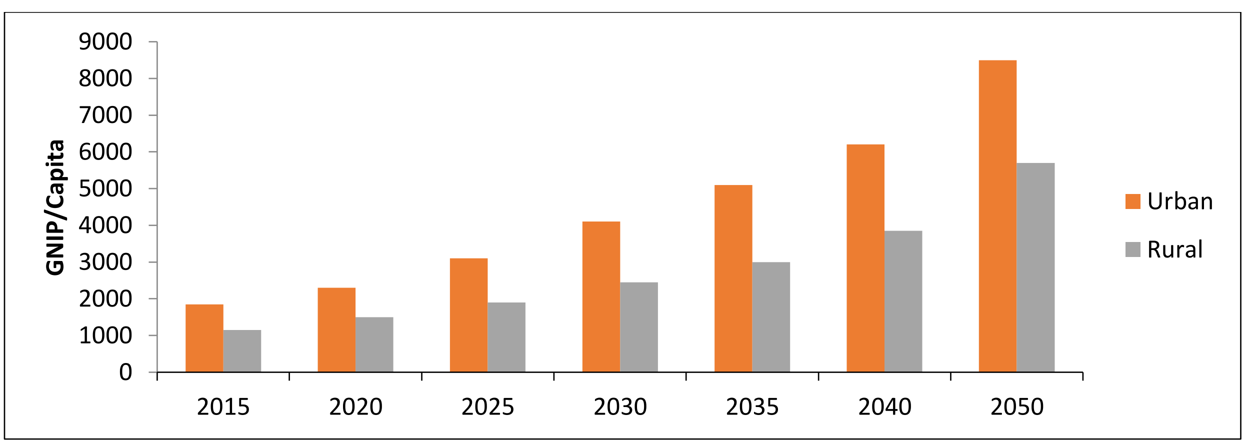

Figure 4 Gross National Income Per Capital of Urban and Rural areas in Pakistan

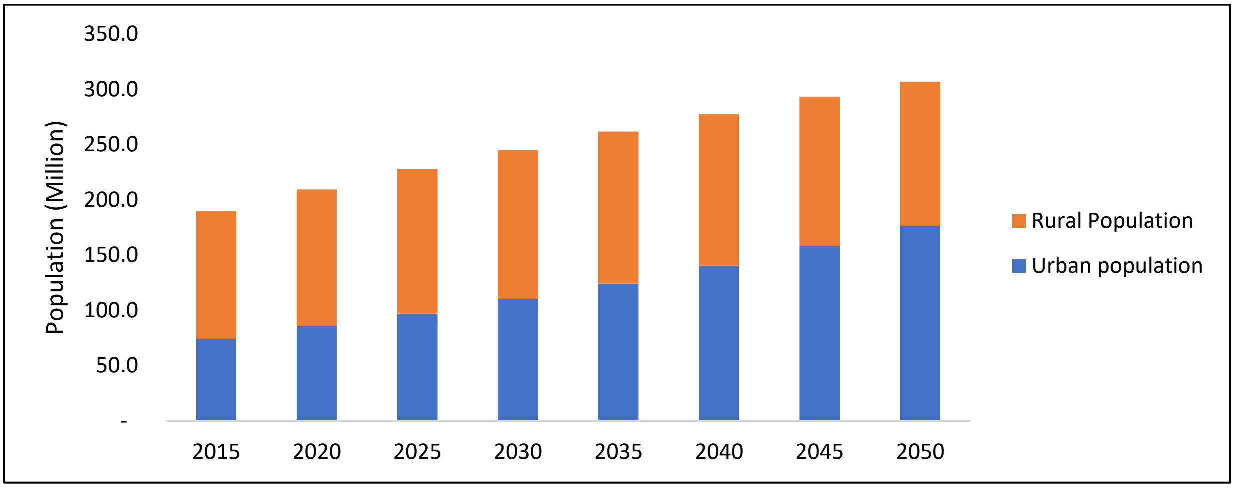

Figure 5 Share of Rural and Urban Population of Pakistan

3.2 Energy transition pathways

Based on the scenarios in socio-economic indicators used in the study, following projections were made:

3.2.1. Energy Flow Processes

Sankey diagram shown in figures 6 to 8 describe the flow of energy from supply side to major demand sectors. The width of each flow describes the quantity of energy that is flowing. This can be used to identify the major demand sectors and the resources they are consuming.

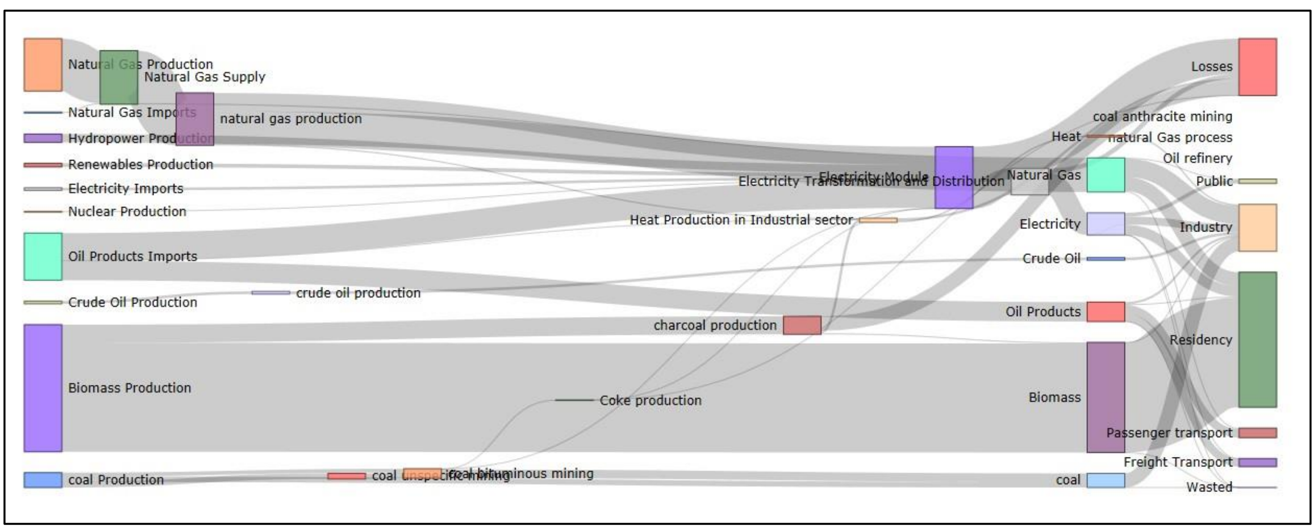

Figure 6 Sankey Diagram of Pakistan in Base Scenario for year 2015

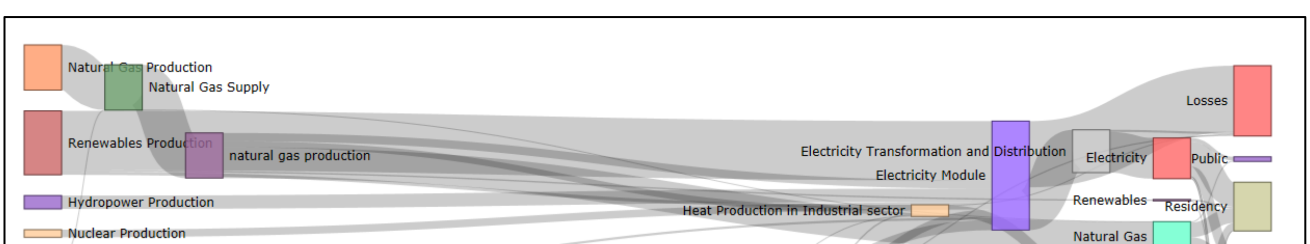

Figure 7 Sankey Diagram of Pakistan in NDC Scenario for year 2050

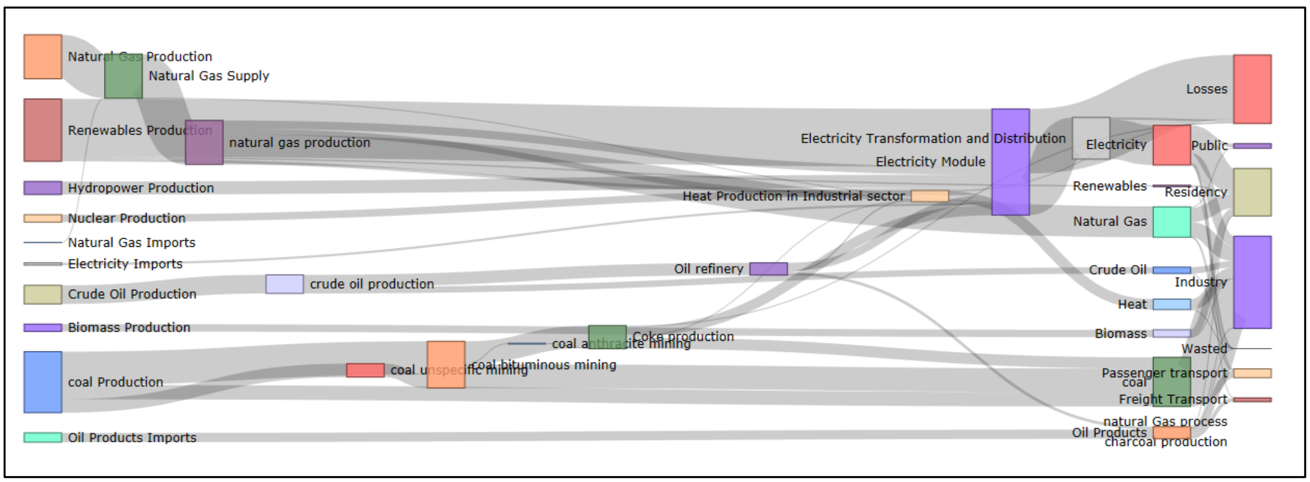

Figure 8 Sankey Diagram of Pakistan in NDC Scenario for year 2050

3.2.2. Energy Supply and Demand

- **Energy Demand:** With an increasing population and energy use per capita, the primary energy demand in all three scenarios will increase substantially. By 2025, energy demand in three scenarios will be 156 Mtoe in the baseline scenario, 146 Mtoe in NDC scenario, and 134 Mtoe in the energy transition scenario. This value in the energy transition scenario is 14% lower than the baseline scenario which indicates that measures adopted in this scenario will lead to a better energy outlook for Pakistan as compared to our baseline measures. In 2050, the demands will increase to 430 Mtoe, 332 Mtoe and 263 Mtoe respectively growing with an ACGR of 4.13%, 3.34%, and 2.73% [Figure-9 to Figure-12]. This represents the increase of demand in each scenario due to different values of demand drivers.
- By 2015, **final energy use** in energy transition scenario will be 241 Mtoe, which is 28.3% lower than that in baseline scenario, and 14.3% lower than that in NDC scenario. Hence, the energy profile of energy transition scenario is more suitable for Pakistan since it saves a significant portion

of energy as shown in the figure 9. Share of electricity in final energy demand increases from 14.4% in 2015 to 30.3%, 32.3%, 34.1% in 2050 for baseline scenario, NDC scenario and energy transition scenario respectively [Figure-13 to Figure-16]. The major reason behind this increase in share is an increase in the electrification rate.

