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ENERGY MIX – CHANGE OF FOCUS FOR THE ENERGY SECTOR OF PAKISTAN

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Abstract:
A preferred energy-mix could be identified for Pakistan. The next step would be to identify the infrastructure needs and the finance needs for building the energy sector to follow this chosen scale of preferences.

The preferences are set in the descending order:

- ***National Energy Sector:*** Local hydro-power; Local nuclear; Local coal gasification; Local oil, gas and coal; Solar, wind and wave energy; Imported hydro-power; Imported oil, gas and coal; Imported nuclear

- ***Punjab:*** Nuclear; Imported oil, gas and coal; Local hydro-power; Solar, wind and wave energy; Imported hydro-power; Local oil, gas and coal; Local coal gasification

- ***KPK:*** Local hydro-power; Imported hydro-power; Local oil, gas and coal; Solar, wind and wave energy; Imported oil, gas and coal; Nuclear; Local coal gasification

- ***Sindh:*** Local coal gasification; Local oil, gas and coal; Solar, wind and wave energy; Imported oil, gas and coal; Nuclear; Imported hydro-power; Local hydro-power

- ***Karachi:*** Nuclear; Imported oil, gas and coal; Local coal gasification; Local oil, gas and coal; Solar, wind and wave energy; Local hydro-power; Imported hydro-power

- ***Baluchistan:*** Local oil, gas and coal; Imported oil, gas and coal; Solar, wind and wave energy; Nuclear; Local coal gasification; Local hydro-power; Imported hydro-power

Key words: Future Energy Systems; Year 2047; Preferred Energy-Mix; Consumer Choice Preference.

1. INTRODUCTION:

The structure of energy sector, both: fossil-fuel based and hydro-power, are in transition with increasing demand in Pakistan. Renewable energy sources are becoming significant with time. The need to identify a new chosen scale of preferences for energy-mix in Pakistan is based on two facts: Firstly, gap between energy demand and energy supply; Secondly, financial mechanism resulting in Circular Debt among Public Institutions [1].

As energy demand has grown in Pakistan, the local energy supply sector has not kept-up and hence, reliability on imported energy sources has grown. The imported energy sources gradually became a heavy burden on the foreign-exchange reserves of Pakistan. Since 1990 and particularly, since year 2000, Pakistan's imports of the energy sources have cost more than the earnings from exports. This increased reliance on debt and loans rather than local monetary reserves for payment of imported energy sources.

After unbundling of Water and Power Development Authority (WAPDA) - as suggested by the World Bank (WB) and the Asian Development Bank (ADB); there is no mechanism to buy or sell energy and electricity within the country among Public agencies and institutions. The idea they floated was: unbundle WAPDA into Production; Transmission; and Distribution Companies. Sell them into corporate sector as these become profitable. That transition never happened. All these companies are still part of the Public Sector. From one centralized WAPDA, now there are many companies, all depended on government money.

In reality, there is no smooth flow of finances from: Distribution to Transmission to Production

companies. For example: The subsidy in the electricity bills is not paid in time; resulting in payments delay to Transmission and Production/Purchase Companies. The debt accumulates with energy purchasing and electricity producing companies. The State Bank has involved most commercial banks to invest in Government energy sector purchases. Still some payments don't reach in time and result in delay in purchase order for oil by Pakistan State Oil (PSO) to the oil supplying countries. January 2015 is one such example, where PSO oil tanker ship was too late and electricity producing factories and petrol pumps started rationing oil.

In 2018, the circular debt in Pakistan is about a trillion rupees, that means that for every MW electricity out of total of 22,000 MW, about 4.5 crore rupees are payable internally in Pakistan. To understand the energy sector circular debt in Pakistan, it is imperative to review the structure of the energy sector in Pakistan and how local and international financial institutions play their role. To set a path to make Pakistan an energy surplus country, both local and international financial institutions will need to modify their role and outlook.

In terms of international cooperation, in Asia, three countries are under Economic Sanctions: Iran; North Korea; and Russia. Looking at future energy needs in Pakistan, China; Iran; and Russia could play a pivotal role along with Pakistan's traditional Islamic country partnerships for oil and gas. With the easing of Economic Sanctions, it is anticipated that regional countries will provide additional energy sources to Pakistan.

This paper is an exercise in designing an energy-mix preference scale for the future. It will also attempt to identify the infrastructure and financial need attached to this energy-mix. The next section details all the possible energy-mix preferences. Once the energy-mix preferences are identified under Section II, Section III will identify related Infrastructure and Financial needs. Section IV will conclude the discussion.

