

## ADVANCED ECONOMIES OF THE WORLD AND COMPARATIVE ENERGY PROJECTIONS OF PAKISTAN

Usman Awan<sup>\*1</sup>, Roshana Zeenat Khizer Mufti<sup>2</sup>

<sup>\*1</sup>Assistant Professor, University of Engineering and Technology, Lahore, Pakistan

<sup>2</sup>Architect at Design Line Construction, Lahore

<sup>1</sup>usman.awan@live.co.uk, <sup>1</sup>usmanawan@uet.edu.pk, <sup>2</sup>ar.roshanazeenat@gmail.com

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Corresponding Author: \*

Usman Awan

### Abstract

The developing countries face the difficulty of energy demand forecasting due to not having adequate facilities and the types of equipment required. Pakistan also deals with such challenges when it comes to developing strategies to meet energy supply and demand. One possible approach to estimate the future demands could be to look for the per capita consumption of other advanced and developed countries by comparing values taken from historic and current statistical data.

This research compares the historic growth in energy demand within Pakistan from 1973-2015 against advanced and neighbouring economies of the world. It uses these figures to predict the likely unfulfilled and unmet demand per capita for energy of Pakistan, both at present and up to 2050. Further, the domestic sector electrical energy consumption, especially of the province of Punjab, is compared with Service-led, industry-led & mixed economies of the world. The results show that Pakistan's current per capita consumption is far less than the advanced economies.

Pakistan would consume 2237.5 Mtoe, 874 Mtoe & 429.5 Mtoe if we compare it with upper, medium and lower consumers respectively in the year 2050, when its current, 2015, consumption is only 177 Mtoe. The domestic sector of Punjab would need 957127.5 GWh, 230690 GWh and 107970 GWh as projected for these three tiers of users. The research is especially useful for the policy makers of the future forecasting and developing mitigation strategies for energy demands.

### INTRODUCTION

Pakistan is facing difficulties in almost all sectors of energy due to its scarcity. Human negligence, lack of awareness and expertise, and improper strategies to meet energy demands are key issues (Awan and Knight, Domestic sector energy demand and prediction models for Punjab Pakistan. 2020). The neighbours like India, China, Iran and Afghanistan could be alternative sources of energy supply when required to make its supply system more resilient, but the country does not have much relationship

with them. Pakistan's main source of electrical energy supply is hydro, and unreliable. (GOP 2025) Among other neighbouring countries, China can be a useful potential, and it has been throughout the history of Pakistan, and shares a very friendly relationship. The economic condition of Afghanistan is not very certain, and with Iran, there are some religious clashes, and foreign relations are not very stable. So fairly China and Iran have the potential for the country in times of need for the demand side management of energy and power.

Pakistan have diverse climatic conditions; it faces extreme summers(51c) and winters(-10C). These conditions of temperature require much input of energy to make it comfortable and inhabitable for the people of the Country w.r.t thermal comfort. Currently, Pakistan has a population of 241.4M (Punjab 127.6M). with the growth rate of 6%/annum it would be 245 M and 310M by 2030 & 2050 respectively. This trend of rapid increase in population would demand rational mitigation of resources (Figure 1).

The current population density of 255p/km<sup>2</sup> is increasing at the rate of approximately 7% per 5 years, by 2030 it would be 318p/km<sup>2</sup>, which is 25% more than the current value. So energy usage per km<sup>2</sup> would also increase at rapid speed. Out of the total population, 39.2% is Urban and 60.8% rural( Punjab-urban 64%) (WM 2017) and there is an increasing trend of urbanisation in the country, around 60% of the population tends towards a modern lifestyle of urban life, which will completely

shift the energy usage patterns of the country (Figure 1) with 5% emigrants every 5 years.

The energy consumption trends in the advanced world will be taken up by the local population soon. To enable the authorities for such scenarios, this research is focused on comparing the energy demands of different economies of the world to Pakistan’s demand.