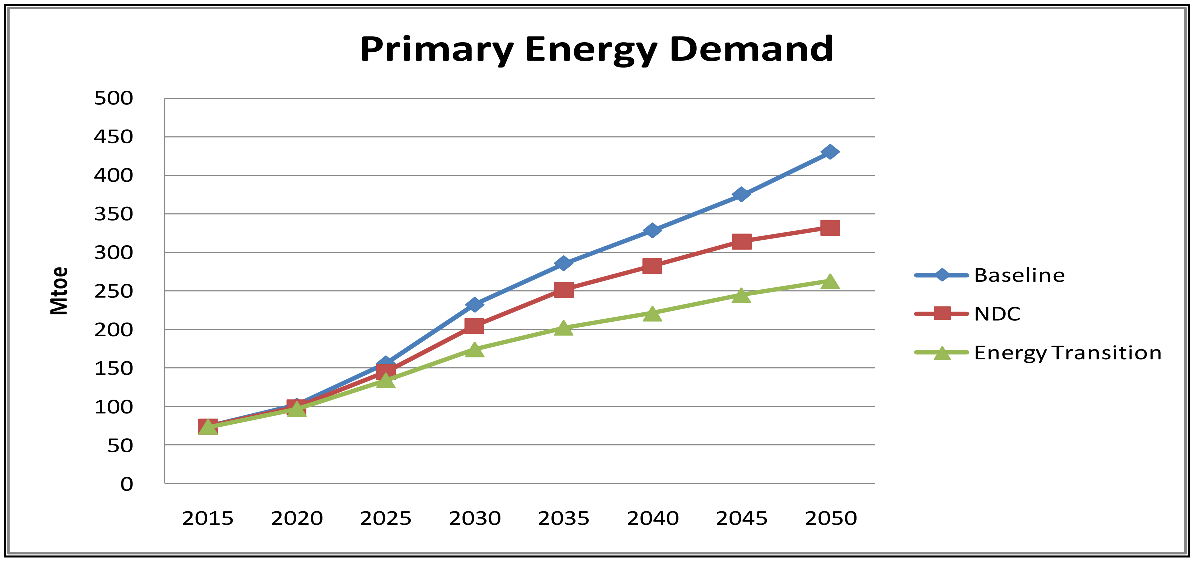

Figure 9 Primary energy demand in respective scenarios

- Primary energy demand in the baseline scenario is highest mostly because of high energy consuming devices which were then replaced in other scenarios by more efficient devices. Use of more efficient devices in demand sector reduces the energy consumption hence a lower demand. The major energy savings were observed in the residential/commercial sector where use of both active and passive housing techniques (through reduced losses, better ceilings, and etc. in short by improved 'U" values.) significantly controls the energy leaks. Similarly, the transport sector in energy transition scenarios started using electricity as a fuel for electric vehicles. The model results showed that the penetration of private electric cars saved approximately 20 PJ of annual energy.
- Further, the model results indicate that an increase in energy supply capacity of Pakistan will not solve problems because of the high costs associated with such high capacity and other issues such as the constantly rising circular debt. Maintaining the power sector's reliance on fossil fuel-based power may further increase the debt. A better method to counter this is by reducing T&D losses and controlling electricity theft. The energy transition scenario considers lower theft resulting in lower energy wastage thus providing a better energy outlook.

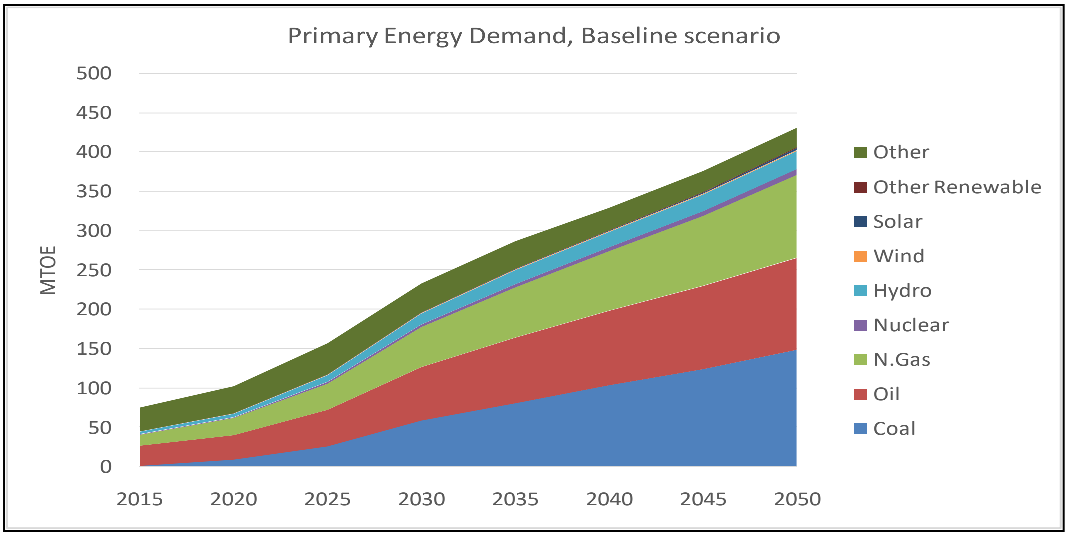

Figure 10 Share of Primary Energy Resources in Baseline Scneario.

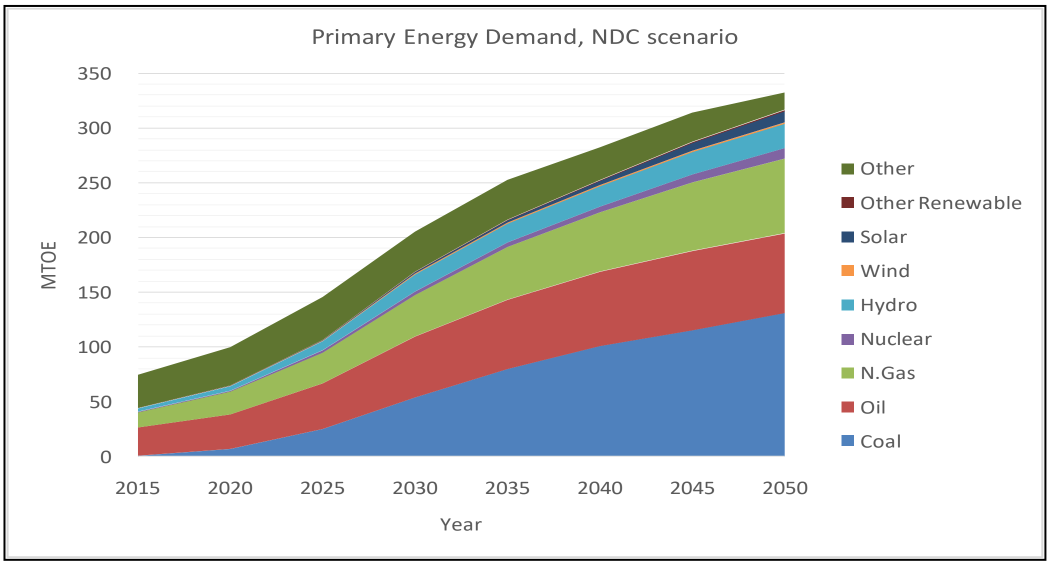

Figure 11 Share of Primary Energy Resources in NDC scenario

- From the figures, it can be seen that the energy transition scenario constitutes a larger share of renewable energy sources as compared to the other two scenarios. This helps in terms of energy supply security as Pakistan can rely on indigenous renewable resources as opposed to high cost imported fossil fuels. The major share of renewables is from commercial use of biomass and decentralized use of solar energy. The continual decrease in the cost of these technologies will makes a strong case for transitioning to a more renewable based energy system. However, this requires Pakistan to take concerted action in view of national commitments such as the Paris Agreement and the SDGs.
- Moreover, the constant increase of coal share can be attributed to the fact that 70% of the 14 GW installed capacity planned under CPEC will be coal-fired. Additionally, Pakistan is recently expected to start producing power from local coal reserves in Thar. Hence, coal is expected to be one of the

more prominent energy sources in Pakistan's energy mix outlook.

- Owing to the expected increase in coal, resulting emissions are expected to grow significantly, at least by 2030. This would have severe implications considering global challenges such as climate change. However, for a country like Pakistan that contributes to less than 1% of global emissions, concerns about long-term environmental sustainability is often overshadowed by more immediate concerns such as energy access and affordability. This may not be cognizant to the potential stranded assets risk that current coal investments present, especially as cost of renewable technologies continues to decline.

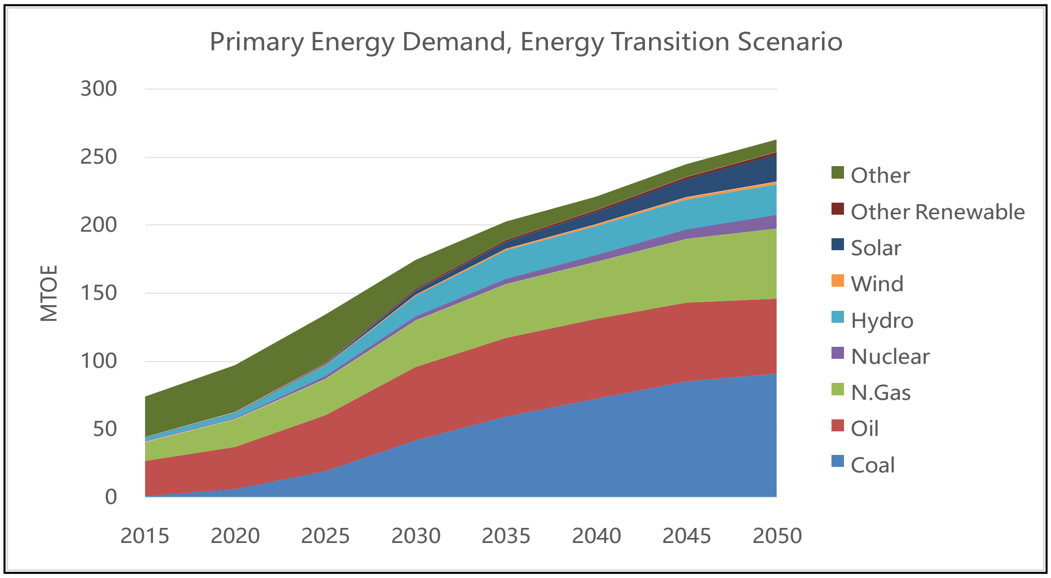

Figure 12 Share of Primary Energy resources in Energy Transition Scenario

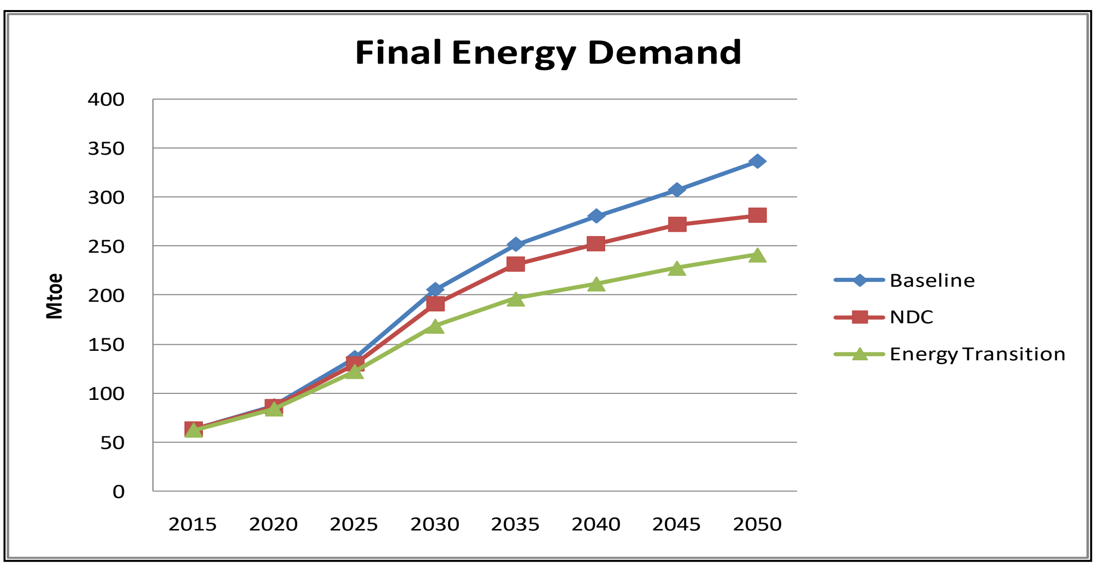

Figure 13 Final Energy Demand of Pakistan in Different Scenarios

- Final Energy demand in different scenario is shown in the figure above while the final energy demand from different sources in each scenario will also be discussed in the figures below.