2. IDENTIFYING ENERGY-MIX PREFERENCES:

The energy-mix consists of actual, planned and anticipated energy resources for Pakistan. The main focus is on the viability for each province. The energy-mix consists of both fossil fuels and renewable energy sources. Preference is given to the renewable energy sources but practicality guides that realistic group of energy sources are identified.

With multiple sources for electricity production in the future; it would become possible to provide electricity to the business consumer from the source of their choice. The distribution and transmission companies will need to coordinate with the electricity producers for this spectrum of choices. For example, if an industry requires electricity from only renewable sources, then the transmission and distribution company would need to ensure that. Another innovation could be that large cities in Pakistan have their own urban nuclear electricity supply. This would mean city specific construction of nuclear electricity facilities. It is planned that in the future, local nuclear electricity would be mainly constructed around urban centers to meet their demand.

In Pakistan presently total electricity production is about: 22,000 Megawatt (MW); with twenty two crore people that mean that on average for every ten thousand persons there is one Megawatt of electricity available. In some future date, let us suppose in year 2047; Pakistan's population could be thirty crore people and electricity production at 300,000 MW (Table 1.). That would mean that on average one thousand persons will have one Megawatt of electricity available. Based on this assumption an energy-mix is designed.

Table 1. Financial and Electricity Supply Estimates for National Energy Plan

Technology	**Location and Sources**	**Electricity Produced Megawatts (MW)**	**Financial Estimate (Billion and Trillion PK Rupees)**
Hydro-Power			
	Built within Pakistan	70,000	One Trillion Four Hundred Billion
	Imported from outside of Pakistan border (with China and Afghanistan)	40,000	Eight Hundred Billion
Oil, Gas and Coal			
	Discovered and Refined within Pakistan	20,000	Four Hundred Billion
	Imported from outside of Pakistan	20,000	Four Hundred Billion
Nuclear			
	Structure built within Pakistan	30,000	Six Hundred Billion
	Structure built outside of Pakistan border (with China and Iran)	40,000	Eight Hundred Billion
Coal Gasification			
	Built within Pakistan	60,000	One Trillion Two Hundred Billion
Solar, Wind and Wave Energy			
	Built within Pakistan	20,000	Four Hundred Billion
		300,000 MW	**Six Trillion PK Rupees**

To identify energy-mix preferences, short introduction is provided for each type of the energy source considered in this paper.

2.1 Local and Imported Hydro-Power:

Starting with hydro-power, the structures built on rivers flowing within Pakistan and energy transmission lines connecting World Bank power project type country grouping. The WB project is: Central Asia-South Asia Power Project CASA 1000, the connecting countries include: Kyrgyz Republic; Tajikistan; Afghanistan; and Pakistan. New and similar projects involving China, Iran and other Russian Islamic States could also be designed. A total of 110,000 MW would be supplied from this sector; with 70,000 MW produced locally and 40,000 MW imported using an international electricity grid-line.

2.2 Local and Imported Oil, Gas and Coal:

In Pakistan, due to seasonal variations and increasing demand, additional energy sources are needed besides hydro-power generation. Pakistan relies heavily on thermal energy for electric power and transport fuel. Pakistan imports significant proportion of thermal energy resources from abroad each year. Oil and Gas Development Company limited (OGDCL) is one of the success stories of commercialization of a Public Enterprise in Pakistan. OGDCL is involved in: Exploring; Drilling; Refining; and Selling oil and gas in Pakistan. For the year 2047, it is estimated that 40,000 MW would be produced using oil, gas and coal. The imported fossil fuels will produce 20,000 MW of electricity only for the Punjab province. The electricity produced using local oil, gas and coal will be used in all other provinces.

2.3 Local and Imported Nuclear:

It is estimated that in year 2047, 70,000 MW would be provided by nuclear electricity technology. With 30,000 MW produced within Pakistan and 40,000 MW provided by China and Iran (if permitted, and not under international sanctions). The nuclear electricity production sites would be placed just outside of Pakistan's boundary with international electricity grid-line crossing the border.

2.4 Local Below-Ground Coal Gasification:

With massive coal reserves in Thar Desert in the Sindh province, a new technology has been tested. Below-ground gasification of coal produces energy for running electricity turbines and provides coal gas for transport fuel. This technology is still at an experimentation stage in Pakistan.