This brief background of Pakistan gives an insight into energy and power usage in the country and places this research in context, as there is a huge energy crisis going on and there is a power shortage of 6- 8 hours & 10-12hrs in the urban and rural areas, respectively. Since the building sector is one of the prime consumers of energy and power in Punjab, Pakistan, this research would look at the comparative situations and suggestions for the implementation of frameworks for the sustainable energy and power supply of Pakistan.

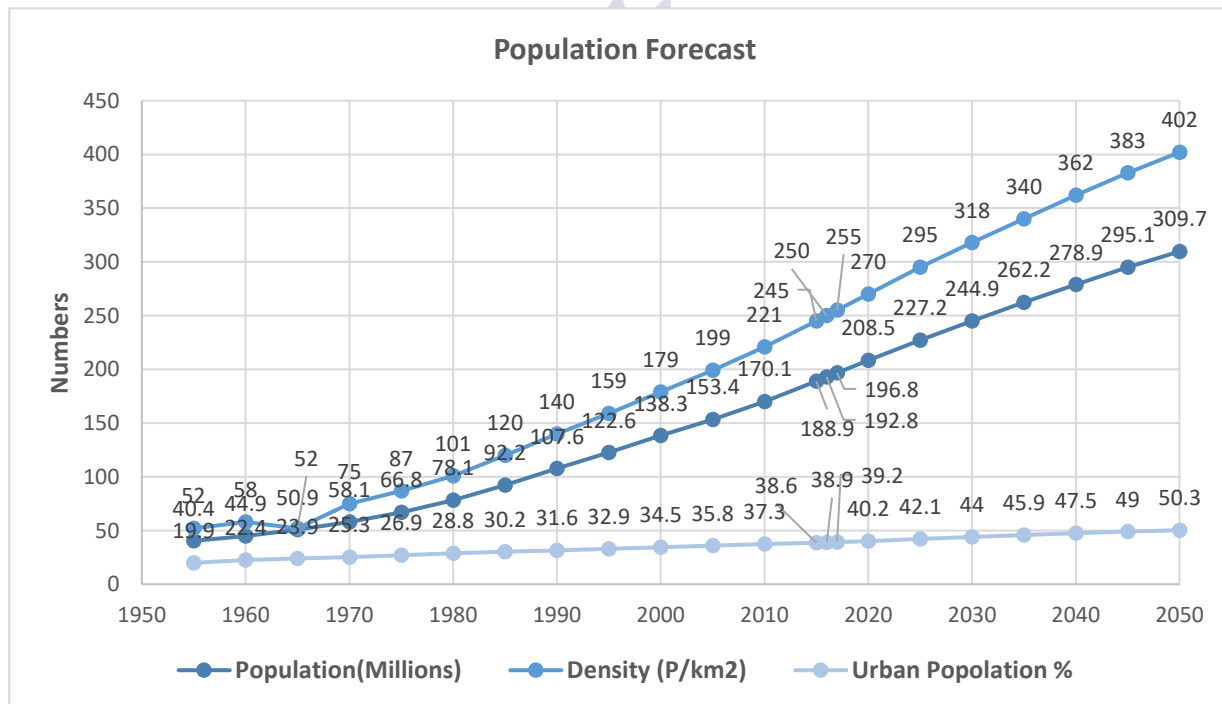


Figure 1 Urbanization, Population growth and Density of Pakistan Source: (WM 2017) (GOP 2025)

The energy demand estimation is based on statistical numbers and idiosyncratic usage patterns of consumers, a need model, and the impending

tendency of energy demands in the context of Pakistan.

In this research, the hypothesis is broadly to be tested:

Present methods used for estimation of energy demands are unrealistic, it is not based on the actual demands or it is based on the uneven and unstable affordability patterns of consumers and likewise usage of energy. Whereas actual demand of energy is much higher if based on the 'NEED MODEL' of energy in the domestic sector of Pakistan, in comparison to the international standards.