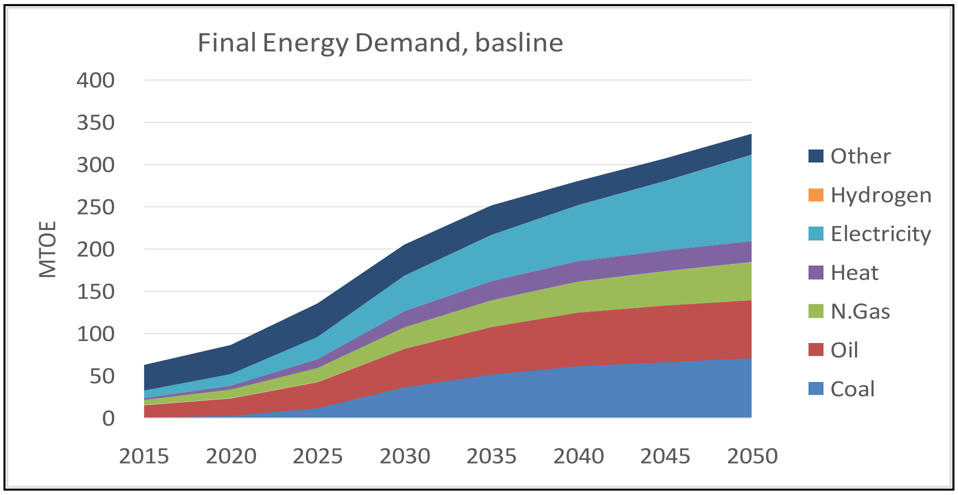

Figure 14 Share of Differernt Fuels in Final Energy Demand of Pakistan in Base Scenario

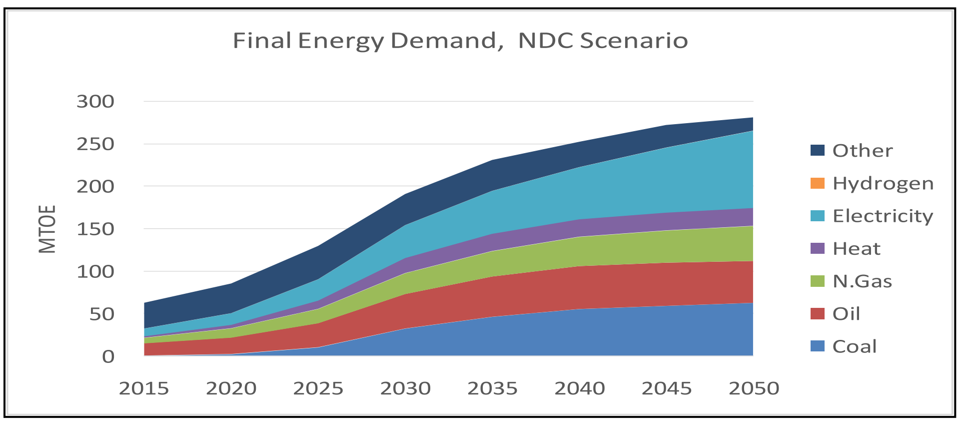

Figure 15 Share of Differernt Fuels in Final Energy Demand of Pakistan in NDC Scenario

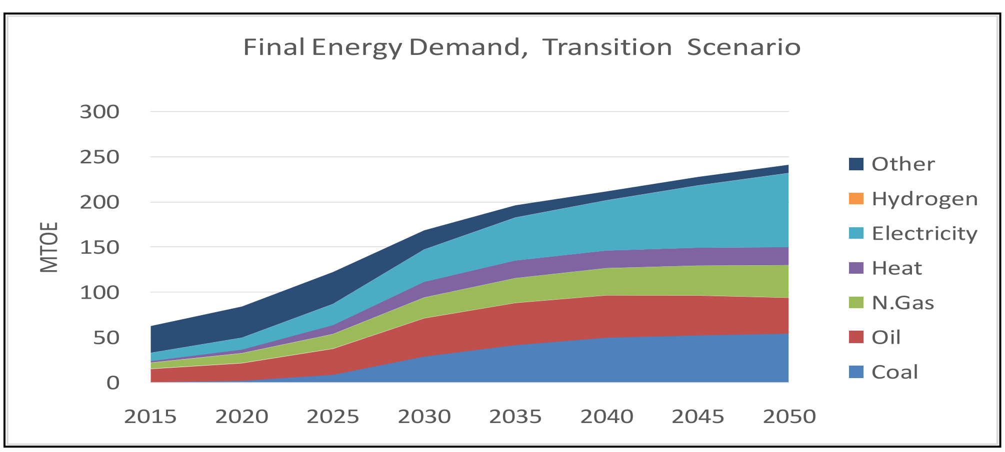

Figure 16 Share of Differernt Fuels in Final energy demand of Pakistan in Energy Transition Scenario

3.2.3. Power Generation

- **<u>Power Generation Scenarios</u>**: Power outputs sharply increased in three scenarios, from 127 TWh in 2015 to 1262.7 TWh, 1117 TWh, and 1007 TWh in three scenarios by 2050. This depicts an annual growth rate of 6.77%, 6.4% and 6.1% in all three scenarios (figure 17) and can be attributed to the target of increasing generation capacity through investments in power sector in CPEC as well as other energy sources. Investments in the energy sector by 2040 will be approximately $80 billion and based on the model power plants will consume at least 15% of this investment.
- In the energy transition scenario, non-fossil fuel power generation would increase rapidly with the installation of new solar and wind power plants (new RE policy), as well as hydel. Hydro power shows a rapid increase growing from 42.7 TWh in 2015 to 142 TWh in 2025 and then 669 TWh in 2050. This constitutes a share in total power generation of 33.4%, 47.8%, 66.4% for respective years.
- Figure-18 to figure-21 shows the power generation through different sources in respective scenarios. The Energy transition Scenario correlates to a lower power generation requirement due to introduction of more efficient technologies used on the demand side for example in residential/commercial sector (lightning, heating, cooling, etc.), and transport sector with the introduction of more electric vehicles (EV's).
- Energy industry will be a prime source of carbon emissions as it is expected to make up 50% of carbon emissions by 2030 - Table 1. As the analysis in figure 10 and 11 suggests, coal is going to have around 25-30% share in energy market by 2050.

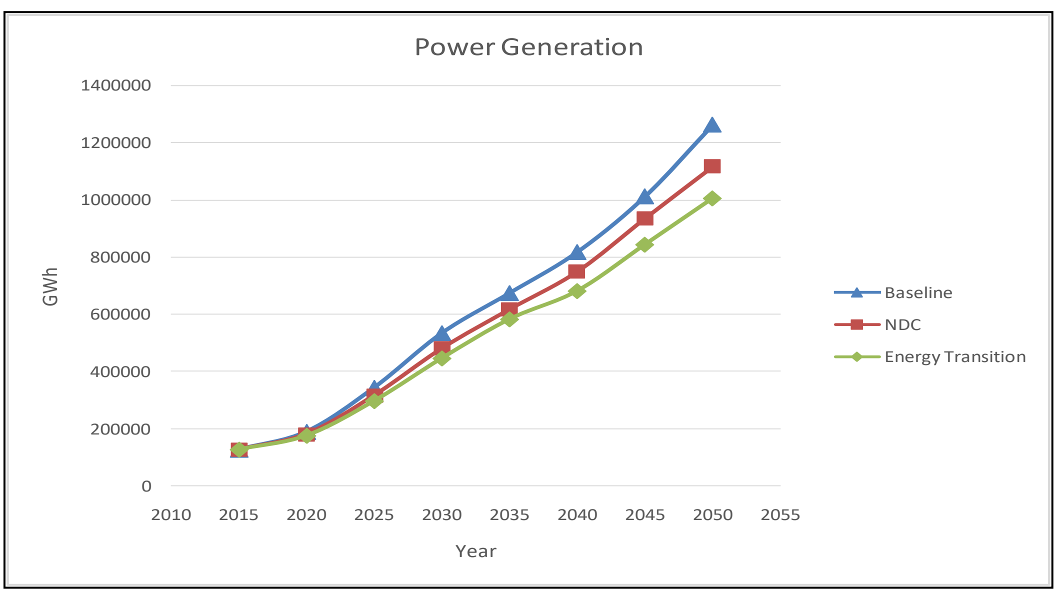

Figure 17 Change of Power Generation in Different Scenarios.