2.5 Local Solar, Wind and Wave Energy:

The renewable energy technologies of: solar panels; wind turbines; and seawater wave turbines have been on the horizon for some time and growing at an exponential rate in the rich countries. These technologies are expensive and need to be imported in most of the developing countries like Pakistan. It is assumed that in about thirty years, this technology will be considerable affordable for all.

2.6 Energy-Mix Preferences:

The national and provincial energy-mix preferences are presented as follows:

2.6.1 National Energy Sector:

Looking at Pakistan's future energy plan, seventy percent or 210,000 MW would come from two local and two imported sources. According to the estimates, Local Hydro-Power (70,000 MW) and Local Coal Gasification (60,000 MW) are at the top of this list; followed by: Imported Hydro-Power (40,000 MW) and Imported Nuclear energy based electricity (40,000 MW). The remaining thirty percent or 90,000 MW would come from Local Nuclear (30,000 MW); Solar, Wind and Wave Energy technologies (20,000 MW); and local and imported oil, gas and conventional coal electricity technologies (40,000 MW). This means that local and international fossil fuel reserves would be utilized for 40,000 MW from oil, gas and conventional coal and for 60,000 MW from below-ground coal gasification technology out of a total of 300,000 MW in the year 2047.

2.6.2 Provincial Energy Sector:

In the year 2047, it is estimated that Punjab will produce 116,000 MW and consume 163,000 MW; KPK will produce 75,000 MW and consume 53,000 MW; Sindh will produce 81,000 MW and consume 67,000 MW; and Baluchistan would produce 28,000 MW and consume 17,000 MW of electricity from various sources.

2.6.3 Punjab:

It is estimated that 163,000 MW or fifty four percent of total electricity would be supplied to the Punjab province out of total of 300,000 MW (Table 2.). The top three sources that would provide 94,000 MW are: Local and Imported Hydro-Power; and Imported Nuclear based electricity. Local Coal Gasification and Imported oil, gas and conventional coal would provide 43,000 MW. Local: Nuclear; Solar, Wind & Wave energy; and Oil, Gas & Conventional Coal would provide 26,000 MW. The idea of Local Nuclear is for specific cities. The electricity from nuclear technology would be produced for the city on premises. This means that specified large cities take control of their electricity production using nuclear energy technology.

Table 2. Punjab Electricity Demand & Supply in the Year 2047

Punjab		Demand	Supply
Hydro-Power	Local	30,000	10,000
Hydro-Power	Imported	35,000	35,000
Oil, Gas & Coal	Local	2,000	-
Oil, Gas & Coal	Imported	20,000	20,000
Nuclear	Local	17,000	17,000
Nuclear	Imported	29,000	29,000
Coal Gasification	Local	23,000	-
Solar & Wind Energy	Local	7,000	5,000
Total		**163,000**	**116,000**

2.6.4 KPK:

For KPK, it is estimated that 32,000 MW out of total of 53,000 MW in year 2047 would be supplied from Local Hydro-Power (Table 3.). At the National level, 70,000 MW would be produced using Local Hydro-Power; this means that KPK would be the largest consumer of this electricity source. Local Oil, Gas & Coal would provide 5,000 MW, while Imported Oil, Gas & Coal would not be used in the province. Both Local and Imported Nuclear would provide 4,000 MW each. Coal Gasification would also provide another 4,000 MW. Imported Hydro-Power and Solar & Wind energy would provide only 2,000 MW each in the KPK province.

Table 3. KPK Electricity Demand & Supply in the Year 2047

KPK		Demand	Supply
Hydro-Power	Local	32,000	60,000
Hydro-Power	Imported	2,000	2,000
Oil, Gas & Coal	Local	5,000	-
Oil, Gas & Coal	Imported	-	-
Nuclear	Local	4,000	4,000
Nuclear	Imported	4,000	4,000
Coal Gasification	Local	4,000	-
Solar & Wind Energy	Local	2,000	5,000
Total		**53,000**	**75,000**

2.6.5 Sindh:

It is estimated that Local Coal Gasification would provide 32,000 MW out of a total of 67,000 MW supplied to the Sindh province (Table 4. & Table 5.). Another 15,000 MW would be produced using Local Nuclear and Local Hydro-Power. Local Nuclear would be mainly used in Karachi and other large cities of the Sindh province. Local Oil, Gas and Conventional Coal would produce 6,000 MW; Solar, Wind and Wave Energy would provide another 6,000 MW. Imported Nuclear and Imported Hydro-Power would supply 8,000 MW. No Imported Oil, Gas and Coal would be used in the Sindh Province by the year 2047.