The above hypotheses are based on the understanding that the building sector is the main consumer of energy, and an in-depth study would reveal where this energy is being consumed. And where can effective measures be taken to reduce its **carbon emissions**? And how can the concept of **Eco-prosumers** be adopted by the building sector? These are some of the related research areas which can be further investigated. We assumed that the overall energy demand of Pakistan is going to be multi-fold, as of its current demand when compared with advanced economies of the world.

Energy supply needs to be integrated with the factual demands of the country. By 2015, the efforts made by the government to produce 96.5 Mtoe of energy in Pakistan proved to be insufficient. This study addresses this problem by linking the actual energy demand per capita of unconstrained energy supply countries with the energy supply of Pakistan per capita, with the focus on domestic needs. This research aims to estimate and satisfy the electrical energy demand and predict future needs. Modernising, developing and comforting the lifestyle of dwellers has increased the energy demand at a rate that has left energy planners and suppliers impromptu. As the quality of life in developing countries, like Pakistan, is improving, there is a perception that adequate access of energy is the basic right of every citizen, and it would match the available and consumed energy for the citizens of developed countries. Nonetheless, according to the economic survey of Pakistan & IEA (2016), 26% of the population has no access to energy and 29.5% live below the poverty line (Development 2018). The government of Pakistan has identified this shortage of energy and a long-term national action plan is developed, trying to meet future energy demands (Raza, Amir and Khatri 2022). Energy generation steps taken by the government are found to be insufficient and by the year 2018, it was estimated

that an additional 16.6GW (Zafar, Usman and Rashid 2018) (Shakeel, Rukh and Takala 2016) of electrical energy by all projects would be generated, which would help in reducing power cuts in Pakistan (awan, Awan and Iqbal 2025).

In this paper historical comparison of the available energy supply and demand of Pakistan with other countries is done. The aim is to establish a peer-reviewed basis for the Pakistan energy demand, historic and future potential. A Periodic per capita availability of energy is compared with the international domestic sector. The core purpose of comparison with other countries is to understand how much the current demand by the housing sector in Punjab is and what it would be in future. The idea is to understand the energy consumption by the housing sector of different countries with unconstrained/uninterrupted energy supply. This will help us to estimate the energy demand of the domestic sector per capita of Punjab, Pakistan.

A consistent approach for the development of the energy sector of Pakistan is missing. It seems as it developed independently, having no coherence with the growing population's need of it by different consumers, especially the housing sector. Attempts made by different governments to overcome the energy shortage in the history of Pakistan have been ineffective. One possible reason, among others, is the inability of authorities to forecast actual energy demand and take effective measures.

The actual energy demand by the domestic sector of Punjab is reflected in this paper, it will help policymakers and energy suppliers to take effective steps to overcome this menace. The current research is an endeavour to estimate the future energy consumption of Pakistan per capita, if Pakistan progress as a 'Service', 'Industry' led and mixed economy by comparing it with other advanced global economies of the same. Pakistan is compared with India, China, Malaysia, Iran, Kuwait, Oman, UAE, UK and the USA. Apart from the conventional future energy demand forecast methods adopted by various researchers as discussed in the literature review part, this paper has estimated the energy demand by making assumptions if Pakistan make progress like other advanced countries.

**Literature Review**

The energy demand forecasting for Pakistan is undertaken at the government, private and academic levels. Energy security policies of Pakistan (Aized, et al. 2018), and the Petroleum department, through the regression analysis, predicted energy demand for various sectors up to 2025. (PakistanPIP) 2015) and National Transmission and Dispatch Company limited (NTDC) 2014) are among the leading institutes. From the government side the regression base load demand of 40.84 Mtoe in 2035. (Aziz Ur Rehman 2017)