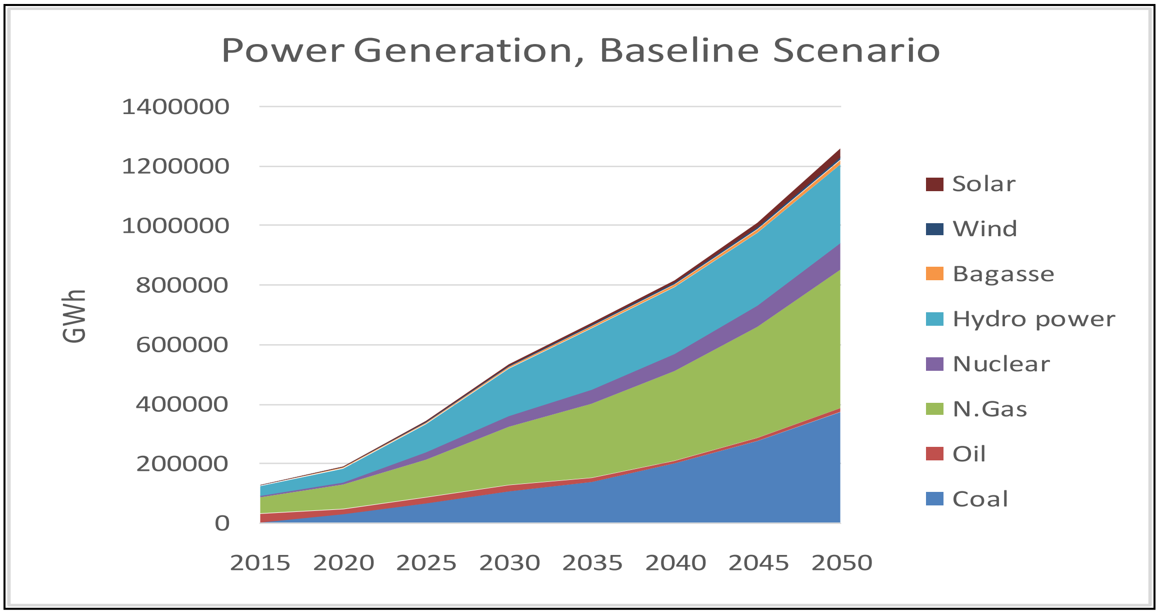

Figure 18 Power Generation from Different Reseources in Baseline scenario

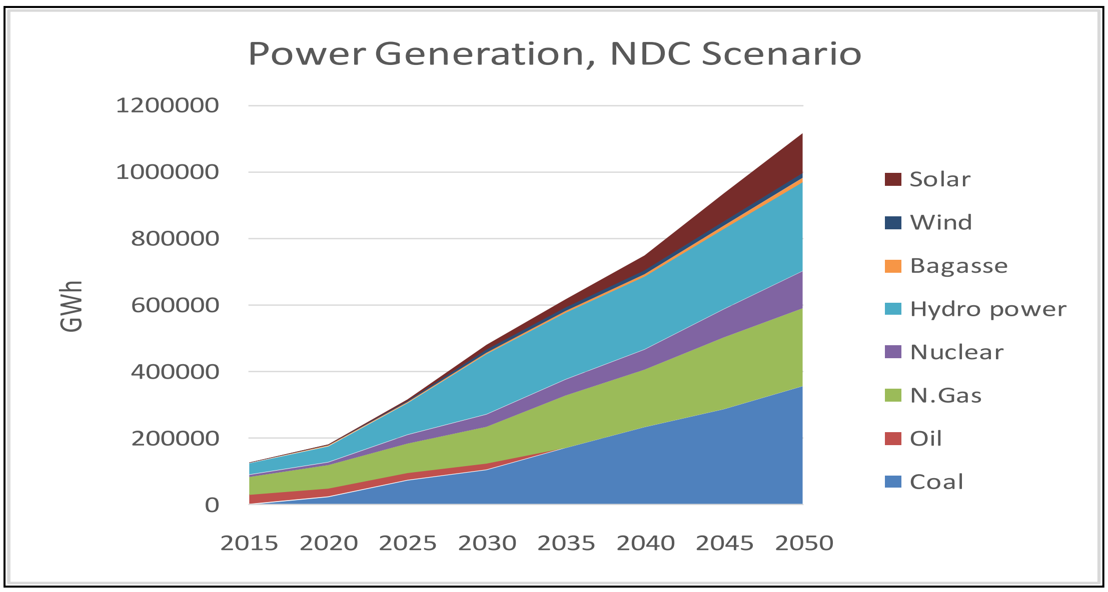

Figure 19 Power Generation from Different Sources in NDC Scenario

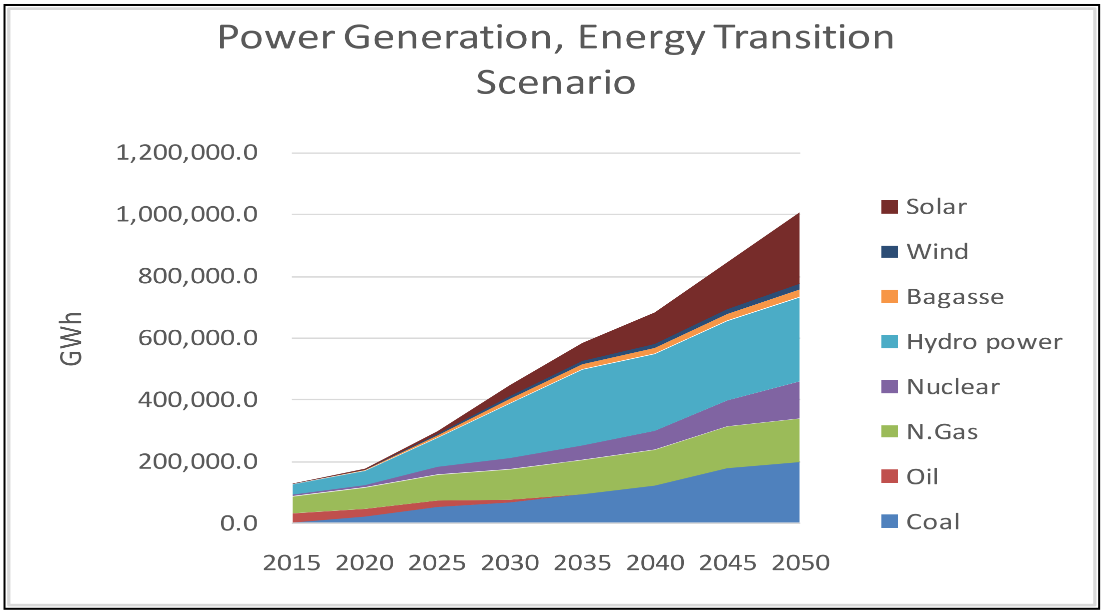

Figure 20 Share of Power Genertion Sources in Energy Transition Scenario

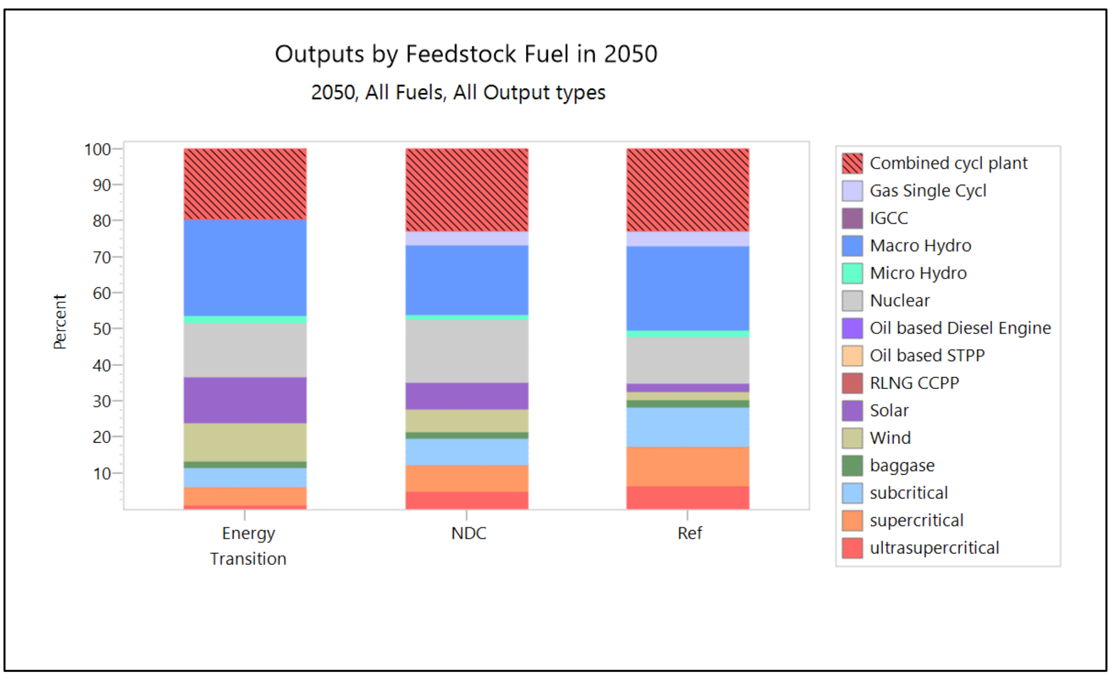

Figure 21 Power Generation Mix by Technologies

3.3. Energy Consumption in Demand Sectors

- **Energy Consumption in Demand Sectors:** Energy demand of various subsectors is shown in figure 22. Based on the values of NDC Scenario, the demand of industrial sectors will show the largest increase from 17.6 Mtoe in 2015 to 164.8 Mtoe in 2050. The increase in industrial sector consumption is driven by demand of larger goods or services and is controlled by using energy intensive technologies in industrial areas. This will further allow the country to optimally use their scarce resources. This is followed by residential sector which changes from 50.7 MTOE in 2015 to 79 MTOE in 2050. Similarly, transport, agriculture, and commercial sector also show an upward trend but still constitute a comparatively smaller share. The share in energy transition scenario is described in the figure below

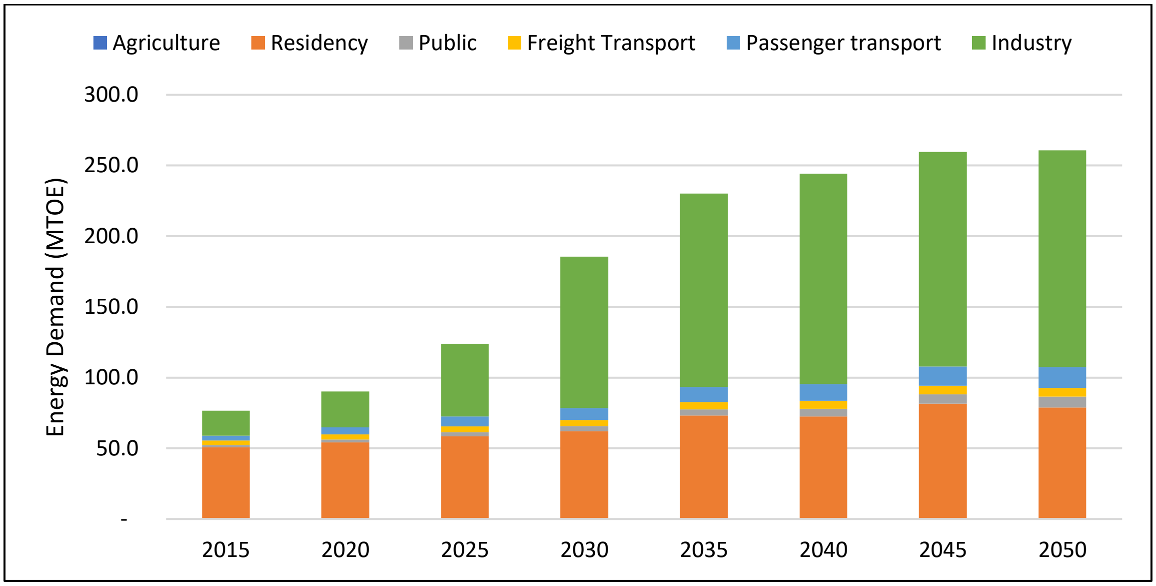

Figure 22 Energy Demand of Different Subsectors in Energy Transition Scenario.

The upcoming sections of the reports describe the energy consumption in sub-sectors. Each subsector will describe energy consumption under different scenarios.

3.3.1. Industrial Sector

Industrial sector is expected to constitute the major share in demand sectors across all scenarios. As figure 23 shows, construction material appears to hold the largest share in 2050 with a value of 50 MTOE. This is followed by automobiles industry which will constitute a share of 47.8 MTOE in 2050.

A ten-fold increase in industrial sector demand is observed at a sustained growth rate of 6-7%. Many studies note that the industrial sector is wasting 20-60% of prime energy in wastages especially in energy-intensive industries such as metal processing, ceramics/polymers, cement, paper and textiles. These wastages are expected to rise enormously given the rise in energy demand. This is primarily attributed to the use of older technologies, poor design/maintenances, waste heat leakages, and poor resource management. To be competitive, the losses and wastages have to be reduced which shall not only reduce the energy demand in addition to cost reductions but also lower the carbon footprint. One mechanism is to incentivize a 'carbon levy'. The units which reduce their prime energy demand (electricity, diesel, Natural Gas, RFO, LPG etc.) by 5-10% in recurring years, given the energy cost/unit is not hampered, should be given carbon-rebate. While those an incurring an increase should be liable to a carbon levy. This can ensure that industries look for conservative measures and become more responsible with respect to their energy and carbon footprint.

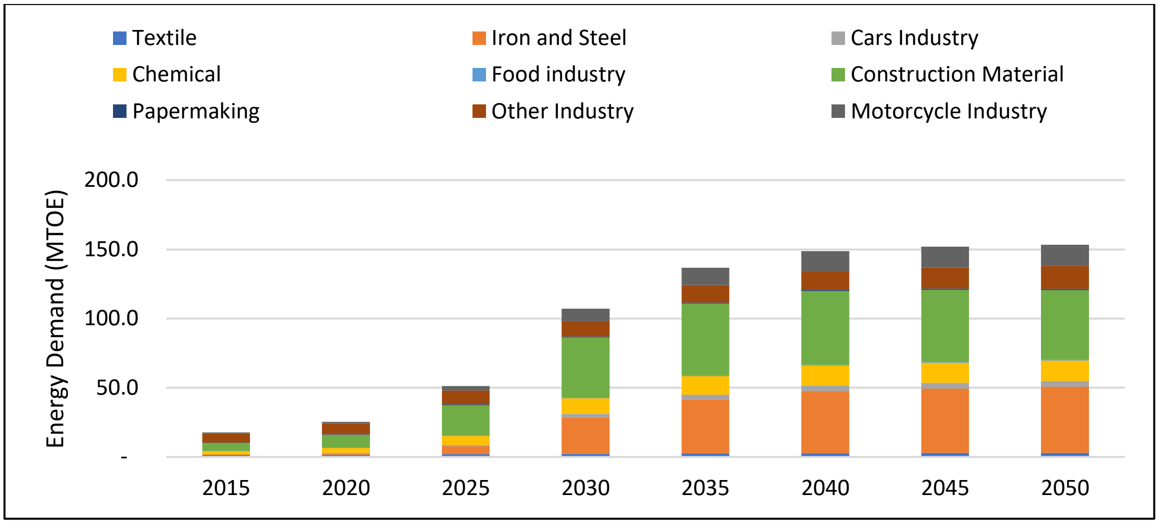

Figure 23 Share of Different Industrial Sub-sectors in Overall Share of Energy Transition Scenario.

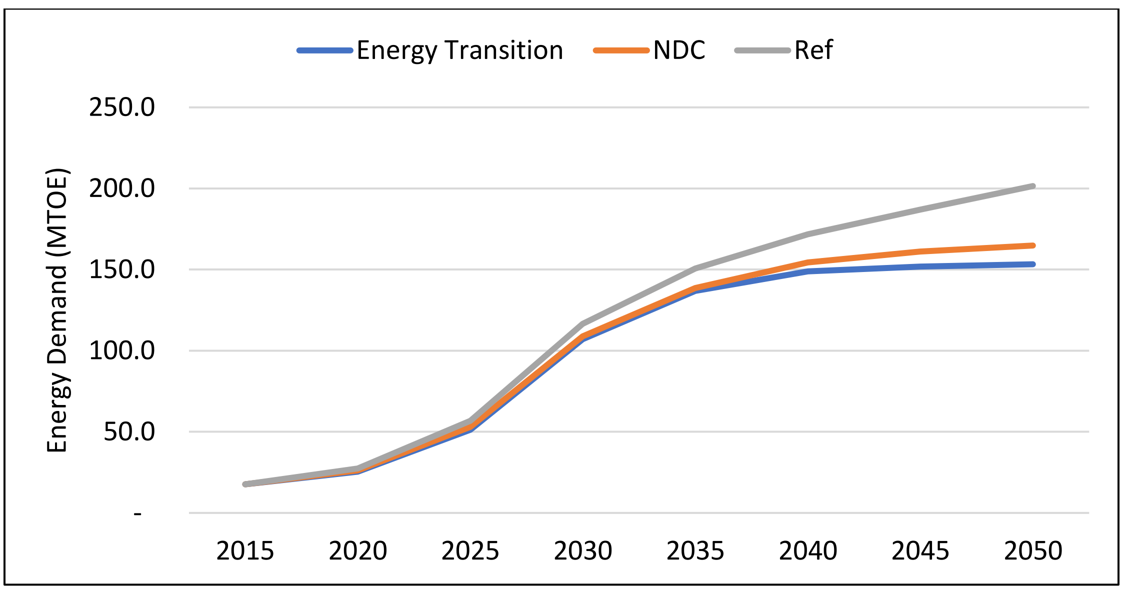

Figure 24 Change in Energy consumption of Industrial Sector in Different scenarios.