Table 4. Sindh Electricity Demand & Supply in the Year 2047

Sindh (Urban & Rural)		Demand	Supply
Hydro-Power	Local	7,000	-
Hydro-Power	Imported	2,000	2,000
Oil, Gas & Coal	Local	6,000	-
Oil, Gas & Coal	Imported	-	-
Nuclear	Local	8,000	8,000
Nuclear	Imported	6,000	6,000
Coal Gasification	Local	32,000	60,000
Solar & Wind Energy	Local	6,000	5,000
Total		**67,000**	**81,000**

Table 5. Sindh (Rural) Electricity Demand & Supply in the Year 2047

Sindh (Rural)		Demand	Supply
Hydro-Power	Local	3,000	-
Hydro-Power	Imported	1,000	1,000
Oil, Gas & Coal	Local	3,000	-
Oil, Gas & Coal	Imported	-	
Nuclear	Local	-	-
Nuclear	Imported	-	-
Coal Gasification	Local	25,000	60,000
Solar & Wind Energy	Local	-	4,000
Total		**32,000**	**65,000**

2.6.6 Baluchistan:

It is estimated that 7,000 MW of electricity would be supplied by Local Oil, Gas and Conventional Coal technology (Table 6.). Another 5,000 MW would be provided by Local Solar, Wind and Wave electricity technology. Hydro-Power and Nuclear, both Local and Imported would provide 1,000 MW electricity each. Local Below-Ground Gasification would provide 1,000 MW of electricity. No Imported Oil, Gas and Conventional Coal would be used for electricity production in the Baluchistan province by the year 2047.

Table 6. Baluchistan Electricity Demand & Supply in the Year 2047

Baluchistan		Demand	Supply
Hydro-Power	Local	1,000	-
Hydro-Power	Imported	1,000	1,000
Oil, Gas & Coal	Local	7,000	20,000
Oil, Gas & Coal	Imported	-	-
Nuclear	Local	1,000	1,000
Nuclear	Imported	1,000	1,000
Coal Gasification	Local	1,000	-
Solar & Wind Energy	Local	5,000	5,000
Total		**17,000**	**28,000**

3. INFRASTRUCTURE AND FINANCIAL NEEDS:

Presently, in Pakistan, ten thousand people get one MW of electricity, to take it to the level where: one thousand people get one MW each of electricity, means re-thinking: production; transmission; and distribution systems for electricity.

3.1 Infrastructure:

Pakistan in year 2047, with thirty crore people and electricity supply of 300,000 MW would need to build a base for systematic planning for both infrastructure and financial investment. It is envisioned that national grid-line would be along provincial border-lines. Each province will connect two types of lines to it: provincial electricity supply lines and provincial electricity receiving lines. Take the example of Hydro-Power electricity production. It is estimated that KPK will be producing 60,000 MW, while consuming 32,000 MW; Punjab will produce 10,000 MW while consuming 30,000 MW; Sindh will consume 7,000 MW; and Baluchistan will be consuming 1,000 MW.

3.1.1 Punjab:

Starting with the Punjab province in Pakistan; half of Pakistan's population lives in this province. Its energy needs are massive and constantly growing. Let us take the example of two largest cities: Lahore and Faisalabad. Presently, Lahore is about two crore people and Faisalabad is about one crore people. This means that presently, Lahore needs about 2,000 MW electricity and Faisalabad about 1,000 MW. In the year 2047, Lahore will increase to 2.8 crore people and Faisalabad would increase to 1.4 crore people. This means that under the future estimates, Lahore would be supplied 28,000 MW and Faisalabad would be supplied 14,000 MW of electricity.

Imported Hydro-Power would provide Pakistan with 40,000 MW. Punjab's demand share would be 35,000 MW. The Hydro-Power electricity supply international grid-line would reach Pakistan's border from Afghanistan and from China, where it will get connected to Pakistan's national grid-line. Both Russia and China would be providing electricity and supply grid-system. Imported Nuclear would provide Pakistan with 40,000 MW. Punjab's demand share would be 29,000 MW. The nuclear technology electricity supply international grid-line would reach Pakistan's border from Iran and from China. At the international border, Pakistan's national grid-line would get connected to it. Both these imported electricity sources would be supplied by connecting national electricity transmission grid-lines with international transmission grid-lines. Each province will get a share of different size; therefore, electricity distribution system will need to be shaped accordingly.