Leap model of Pakistan is used to analyse future demand, period studied from 2011 to 2030, based on three scenarios; estimated growth of electricity consumers in 2030 is 39.7M, and electricity demand is 312 TWh in 2030. The larger demand growth is estimated by domestic sector due to fiscal progress and better income status (Pervaiz and Sohail 2015) (Usama Perwez 2014). The comparative study of energy consumption by energy-rich and energy-scarce

countries of Saudi Arabia and Pakistan has shown that the economic growth in the former and population growth in the latter are the main causes of energy demand (Gazder and Uneb 2017). Energy consumption and growth trend per capita is compared with Saudi Arabia, showing overall energy consumption of Pakistan in 2040 would be  $3.32 \times 10^{11}$  (Kg of oil equivalent) as compared to Saudi ( $3.84 \times 10^{11}$  kg of oi equivalent) (Gazder and Uneb 2017). Pakistan, with an average between 2020-2040 as 9.1%, would have the highest growth rate than Saudi, Middle East, Asia and in the global context, having 2.7, 1.6, 2.0 and 1.5% respectively (Gazder and Uneb 2017).

Pakistan has unidirectional correlation concerning power demand and financial growth (Awan, Awan and Abukeshek, Historical Nexus of the Development of Power Sector in Parallel to Population and Household Growth in Pakistan from 1947 to 2018 2025), hence as a developing country its demand of energy is increasing every year (Pervaiz and Sohail 2015) (Jamil and Ejaz 2010). Time series data used from 1980-2011 with AMIRA model revealed complete and sector-wise power usage in Pakistan and estimated that there would be 81% increase in electricity demand as of 2012. (79442-98598.5 GWH) while domestic sector identified as main consumer (Hussain and Rahman 2016) . The electricity demand is estimated by (Nasir and Salman 2009), while considering the price of electricity, prices of appliances, income, demographics and geographic variables using ARDL Model , In the long run price of electricity, income and house hold size have elasticities of (-0.77), (1.29) and (5.74) respectively which indicates that price of electricity does not affect its demand it's the size of house hold and the number of people living in or population which demands more electricity (Nasir and Salman 2009). Smooth Transition Auto Regressive model(STAR) has been applied to forecast the power demand between 1971-2012. The findings indicated that their lie a non-linear relationship between electricity demand and its price. (Nawaz and Iqbal 2014) the consumption is dependent on the level of development. It is forecasted that with the GDP growth of 6%, the demand of electricity of Pakistan in 2020 would increase 3 folds. (Nawaz and Iqbal 2014) (awan, Awan and Iqbal 2025) The overall and sectoral electricity demand is examined between 1978-2012 using the Panel co-integration test and found that the electricity is more responsive to income than price. (Khan and Abbas 2016). The method adopted in this research paper has never been used by any other author in Pakistan. Some of the work done internationally by other researchers in the compared countries is shown in Table 1. All have used different tools and models to forecast the future energy demand, but no one has adopted

forecast report was made by NTDC using historical data of electrical consumption, Population and Gross Domestic Product growth. The power prediction is made up to 2037 an incudes three rates of GDP of low 3.56%, normal 5% and high 6.5%.

Another study, using different models (AMIRA & LEAP) and 20-year data, predicted Pakistan's energy demand to be 76.1 Mtoe by the industry, transport, and domestic sectors. Industry seems to be the highest consumer, with an energy

the 'Assumption Comparative Model' used in this research paper.