3.3.2. Residential Sector

Residential sector is the second largest consumer of energy after the industrial sector. The various energy consuming devices in residential sector are shown in table 5 below. It describes the various sub-sectors in the Energy transition scenario of both urban and rural residency.

Table 5 Energy Consumption in Residential sub-sector in Energy Transition Scenario of Urban Residency

Sub-Sectors	2015	2020	2025	2030	2035	2040	2045	2050
Lighting	0.5	0.6	0.6	0.7	0.9	1.2	1.6	2.1
space heating[3]	4.1	4.3	5.9	7.7	9.7	12.0	14.9	18.1
Air conditioning[4]	0.4	1.4	5.0	8.1	11.5	11.4	14.8	16.6
Cooking	2.6	1.8	1.7	1.7	1.9	2.1	2.4	2.6
Washing machine	0.0	0.1	0.1	0.1	0.1	0.2	0.2	0.2
refrigerator	0.5	0.5	0.4	0.3	0.4	0.4	0.4	0.4
Water heater	4.0	4.0	3.9	4.0	4.4	4.8	4.9	4.8
Electric Fan	0.3	0.4	0.4	0.4	0.4	0.5	0.5	0.6
Total	12.8	13.0	17.9	23.1	29.3	32.6	39.7	45.6

Table-5a Energy consumption in Air conditioning of Urban Residency under difference scenarios

Scenarios	2015	2020	2025	2030	2035	2040	2045	2050
Energy Transition	0.4	1.4	5.0	8.1	11.5	11.4	14.8	16.6
NDC	0.4	1.5	5.3	9.4	13.3	16.5	21.4	23.4
Baseline	0.4	1.5	5.6	9.9	13.9	17.7	22.9	30.9

Table-5a explains the major reason behind decreased energy consumption of cooling in urban residency. In the case of NDC and the baseline scenario, the final energy demand from space cooling is significantly higher than space heating (30.9 Mtoe for cooling against 18.6 for heating). The energy transition scenario which is based on improved efficiencies in cooling devices will lead to an even lower final energy demand by 2050 (although the demand for cooling itself is rising more rapidly).

Table 6 Energy Consumption in Residential sub-sector in Energy Transition Scenario of Rural Residency

Branches	2015	2020	2025	2030	2035	2040	2045	2050
Lighting	0.6	0.9	1.3	1.9	2.4	2.9	3.1	3.4
space heating	19.9	23.2	24.3	24.2	26.9	22.8	23.7	15.8
Air conditioning	-	0.1	0.3	1.0	2.6	4.8	5.7	6.6
Cooking	10.7	9.8	7.2	4.0	3.4	2.9	2.4	2.0
Washing machine	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1
refrigerator	0.3	0.4	0.5	0.6	0.8	0.9	1.0	1.1
Water heater	5.9	6.2	6.6	6.7	7.3	5.1	5.5	4.1
Electric Fan	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.3
Total	37.9	41.1	40.6	39.0	43.8	39.9	42.0	33.4

[3] The most primary reason being the scenario we are talking about, i.e. Energy Transition (in case of NDC and the baseline scenario, the final energy demand from space cooling is significantly higher than space heating (30.9 Mtoe for cooling against 18.6 for heating and same is the case for NDC scenario with slight change in values but the same trend. Now, the energy transition scenario is highly driven by improved efficiencies in cooling devices even to an extent that this value is smaller in 2050 (although the demand of cooling is rising more rapidly)

[4] ibid

From Table-6, we can interpret that space heating constitutes the major share in energy consumption of residential sector. However, the trend for residential sector should be carefully monitored as the final energy consumption starts declining after 2045 and reaches a smaller value due to use of energy efficient devices. This will further result in a lower energy demand from this sector. The change in energy consumption of industrial sector in different scenarios is shown in figure 25.

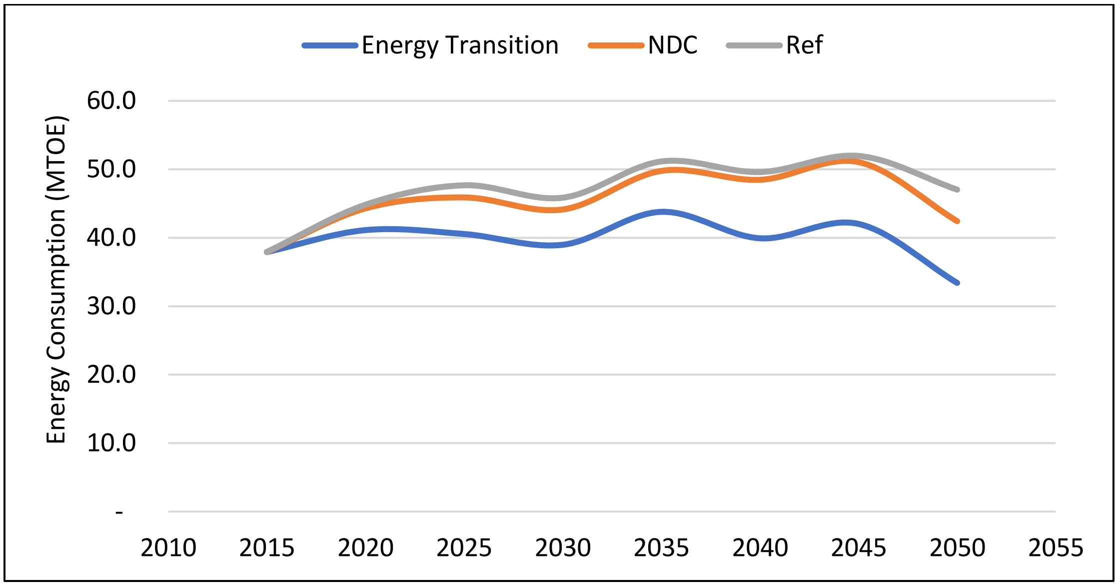

Figure 25 Energy consumption of Residential secor in Different Scenarios.

Figure 25 above shows that energy consumption trend of residential sector shows a declining curve after 2045 due to the use of energy efficient devices. Energy demand remains almost constant after 2035 since deployed energy technologies such as those used in lightening, cooling, heating, etc. are expected to reach a mature market structure.

3.3.3. Transport Sector

Transport sector is one of the largest consumers of fossil fuels. In LEAP Model, transport sector is initially divided into public and private transport which is further divided into railways, roads and aviation. Stock of each vehicle category is entered into the model for base year and then final demand for coming years is predicted under different scenarios. The results of energy transition scenario are described in the figure 26.

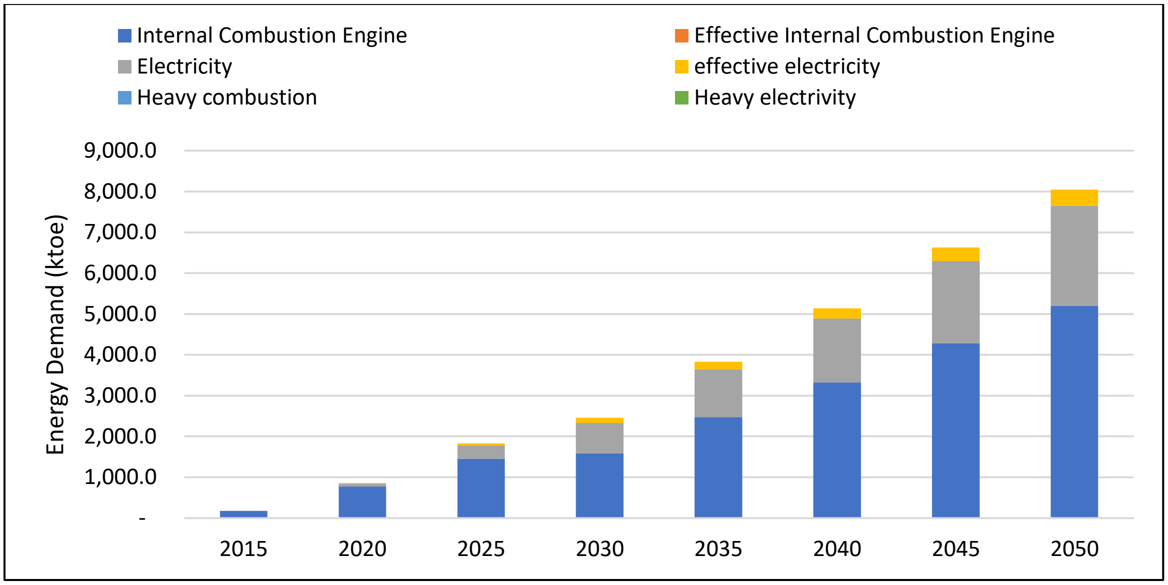

Figure 26 Energy Consumption in Railways in Energy Transition Scenario

Figure 26 shows that even by 2050, the demand of transport sector will be dominated by internal combustion engines. Other than road transport, the major reason behind this is that the railway sector which is highly unlikely to make a shift towards electrification. However, a key takeaway from the results is that in the energy transition scenario, more than 30% of energy will be consumed by electric vehicles. The results are also modeled for other two scenarios and the difference in energy consumption obtained is graphically represented in figure-33 and figure-34.

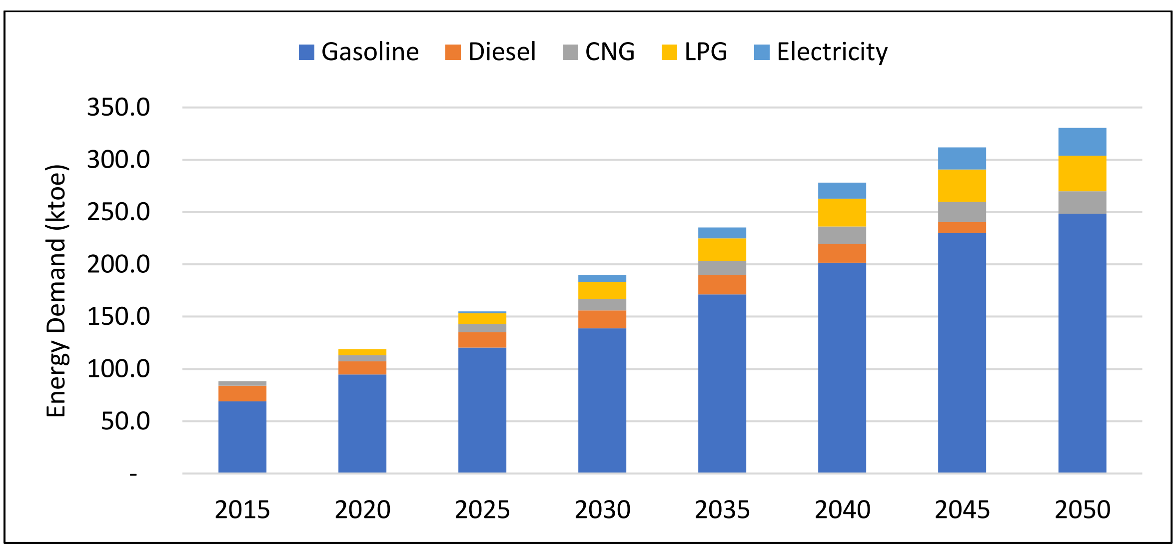

Figure 27 Energy Demand by Public Taxis in Energy Transition Scenario

Figure-27 shown above describes the outlook of public taxis in transport sector of Pakistan. Although, the values are comparatively smaller, electric vehicles will hold a share of 26000 Ktoe of energy consumption by public taxis by 2050. However, among discussed technologies, taxis are the only technology that will still rely on LPG and CNG vehicles. However, the use of diesel as a fuel for public taxis will be phased out by 2045 and that stock will be replaced by electric and gasoline taxis. Small public buses will consume 1100 Ktoe of energy by 2050 with a small portion of electric buses as shown in the figure-28 below. However, like taxis, CNG is expected to be the second largest fuel for small public buses. But, unlike taxis, diesel will be the largest energy consuming fuel. However, due to an increase in the efficiency of urban mass transit system, gross national income, lifestyle, and car ownership, the energy demand of both small and large buses will eventually start decreasing after 2045 thus providing a better energy outlook. Although the same trend has been observed for three-wheeler auto rickshaws, by 2050, electric rickshaws are expected to take up a significant portion of electricity production.