Local Hydro-Power mostly built in the northern mountain ranges of Pakistan would provide 70,000 MW of electricity. Punjab's demand share would be 30,000 MW. Local Coal Below-Ground Gasification, mainly built in Sindh Thar Desert would provide 60,000 MW to the national grid-system. Punjab would

be provided 23,000 MW of electricity from this system. Imported Oil, Gas and Conventional Coal will provide 20,000 MW to Punjab. It is estimated that Local nuclear would provide 17,000 MW to large cities of the Punjab province. The logistics and infrastructure would be built near the cities for full control of the electricity supply system by the city administration. The Solar, Wind and Wave technology electricity will connect each province as it produces and supplies to other provinces. Similar, scenario will take place with electricity production from Local Oil, Gas and Coal from each province supply will come to Punjab.

3.1.2 KPK:

Based on its population proportion, it is estimated that KPK will be demanding 53,000 MW of electricity in the year 2047. With 70,000 MW of electricity production and supply, KPK would be an electricity surplus province. The most prominent source of electricity in KPK would be Hydro-Power. It is estimated that KPK would be able to produce 60,000 MW out of total national production of 70,000 MW of electricity. The provincial consumption of 32,000 MW of electricity will makes KPK the largest consumer. This means that an intricate infrastructure will need to be developed for production, transmission and distribution of the Hydro-Power electricity in the province and to other provinces. The imported Hydro-Power electricity will also pass through the electricity infrastructure of KPK supplying to the other provinces and also for consumption within the KPK. Local Oil, Gas and Conventional Coal produced and refined in Pakistan would be supplying 5,000 MW of electricity to KPK.

Electricity produced using Local Below-Ground Gasification of Coal technology in the Sindh province would supply 4,000 MW of electricity the KPK province. Both Local and Imported Nuclear technology based electricity of 4,000 MW each would be consumed in the KPK province. KPK would produce 5,000 MW of electricity from the Solar and Wind energy technology. Out of this, 2,000 MW would be consumed within KPK, whereas, 2,000 MW would be sullied to the Punjab province and 1,000 MW would be supplied to the Sindh province. This means that KPK would be supplying electricity to the national grid-line and also taking electricity from the national grid-line for provincial consumption. The provincial electricity production/supply; transmission; and distribution systems will need to be planned accordingly. At the national-level, the main focus is on the consumer's choice for electricity technology. With given choice to consume electricity from their preferred electricity technology; the consumer in each province would demand electricity based on their own preferences.

3.1.3 Sindh:

Sindh is another energy surplus province in the year 2047, with total production of 81,000 MW and utilization of 67,000 MW of electricity. Local Below-Ground Coal Gasification in the Thar Desert would be providing 60,000 MW of electricity; out of this, Sindh province would be consuming 32,000 MW (7,000 MW for Karachi & 25,000 MW for rest of the Sindh province). Local and Imported Hydro-Power and Local Oil, Gas and Conventional Coal would be providing another 7,000 MW of electricity.

Infrastructure planning in the Sindh province will focus mainly of the development of the Local Below-Ground Coal Gasification in the Thar Desert. After local Hydro-Power (70,000 MW), Below-Ground Coal Gasification in the Thar Desert would be the second largest single sources of electricity, providing 60,000 MW of electricity to all other provinces of Pakistan. After Sindh (including Karachi), the Punjab province (23,000 MW) would be the largest consumer of electricity from Local Below-Ground Coal Gasification in the Thar Desert.

3.1.4 Karachi:

K-Electric production capacity is about 2,000 MW in 2018, with two and a half crore people; its present electricity need is 2,500 MW. It is assumed that by the year 2047, Karachi population will be three and a half crore. If the total electricity provided to the Sindh province is 67,000 MW; then 35,000 MW would be for Karachi.

Local Nuclear in proximity to Karachi city would provide 8,000 MW of electricity. Imported Nuclear brought to Karachi via passing through Northern Mountain areas, supplied from China and via passing through Western Mountain areas, supplied from Iran would provide another 6,000 MW of electricity to the Karachi city (Table 7.). Due to proximity, let us assumed that Below-Ground Coal Gasification would provide most easily accessible electricity to Sindh province and also to Karachi, therefore, 7,000 MW of electricity would be made available to the Karachi city. The Solar, Wind and Wave technology would provide 6,000 MW of electricity to the Karachi City. Local Oil, Gas and Conventional Coal would provide 3,000 MW of electricity. Local Hydro-Power brought from the Northern Mountain areas would provide another 4,000 MW of electricity and Imported Hydro-Power would provide another 1,000 MW of electricity.