Reference	Country	Scope/Field	Forecasting Method/Tool	Forecasting Period
(Chai and Liang 2018)	China	Natural Gas	LMDI-STIRPAT-PLSR framework	2016-2025
(Lee and Tong 2011)	China	Energy consumption	grey forecasting model and genetic programming	1990–2007
(Biswajit and Mourshed 2018)	China	Energy Forecasting	483 EPMs,(many models tested)	1985-2017
(Xiao, et al. 7-29 July 2015)	China	Oil, gas and totally energy consumption	(GMDH) and GMDH based auto-regressive (GAR) model.	2014–2020
(Ha and Lin 2018)	China	Total energy forecasting	ADL-MIDAS model	13 <sup>th</sup> plan till-2020
(Jan, Yang and Wang 2016)	China	Energy consumption in road transportation	ETS & ARIMA models and multiple regression models	2012–2020
(Li, Yang and Li 2018)	China	Coal Power forecasting	MGM, ARIMA, GM-ARIMA, NMGM	2017-2026
(Yuan , Liu and Fang 2016)	China	Energy consumption	Comparison of ARIMA andGM(1,1)	2014–2020
(A. Deka, et al. 2015)	USA	Energy demand	ANN, regression analysis, ARIMA	2014–2019
(Krishan , Prakash and Xu 2018)	USA	Building energy forecasting	Gaussian Process Regression(GPR)	1-5 day ahead
(Ghalehhondabi and Ardjumand 2017)	USA	Energy Demand forecasting	Different models tested	2005-2015
(Deka and Hamta 2016)	USA	Energy Demand	artificial neural network (ANN), ARIMA	1950-2013
(Kiani, Kiani and Ahmed 2017)	UAE	Energy generation and consumption forecast	LEAP, Design Builder, Energy Plus	2017-2030
(Foul and Bassam 2014)	UAE	Energy consumption forecast	artificial neural network (ANN),	2015-2020
(Barassi and Zhao 2017)	UK	Energy Demand forecasting	ARMA, Holt Winters, (NLANN), (VAR) , VAR (FAVAR)	A day ahead on 22March 2016
(Trutnewte , McDowall and Tomei 2016)	UK	energy scenarios	retrospective analysis	1978-2002
(Amber and Aslam 2015)	UK	Administrative buildings electricity consumption	Multiple regression (MR) model ,Genetic programming (GP) model	2007-2013
(Drysdale , Wu and Jenkins 2015)	UK	Domestic Electricity forecast	Flexible domestic Demand(FDD) analysis	2013-2030
(Alsayegh and Almatar 2006)	Kuwait	Annual monthly energy consumption	Sequential Monte Carlo Methods	1992-2000

(Al-Riyami and Al-Busaidi 2015)	Oman	Electricity demand forecast model	Global and Area-based method approaches	2014-2030
(Islam , Al-Alawi and Ellithy 1995)	Oman	Electricity demand forecast	artificial neural network (ANN)	24 months ahead
(Zamri and Zailan 2010)	Malaysia	final energy consumption, fossil fuels and electricity	Box-Jenkins time series analysis, ARIMA	1996-2007 for 2016
(Suganthi and Samuel 2016,)	India	Energy consumption forecast	R2, SE, and Durbin Watson (DW) statistic	2030-2031
(Muralitharan and Sakthivel 2018)	India	Energy Demand Forecast	Neural Net-work (CNN) approach	A ‘day’ to a ‘year’
(Behrang , Assareh and Ghalambaz 2011)	Iran	Oil demand forecast	GSA (Gravitational Search Algorithm)	2011-2030
(Amjadi and Pour 2010)	Iran	Electricity Demand Forecast	Particle Swarm Optimization (PSO) Algorithm	1980-2000 for 2001-2006
(Neshat and Hadian 2018)	Iran	Electricity Demand Forecast	nonlinear model namely, N-ARIMAX	1990-2015 for 2040
(Barak and Sadegh 2016)	Iran	Energy consumption forecast	ARIMA-ANFIS hybrid algorithm	A year

Table 1: Literature Review of the Compared Countries with different economies

**Methodology**

The research rationale is developed on the following points.

Currently, Pakistan’s energy demand is not met effectively (related literature to support this point would be added here)

Forecasting of energy requirement of Pakistan is not accurate, therefore all efforts made by the government are in vain (related literature to support this argument would be provided here)

Probably, current energy demand per capita of developed countries or countries with un-interrupted energy supply, will provide the guidance for the assessment of the future energy demand of Pakistan, particularly in the domestic sector.