One potential area where electric buses can make the initial transition to electrification is in the Urban Metro System of Pakistan. That may be initially led with the advent of hybrids with plans to later change to completely electric buses. However, due to high associated cost, the transportation technology is expected to remain completely dependent on fossil fuels as their energy source.

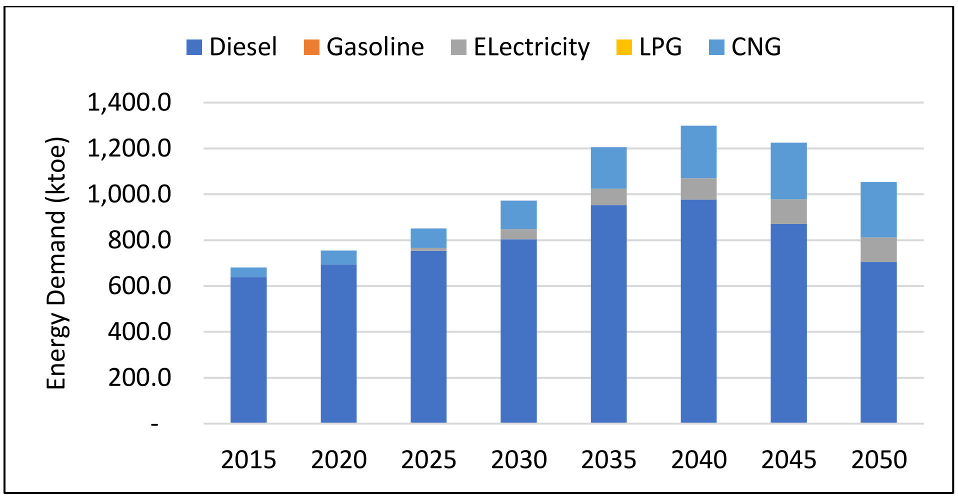

Figure 28 Energy consumption of Small Public Buses in Energy transition scenario

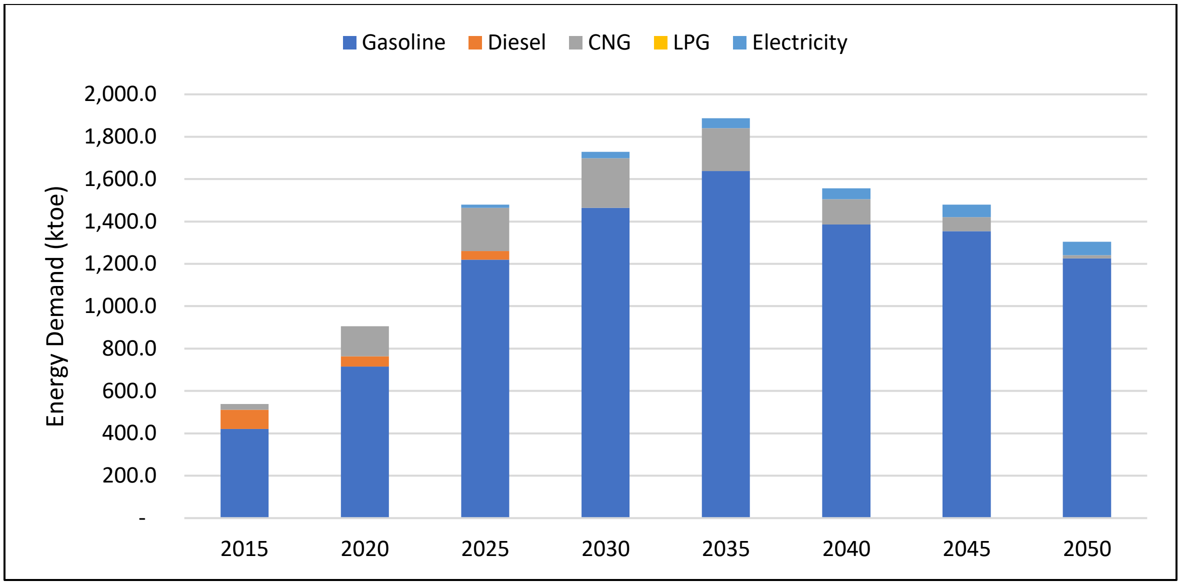

Figure 29 Energy consumption of Private Motorcars in Energy Transition scenario

Figure-29 represents a decrease in energy demand from motor cars after 2035 after constantly increasing till this point. However, it should be noted that this decrease is driven by better performance of cars and fuel efficiency and not the use of electric cars. Out of 1.3 Mtoe of energy consumption from this technology, 1.22 Mtoe is consumed by using gasoline. EVs do not constitute a significant share but this may change under the newly launched National Electric Vehicles Policy which sets a target of electric vehicles capturing 30% of all the passenger vehicle and heavy-duty truck sales by 2030. Although, the EV policy has defined some tax exemptions for these cars, experts have highlighted the need for measures such as relaxing the import tax of electric vehicles to incentivize consumers and effect behavioral preferences in favor of EVs. This can initiate EV growth in the short-term but should be followed up by development of local manufacturing of EVs. This would require further coordination and efforts from both the National Government and Provincial bodies. The charging infrastructure requirements should be studied in depth and appropriate policies and regulations should be designed to promote the relevant industries.

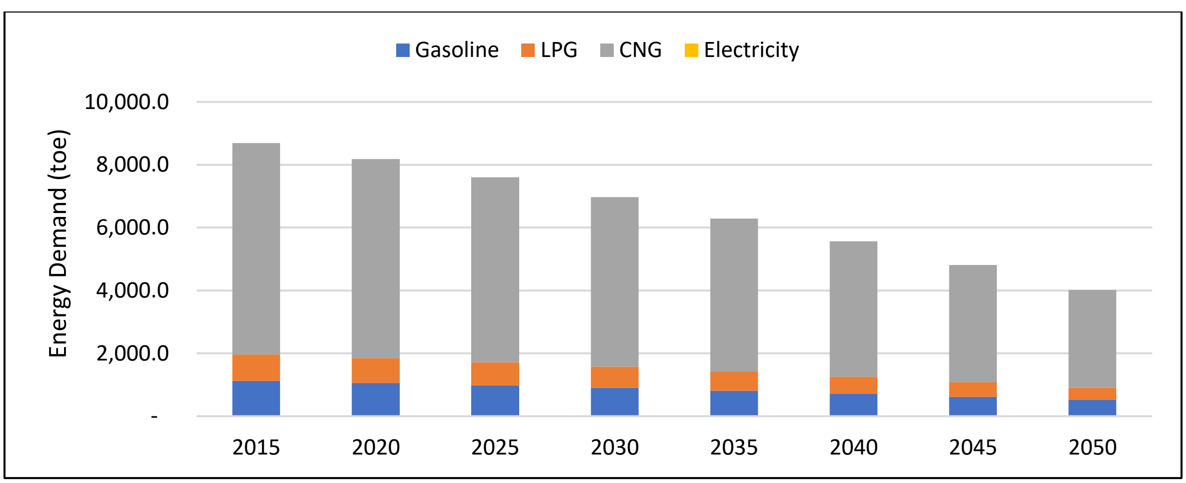

Figure 30 Energy Consumption of Auto Rickshaws in Energy Transition Scenario

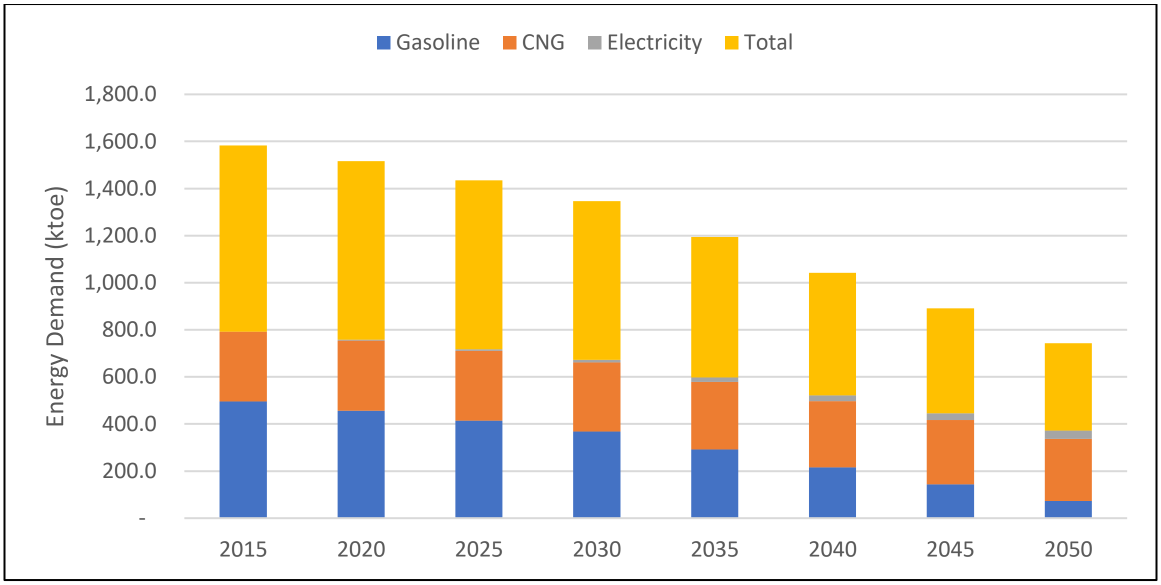

Figure 31 Energy Demand of Two-wheelers in Energy Transition Scenario

Similarly, the aviation energy demand increases from 570 Ktoe in 2015 to 2232 Ktoe in 2050. The overall consumption of freight transport is shown in figure-32 below.

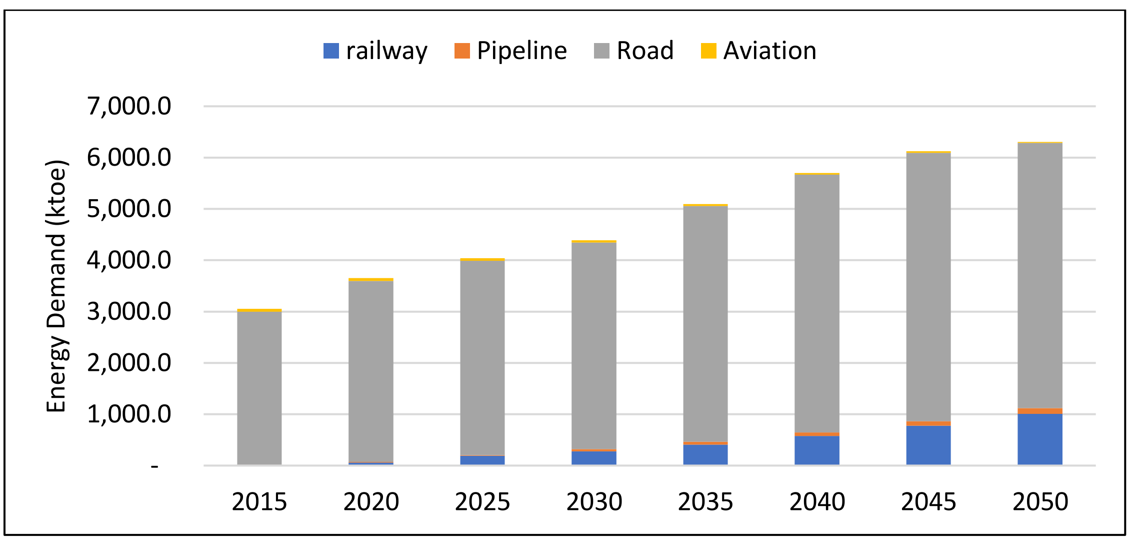

Figure 32 Energy Demand of Freight Transport in Energy Transition Scenario

The demand of freight transport increases from approximately 3000 ktoe in 2015 to 6300 ktoe in 2050. The result indicates that freight transport is mainly responsible for an overall increase in total energy demand from the transport sector. The overall consumption of transport sector is shown in the next figure. The consumption includes all rail, road, aviation transport and their consumption in different scenarios of the mode. However, freight and passenger transports are treated as two different categories.