Table 7. Karachi Electricity Demand in Year 2047

Karachi		Demand	Supply
Hydro-Power	Local	4,000	-
Hydro-Power	Imported	1,000	1,000
Oil, Gas & Coal	Local	3,000	-
Oil, Gas & Coal	Imported	-	-
Nuclear	Local	8,000	8,000
Nuclear	Imported	6,000	6,000
Coal Gasification	Local	7,000	-
Solar, Wind & Wave Energy	Local	6,000	1,000
Total		**35,000**	**16,000**

3.1.5 Baluchistan:

The electricity infrastructure plans for the Baluchistan province will include locally produced and distributed electricity and supply infrastructure for the Punjab province of imported Oil and Gas electricity from Iran.

With 28,000 MW electricity production using various technologies, and consumption of 17,000 MW of electricity, Baluchistan would also be an electricity surplus province. Local water storage and Hydro-Power electricity would provide 1,000 MW of electricity from this technology. Local Oil, Gas and Conventional Coal produced and refined in the Baluchistan would be supplying 20,000 MW of electricity. Out of this, 7,000 MW would be consumed within Baluchistan; 6,000 MW would be supplied to the Sindh province; 5,000 MW would be supplied to the KPK province; and 2,000 MW would be supplied to the Punjab province.

The Solar, Wind and Wave technology would provide 5,000 MW of electricity to the Baluchistan province. Both Imported and Local Nuclear technology would provide 1,000 MW each of electricity to the Baluchistan province. Imported Hydro-Power from Russia/China and Local Below-Ground Coal Gasification in the Thar Desert would provide 1,000 MW of electricity each.

3.2 Financial Needs:

To build an energy system that is efficient and can provides at an increasing scale, needs a substantial amount of financial investment. PK Rupees six trillion is an estimated amount for this process. This means that institutional and infrastructure development will end-up costing two crore rupees or twenty million rupees for each MW of electricity. If the GNP growth is less than two crore rupees from each MW of electricity, then this plan would not be economically viable on financial grounds.

The assumption here is: cost of installation of each MW will become a fraction of what it is today. In Pakistan installation of each MW of electricity costs USD 1.0 to 1.5 million or about twenty crore rupees or two hundred million rupees in 2018. The transmission grid and distribution system cost are additional. For the present study the cost are assumed to be about $1/10^{th}$ or $1/15^{th}$ of the present day costs i.e. two crore rupees for each MW installed. If the cost assumptions were ten or twenty crore rupees for each MW, then the investment requirements would be thirty or sixty trillion rupees. Important assumption here is that 300,000 MW of electricity would be demanded in Pakistan in the year 2047. This means that technological innovations in the: production; installation; import systems; and transmission; and distribution systems for electricity will be in effect.

For ease of estimation it has been assumed that population proportions will remain the same among the provinces while population will increase to thirty crore by year 2047. This means that per capita electricity needs will grow proportionally among provinces. For ease of estimation, production of each unit of electricity is assumed at similar constant cost. This is not the case in the real world, cost vary among electricity production technologies and eventually increase at increasing, constant or decreasing rates.

3.2.1 National Energy Sector:

The three main electricity sources in Pakistan, in year 2047 would be: Hydro-Power; Below-Ground Coal Gasification; and Nuclear technology. All three sources would need substantial amount of investment. PAK Rupees 3,200 billion or 3.2 trillion would be needed in investment. PK Rs. 1,400 billion or 1.4 trillion for Hydro-Power; PK Rs. 1,200 billion or 1.2 trillion for Below-Ground Coal Gasification; and PK Rs. 600 billion for Nuclear technology based electricity. To develop Solar, Wind and Wave Energy PK Rs. 400 billion would be required. Local exploration, refinement and supply of fossil fuels: oil, gas and conventional coal would also require additional PK Rs. 400 billion. A total of PK Rs. 4,000 billion or 4 trillion would be required in investment for locally produced electricity supply. This would mean that extensive infrastructure development and modifications would be required. Public Sector Development Program (PSDP) for Pakistan is half trillion rupees in 2018, let us assume it would be fifteen trillion PK Rupees; then four trillion for the energy sector could be seen in that context.

It is assumed that the electricity from Local Solar, Wind and Wave Energy could be in high demand due to its renewable nature [2]. With possible provision of choice to consumers regarding source and type of electricity technology; the pricing methods by the electricity distribution companies would vary. Local Oil, Gas and Conventional Coal will need to compete with the imported items of same nature for quality and pricing.