The optimistic and progressive approach for Pakistan indicates that the future energy demand per capita can be estimated by comparing the energy demands of ‘Service’ and ‘Industry’ led economies or ‘Mixed

economies’ of neighbouring and other global countries.

Pakistan’s future energy demand is also estimated in the regional context. The global future energy demand estimation gives regional (south-Asia) energy forecasts and future demand of Pakistan as well.

In compiling the framework for this research, we have made some assumptions that if Pakistan in the near future make progress in either the industrial or services sectors, how much would be the increase in the overall energy demand may occur. The research starts with the historical data collection of all compared countries, and the forecasting for Pakistan’s needs is based on this data analysis Figure 2. A self-explanatory research framework is shown in Figure 2 below.

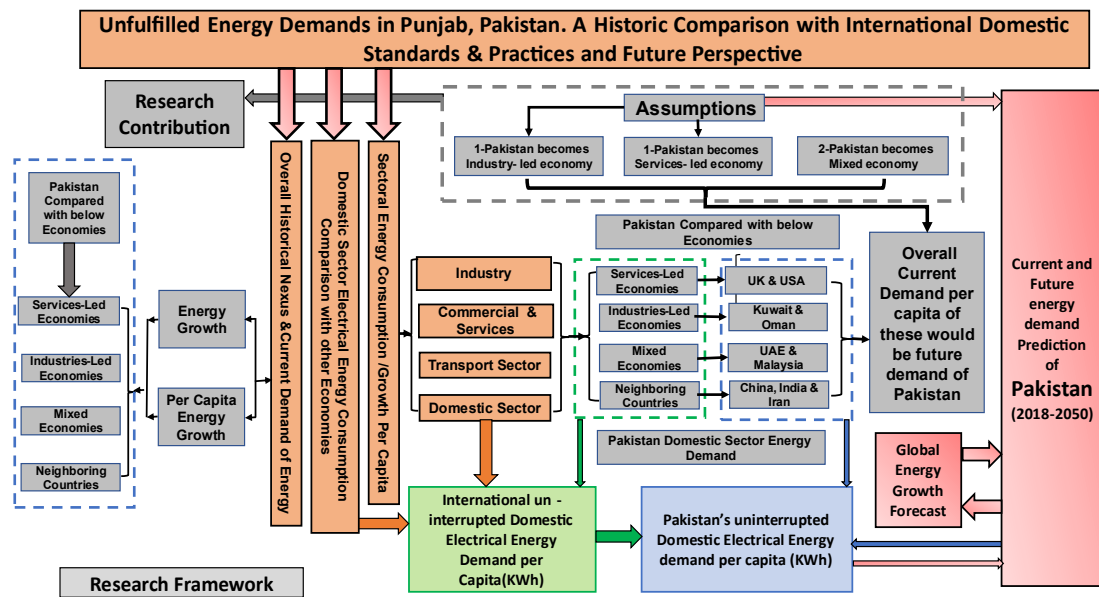


Figure 2 Research Framework and Methodology

Pakistan is compared with other countries based on the type of economy they depend upon, and is divided into four main categories as  
 Services-led Economy, Pakistan is compared with the UK & USA  
 Industry-led Economy, Pakistan is compared with Kuwait, Oman

Mix Economy (Services & industrial sector) Pakistan is compared to Malaysia & UAE  
 Pakistan is compared to Neighbouring Countries, China, India & Iran  
 For the overview of Pakistan's and all compared economies GDP shares of industry and services in given in Figure 3, which clearly identifies countries as their leading sectors to support GDPs.