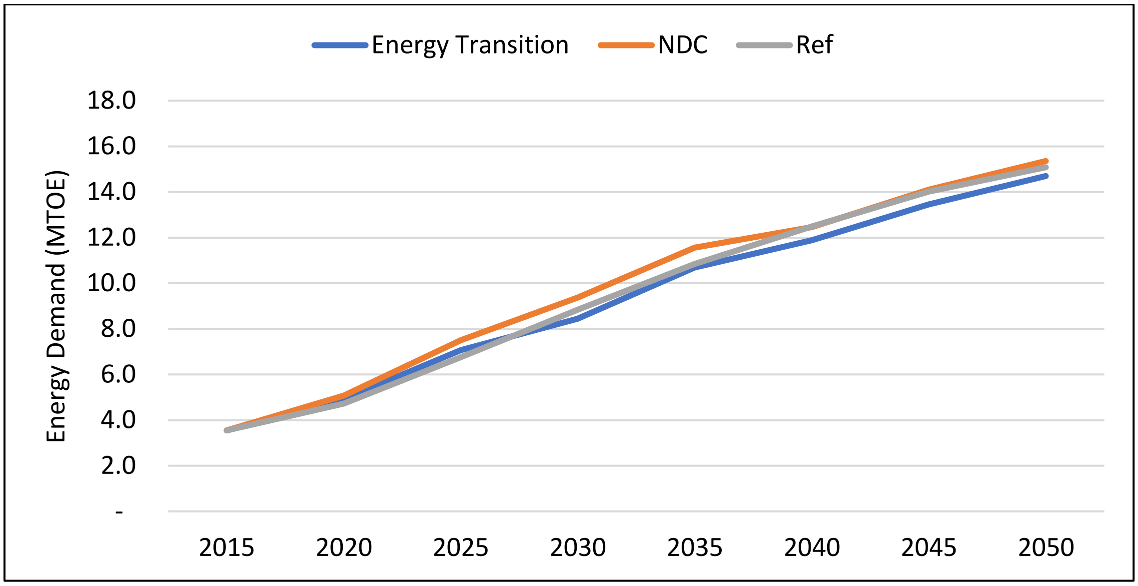

Figure 33 Energy Demand of Passenger Transport in Different Scenarios

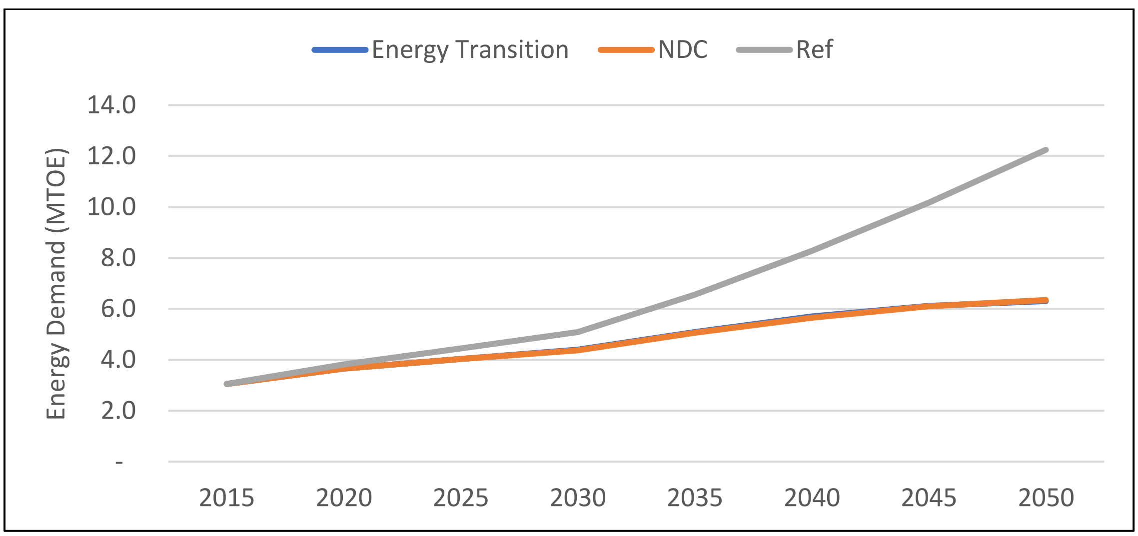

Figure 34 Energy Demand of Freight transport in Different scenarios

The model results of transport sector indicate that this sector is going through one of the most critical transitions. Hence, measures for increasing efficiency and thus reducing energy demand must be deepened for compliance with Paris agreement and Goal 7. Policies depicted in each of the three scenarios does not account for any leniency that can be shown in these agreements and hence strict measures should be taken for reaching these targets. This turn in transportation market also stables the emissions associated with this sector. Efficiency measures taken in the model includes managing of travel demand, dependence on higher energy intensive modes, deployment of energy efficient technologies for transportation, and their driving fuels. To ensure this transition, regulatory measures such as defining efficiency standards for vehicles low carbon fuel can be used.

3.3.4. Commercial Sector

Energy consumption of commercial/public sector is dominated by the consumption in office buildings which consumes 3263 ktoe of energy in 2050. The demand in different scenarios is described in the figure-35 below.

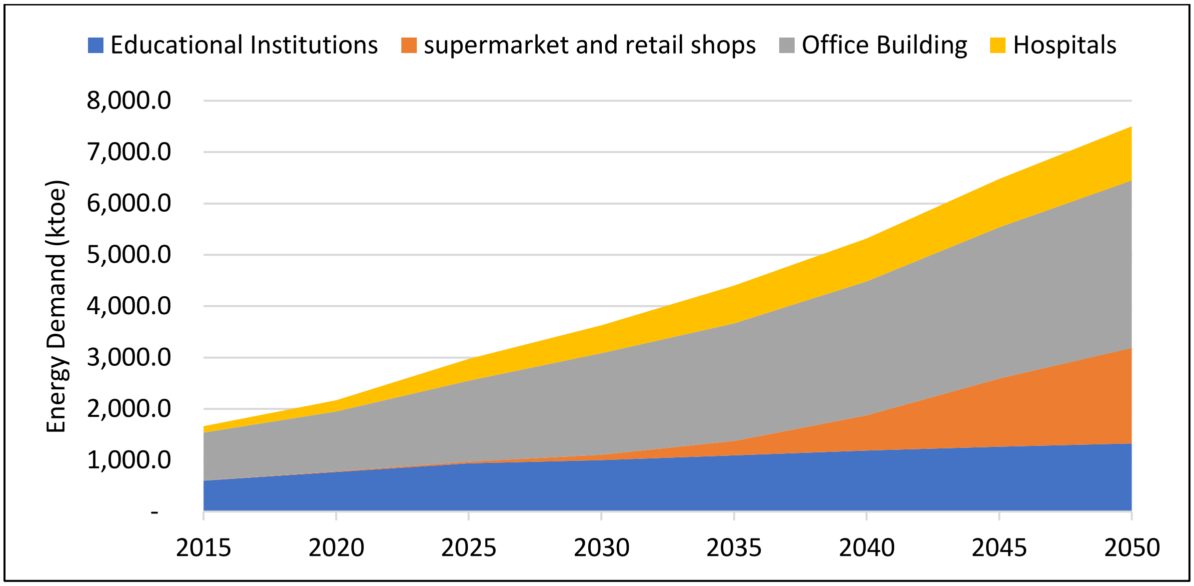

Figure 35 Energy Consumption of Commercial Sector in Energy transition Scenario

Model results shows a constant increase in overall energy demand of commercial sector. The value is expected to increase from almost 1500 ktoe in 2015 to approximately 8000 ktoe in 2050. This sector has observed a similar growth as residential sector and reform priorities for residential sector can be adopted here as well.

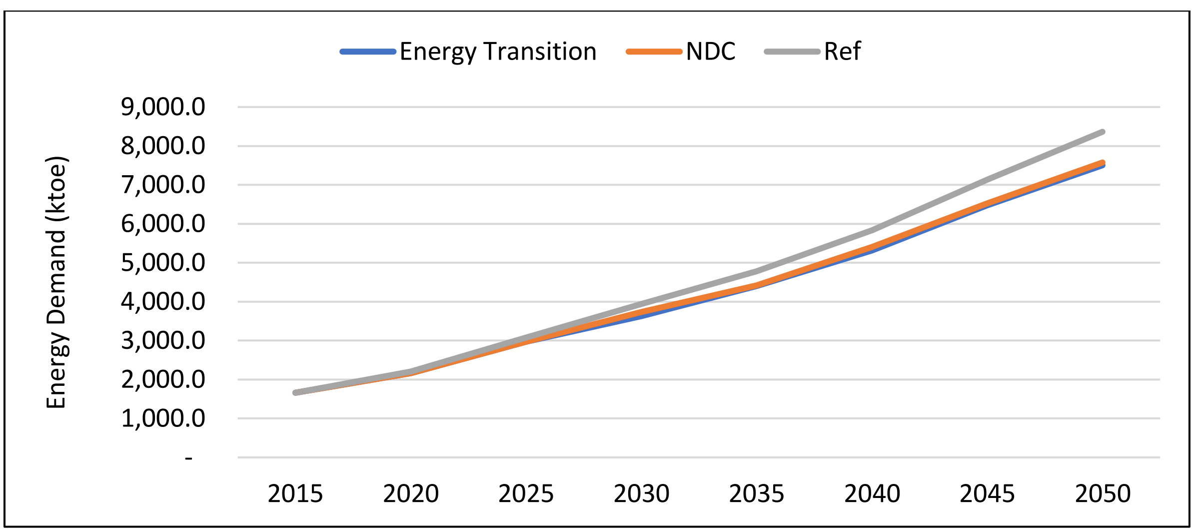

Figure 36 Energy Demand of Commercial Sector in Different Scenarios

3.4. Transformation in Pakistan Energy Sector:

This sector defines the transformation of various energy sources in the model. This includes subsectors as defined below in table-7. The table -7 is made for scenario of energy transition. The major portion is occupied by mining of bituminous coal, which is then followed by production of natural gas and then transformation and distribution of electricity.

Table 7 Transformation of Different Sources in Energy Transition Scenario

Branches	2015	2020	2025	2030	2035	2040	2045	2050
All Others	1.4	0.6	1.0	2.5	2.8	2.5	2.0	1.4
Electricity Transformation and Distribution	8.3	11.3	19.7	31.0	42.0	49.4	58.0	65.8
Electricity	10.0	12.9	21.4	33.2	44.2	52.0	61.0	69.3
Heat Production in Industrial	0.6	1.2	4.0	10.6	14.9	17.1	17.5	17.6
Oil refinery	-	20.3	20.3	20.3	20.3	20.3	20.3	20.3
Coke production	0.2	0.7	3.9	19.5	29.0	33.6	35.2	36.4
coal bituminous mining	3.5	7.6	23.3	52.7	70.2	74.5	76.5	77.7
coal unspecific mining	2.1	3.4	8.5	17.7	21.3	21.9	22.2	22.3
crude oil production	1.0	22.1	24.4	28.3	30.1	30.8	30.9	30.9
natural gas production	19.7	26.2	36.3	53.0	66.0	69.5	77.4	73.0
Total	46.7	106	162	268	340	371	401	414

The values in other two scenarios differ slightly as also explained in the previous section.