As estimated, Pakistan would have 300,000 MW of electricity available by the year 2047. This would include 100,000 MW of imported electricity. The three sources of imported electricity would include:

- Russian Islamic States and China to provide Hydro-Power electricity, 40,000 MW.
- Arab States, Iran and Russia to provide Oil, Gas and Conventional Coal based electricity, 20,000 MW.
- China to provide Nuclear technology based electricity, 40,000 MW.

For these foreign sources of electricity PK Rs. 2,000 billion or 2 trillion investment would be required. A comprehensive investment plan will need to be prepared starting from year 2020 and ending at completion of most electricity projects by the year 2047 for both local and imported electricity sources. This twenty seven year plan will need to focus on institutional investment and institutional lending organizations. Bilateral agreements with countries that would be exporting electricity to Pakistan would include pricing mechanism for electricity rates and infrastructure costs. The following seven institutions could be invited to participate in the investment process:

- World Bank
- European Investment Bank (EIB)
- Islamic Development Bank (IsDB)
- OPEC Fund for International Development (OFID)
- Eurasian Development Bank (EDB)
- Asian Development Bank (ADB)
- Asian Infrastructure Investment Bank (AIIB)

With the investment plan 2020-2047 underway, infrastructure development and technology development processes would be initiated. Each province has different energy plan (Table 9.). Only for the Punjab province, electricity demand (163,000 MW) is greater than electricity supply (116,000 MW), resulting in 47,000 MW difference. Rest of the three provinces will be electricity surplus provinces by the year 2047. The Sindh province would be providing 14,000 MW to the Punjab province; the KPK province would provide 22,000 MW and the Baluchistan province would provide 11,000 MW to the Punjab province. This means that the Punjab province would provide PK Rs. 940 billion for this supply of electricity. The Baluchistan province would receive PK Rs. 220 billion; the KPK province would receive 440 billion; and the Sindh province would receive PK Rs. 280 billion.

Table 9. National Electricity Plan for Year 2047

	Pakistan	Punjab	KPK	Sindh	Baluchistan
Total Electricity MW Produced/Supplied	**300,000**	116,000	75,000	81,000	28,000
Total Cost in Billions of PK Rs.	**6,000**	2,320	1,500	1,620	560
Electricity Supplied to Punjab Locally		(47,000)	22,000	14,000	11,000
Total Cost in Billions of PK Rs.		(940)	440	280	220
Total Imported Electricity	**100,000**	84,000	6,000	8,000	2,000
Total Cost in Billions of PK Rs.	**2,000**	1,680	120	160	40
Total Local Production of Electricity in MW	**200,000**	32,000	69,000	73,000	26,000
Total Cost in Billions of PK Rs.	**4,000**	640	1,380	1,460	520

The Federal Government would establish new institutions or modify the existing institutions to manage the electricity import; production; and supply in the country [3]. When each province buys and sells electricity within the country, the responsible institution will manage the supply and demand of electricity and its finances. Similarly, to import electricity from outside the country, the responsible institutions will manage the finances and the availability of electricity supply. The Punjab province would be consuming 84,000 MW of electricity worth PK Rs.1 trillion and 680 billion of imported electricity from Nuclear; Oil, Gas & Coal; and Hydro-Power sources. The Sindh province would be consuming 8,000 MW of electricity from Imported Hydro-Power and Nuclear electricity sources worth PK Rs. 160 billion. The KPK province would be consuming 6,000 MW worth PK Rs.120 billion from Imported Hydro-Power and Nuclear electricity sources. The Baluchistan province would be consuming 2,000 MW worth PK Rs.40 billion from Imported Hydro-Power and Nuclear electricity sources.

Local electricity production of 200,000 MW would be supplied by: Sindh 73,000 MW, worth PK Rs. 1 trillion and 460 billion; KPK 69,000 MW, worth PK Rs. 1 trillion and 380 billion; Punjab 32,000 MW, worth PK Rs. 640 billion; and Baluchistan 26,000 MW, worth PK Rs. 520 billion.

IV CONCLUSION:

In the first Table of this paper, it has become evident that two issues have been highlighted: firstly, the desired amount of electricity that each person would like to consume by year 2047; and secondly, what would the electricity production/supply capacities look like in Pakistan in the year 2047.

In this paper, a preferred energy-mix is identified for Pakistan electricity supply, providing details for each of the provinces. The next step was to identify the infrastructure needs and the financial needs for building the electricity sector to follow this chosen scale of preferences. Starting from year 2020, Pakistan would have twenty seven years and hopefully

would be able to raise 6,000 billion or six trillion Pakistani Rupees for this task. The infrastructure would be designed in such a way that tighter inner circle would consist of electricity source that is urban based; followed by provincial sources; with additional sources provided by the other provinces; and finally beyond border electricity sources.

4.1 Punjab:
In the Punjab province, 84,000 MW out of total 163 MW of electricity is from the imported sources. Imported electricity produced from: Hydro-Power overseas; nuclear technology at the borders with China and Iran; and oil, gas and conventional coal based thermal electricity technology from across the region. Less than half or 79,000 MW of electricity is from the local sources. The three local source of electricity, produced within the Punjab province are: Local urban areas nuclear electricity technology; Hydro-Power from the mountain areas; and solar, wind and wave technology. The Local electricity also includes contributions from the Sindh province: Local below-ground coal gasification; KPK province: Local hydro-power and solar, and wind technology; Baluchistan province: Local oil, gas and conventional coal.

4.2 KPK:
KPK province would be energy surplus province in the year 2047, providing electricity to other provinces from: Local hydro-power; and Solar and wind renewable energy technology. KPK would also be using electricity produced in the other provinces: Sindh would be providing electricity from Local coal gasification; and Baluchistan would be providing electricity from the Local oil, gas and conventional coal thermal technology. Two sources of imported electricity: Imported hydro-power; and Imported nuclear would be connected to Pakistan in the KPK province, using international grid-line. Only 6,000 MW out of total of 53,000 MW of electricity in the KPK province would come from the imported sources: Imported hydro-power; and imported nuclear technology electricity.

4.3 Sindh:
The Sindh province would also become one of the electricity surplus provinces, consuming 67,000 MW out of total of produced/supplied 81,000 MW of electricity. The Sindh province would be consuming 32,000 MW out of 60,000 MW of electricity produced within the province using Local below-ground coal gasification technology. The KPK and Baluchistan province would be providing 14,000 MW of electricity from: Local hydro-power; Local oil, gas and conventional coal; and solar and wind energy technologies. Sindh province would be consuming 8,000 MW of imported electricity from imported nuclear and imported hydro-power technologies.

4.4 Karachi:
Karachi city would be producing 8,000 MW of electricity from the local nuclear installation for the metropolitan's consumption. All of the electricity available to the Sindh province from the two sources: imported nuclear; and solar, wind and wave energy would be made available to the Karachi city. Electricity from the local below-ground coal gasification, produced in the Sindh would provide 7,000 MW to the Karachi city. Fifty percent of the electricity provided by the KPK (Local hydro-power) and Baluchistan (Local oil, gas and coal) provinces to the Sindh province would be delivered to the Karachi city.

4.5 Baluchistan:
The Baluchistan province would also be electricity surplus province in the year 2047. National production of 20,000 MW of thermal electricity from local oil, gas and conventional coal would come from the Baluchistan province. Both KPK province and the Sindh province would supply electricity to the Baluchistan province from the provincial production of: Local below-ground coal gasification; and Local hydro-power. Imported hydro-power and imported nuclear would provide 2,000 MW of electricity. Provincial production of 5,000 MW of electricity from the local solar, wind and wave energy would be consumed within the province. The local urban nuclear technology would provide 1,000 MW of electricity.

As an Upper-Middle Income to Upper-Income country in the year 2047, Pakistan would prefer to develop its: local hydro-power; local nuclear technology based electricity; local below-ground coal gasification; local oil, gas and conventional coal based thermal electricity; solar, wind and wave energy based renewable electricity. The electricity supplied in the future in Pakistan would be supplemented with imported electricity sources. These would include: Imported hydro-power; Imported oil, gas and conventional coal; and Imported nuclear technology based electricity.

As mentioned earlier in this paper, in Pakistan, each MW of electricity serves ten thousand people in 2018. In the year 2047 it would increase to: each MW of electricity for one thousand people; from 22,000 MW of electricity in 2018 for twenty two crore people to 300,000 MW of electricity in year 2047 for thirty crore people.

Finally, in next twenty nine years, each province of Pakistan would need to identify the means to grow economically, each new industry, and each new sector would need to be well grounded with well trained labor force. New technologies would be developed by then for the food that those future people would eat, its growth, processing and transportation; its proximity to the urban areas. Other needs: clothing and housing. The agriculture and manufacturing industries, transport and urban living, all need energy resources. The choice preference that the consumers would demand, will lead to a design structure to types of technologies used for producing/supplying electricity. The opportunity given to the electricity consumers to choose their preferred type of electricity technology is the main focus of this future planning.

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