3.5. Carbon emissions pathways

CO_2 emissions in three scenarios are projected to be 1568 Mt-CO_2eq (baseline), 1233 Mt-CO_2eq (NDC), and 961 Mt-CO_2eq (Energy transition) in 2050 (figure 8). CO_2 emission per capita was found to be 5.11, in baseline scenario which is closer to the current per capita emission of CO_2 of the biggest contributor (China). However, in transition to use of clean technologies, the emissions were still found to be 3.13-ton CO_2eqt, , that could be attributed to the current investments in coal power plants that would contribute to the emissions.

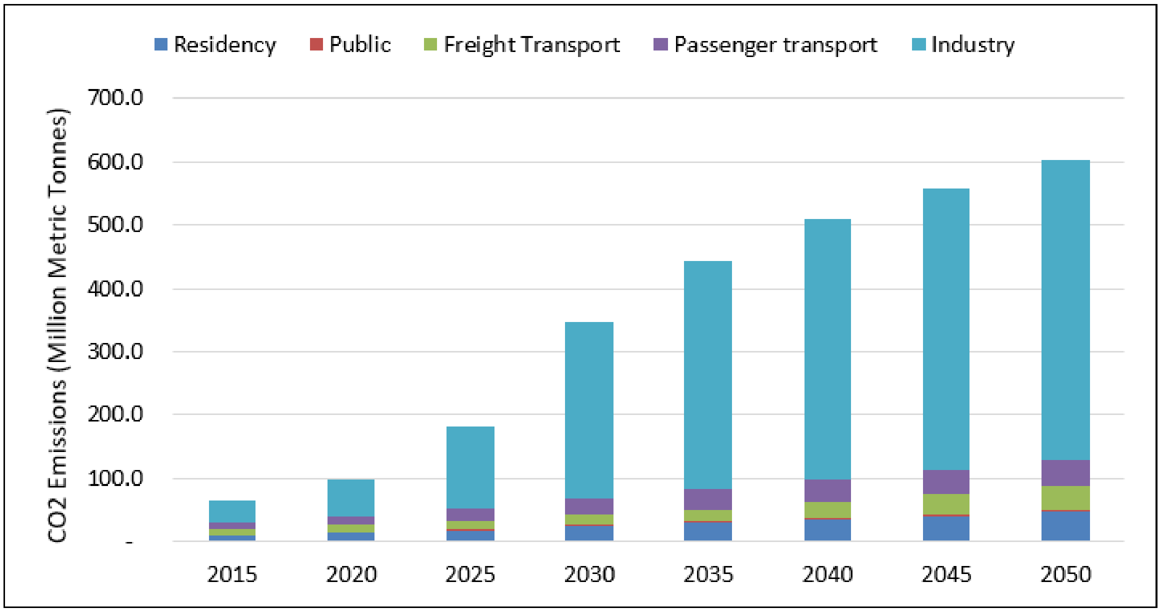

Figure 37 Growth Emission from Different Subsectors

Just like energy consumption, the major contribution of these emissions can be attributed to the industrial sector. Further, the emissions from different sub-sectors in each scenario have also been obtained from the model. However, some modest improvements have only been made in the industrial sector and an accelerated effort is needed to bring it in track with climate agreements. Even globally, the industrial sector accounts for almost 24% of global emissions. Energy mix of Pakistan's industrial sector has also remained unchanged.

3.6. Interlinkages between energy transition and climate change

Box 1 Vision of the Government- A Broader Picture

"The Government of Pakistan is putting an utmost priority on emphasizing the need to utilize indigenous and environmentally clean energy generation resources. In this regard, the exploitation of alternative and renewable energy sources and technologies are promoted to ensure sustainable supplies and energy security in the country.

Several initiatives have been taken to create a conducive environment for the sustainable growth of the clean energy sector in Pakistan in order to harness the potential of indigenous renewable energy resources.

- The development of large-scale grid connected renewable energy-based power generation projects are being pursued through private investors. The following progress has been achieved on development of renewable energy-based projects during the fiscal year 2018-19 so far:
  - -Five (05) wind power projects of 246.6 MW capacity were completed and started supplying electricity to the national grid.
  - -Two (02) bagasse cogeneration projects of 58 MW capacity were completed.
- The GOP's strategic objectives of Energy Security, Economic Benefits, Environmental Protection, Sustainable Growth and Social Equity with indigenous resources is further harnessed under the Renewable Energy Policy 2019.
- Apart from on-grid, large scale renewable based power projects, smaller renewable energy applications are also being promoted for lighting purposes, water pumping, heating and power generation etc. As such, distributed energy generation and its synchronization with the grid includes our way forward".

Source: Economic survey of Pakistan, 2018-19

Although the Government has taken measures and reforms to promote greener technologies and use of renewable sources, the solution to Pakistan's energy crisis is rooted in addressing governance relevant issues and infrastructural inefficiencies on the power supply side [19][20]. Yet, there are also investments in coal-based power plants. However, the government's plan to generate around 18,000 MW of renewable energy by 2030 could hit a roadblock in the shape of a pipeline of coal fired projects of more than 5 GW capacities [21]. At the same time, these projects present a significant risk of becoming stranded assets if the plans for renewable development come to fruition. Even in the best-case scenario, new coal generation is likely to operate at low capacity factors and thus at low efficiency.

Pakistan is well suited for renewable energy sources and the Government has announced incentive plans and policies to create enabling environments for promoting green investments in the "renewable energy (RE)" sector. It plans to increase the share of renewable energy in total power generation to 30% by 2030, referring to power from wind, solar, small hydro, biomass and aims at achieving 5-6% of its total on-grid electricity. According to the new Renewable Energy policy 2019, the Government has taken initiatives for technological advancements in the sector along with new financing mechanisms for the private sector, public sector and public-private partnerships (PPP), encompassing distributed generation system, off-grid solutions, B2B methodologies, and rural energy services.

Box 2 Salient features of Pakistan's new Renewable Policy (RE) 2019

"The new RE policy 2019 is developed under the government's strategic objectives of energy security, affordability of electricity, availability for all, environmental protection, sustainable growth and social equity, and states that:

- Alternative / renewable energy based Independent Power Producers (ARE-IPPs) will be ARE based power generation companies established for dedicated sale of power under guaranteed agreements with NTDC/ CPPA-G/ DISCOS.
- Include variety of investment options for tapping different ARE resources different ARE resources for off-grid applications as well as encouraging consumer driver applications and initiatives.
- Any production and use of electricity for self-consumption shall be treated as part of the normal business process for the purposes of income tax, but the sale of electricity from such projects to another entity, shall be exempted from income tax.
- Any equipment imported for such projects shall enjoy same custom duty exemptions as enjoyed by projects intending to sell to the grid.
- All the same incentives that are applicable to grid-based projects shall remain available for private projects".

Hence, it is advisable to consider the new energy targets to be achieved using renewables, so that benefits can be achieved inclusive of economic, social and environmental considerations.

4 Conclusion and key policy Recommendations

Based on the studied dynamics of energy transition in Pakistan towards the commitment to the Paris agreement the following conclusions can be drawn:

- Pakistan's economy will maintain rapid growth in future and will rely on secure energy supply with high growth rate up to 2050. Policies are necessary to make the energy system secure for supply, to be low carbon or zero carbon emission to support Paris climate change targets, and also reduce air pollution. Green energy transition is feasible and can be done at low cost given the recent technological developments and learning curve effects.
- From the scenario analysis, Pakistan's energy sector needs further prioritization of renewable energy to meet the commitment in Paris Agreement. Further analysis is needed to look for opportunities to further reduce CO_2 emission. With technological progress of solar and wind power, it is possible to develop more solar energy, but technology development today requires power supply system change, which needs to be designed in advance.
- Based on the studies for renewable energy cost, it is expected that within 2 to 3 years cost of wind

and solar power generation could be lower than coal fired power plants. There will not be much additional cost to develop wind and solar power generation system.

- Developing hydro power including large hydro and small hydro is one of key options for Pakistan's energy system in future and can greatly contribute to rural area energy supply.
- There are more than 10 coal fired power plants under development and planning in CPEC and other commitments [22]. This should be re-considered. Lock-in effects of coal fired power plants could have potentially high costs in future CO_2 mitigation, especially considering the 1.5℃ target. Most coal fired power plants are collaborating with Chinese companies. China's policy on investment in the Belt and Road Initiative (BRI) are shifting to be green and low carbon based on the speech of President Xi Jinping in the recent BRI Summit 2019 [23]. There is good opportunity to shift from coal fired power plants to other renewable energy power generation.
- The key reasons why private sector shies away and doesn't invest in new green technology is that the existing energy supply chain suffers from circular debt. This needs to be dealt with in order to mobilize private sector actors.

Source: Jiang and Chenfei, 2019[26]

Based on the aforementioned results and to facilitate development to achieve 30% renewable energy (in its energy mix by 2030 including 30% hydro, ultimately constituting next steps using 100% renewable energy), following recommendations can be made along with concrete proposed actions (PA) for the relevant stakeholders:

- An urgent need to ensure that any new investment in infrastructure supports the climate agenda along with fostering economic development [24]. These short-term costs for low carbon energy transition will just be a fraction of the total infrastructure cost. Hence, new funding sources need to be mobilized.
- International collaboration to promote energy transition is important. Low carbon and green principal should be set up for international investment.
- There is a need to consider the taxation beyond energy alone. Carbon transition is generally slowed down due to some tax expenditures and low prices. However, other tax provisions such as property taxes, and other corporate tax provisions may encourage better carbon-intensive choices.
- Addressing the potential skill gaps through education, training schemes, and labor market policies. Rather than following a separate model from each organization/department, any decision making should be based on a proper integrated energy model that provides a complete large-scale outlook. Although, Pakistan had two integrated energy plans before, but due to the lack of the co-ordination, both of them were later shelved. Hence, a proper integration among different departments for policy making will be required.
- In order to make the transition, a development strategy on energy transition is essential to guiding the transition. With the development strategy, every five-year plan and other energy and climate change policies could follow the strategy. Policies to promote an energy transition should also correlate with other SDGs in particular Goal 7.

Proposed Actions (PA) 1: Assigning accountability for achieving the policy to a single entity- a need to better coordinate energy policy and programs amongst the various government entities responsible.

PA 2: Hydropower integration into the renewable energy policy can be optimized to overall Pakistan's energy mix. However, this would need further development in the grid systems in terms of capacity, reliability and transmission.

PA 3: Attractive investments to support local manufacturing and assembling of renewable energy technologies must be provided.

PA 4: Sovereign guarantees to allow sufficient enabling environmental for the investors. Also, developing open and transparent capital markets to allow financing of renewable energy requires a conducive policy to create viable competitive markets.

PA 5: Develop a knowledge-based management framework to support the development of innovative models of energy, addressing energy and climate change issues on all local, regional and global scale.

PA 6: Distributed generation should be used to empower local communities and make socioeconomic benefits and participatory opportunities available to them.

PA 7: Given infrastructure development and country risks differ by country, risk premiums for renewable energy projects need to be priced as per Pakistan country risk and individual project risk.

PA 8: Capacity building and training programs to address the gaps in human resources and technical engineers and experts should be created.

PA 9: Modern energy services should be extended to the grid along with the distributed generation and rural electrification. Moreover, there should also be a regional trade of clean energy [25].

PA 10: Noting the expectation of low gas reserves in ~15 years, a long-term transition plan for gas-reliant industries may be helpful as part of the broader energy policy.

PA 11: Strict regulations and monitoring in terms of Environmental Impact Assessments, Strategic Environmental Impact Assessments.

PA 12: Adopting state of the art coal technologies- ensuring that all new coal generators are carbon capture-ready. The key reasons why private sector shies away and doesn't invest in new green technology is that the existing energy supply chain suffers from circular debt.

PA	Relevant body									
	Ministry of Energy	MoPDR	AEDB	NEECA	NEPRA	Generation companies, GENCOs, IPPs, CPPs	Distribution: DISCOs, K-electric, WAPDA	Transmission: NTDC, HVDC, STDC.	MOCC &relevant partners	CSOs, NGOs, Development partners
1	○	○	○	○	○					○
2	○		○	○	○				○	○
3	○			○	○	○	○	○		
4	○									○
5	○	○	○	○					○	○
6	○						○		○	○
7	○	○	○							○
8	○	○	○	○	○				○	○
9	○	○					○		○	○
10	○	○		○	○					○
11	○	○	○	○	○	○	○	○	○	○
12	○	○		○	○	○	○	○	○	○

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