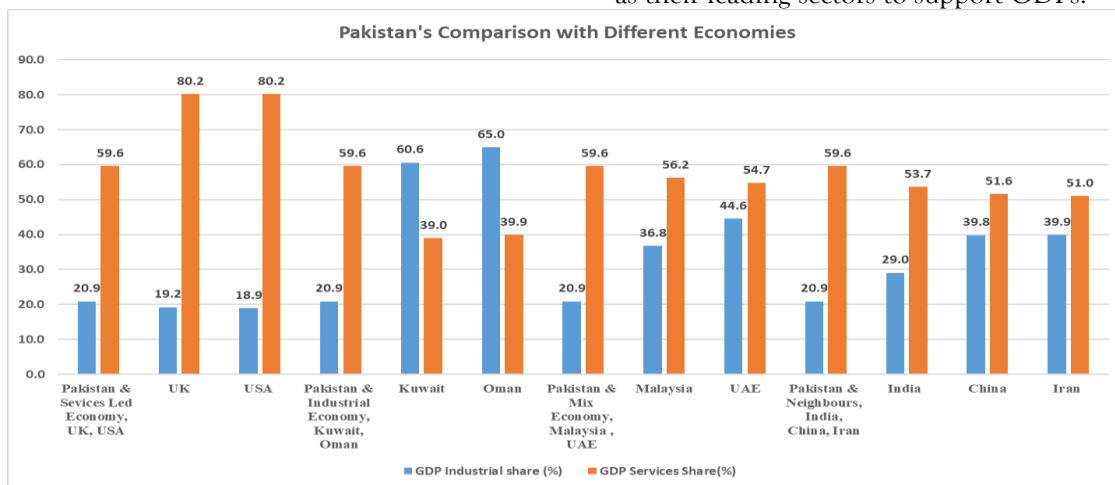


Figure 3 Pakistan's GDP comparison with different economies (IEA 2018) (World Bank 2018)

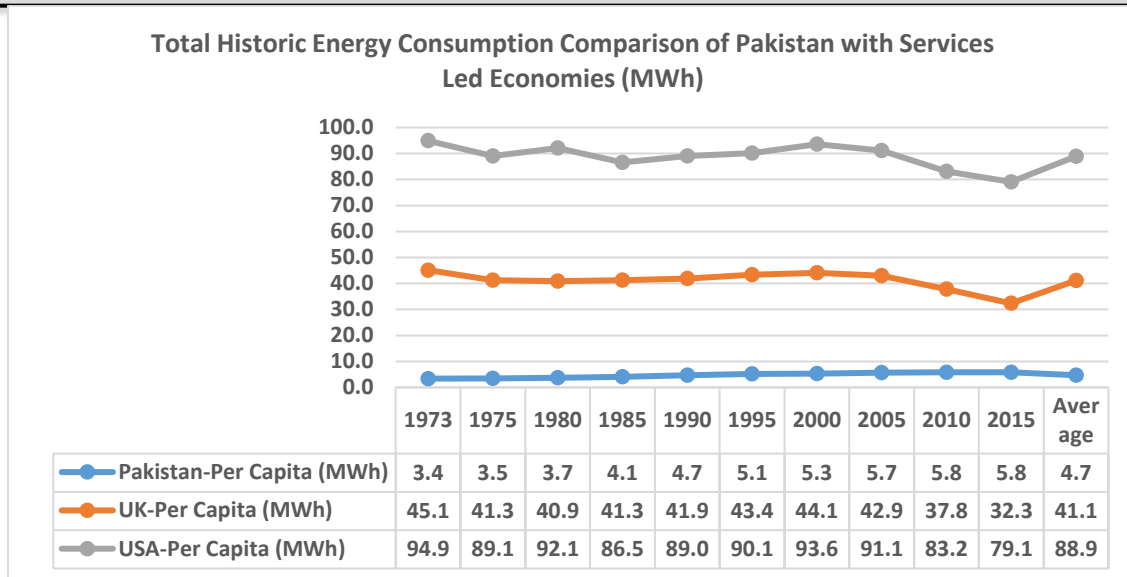


Figure 4 Total Historic Energy Consumption Comparison of Pakistan with Services Led Economies per capita, UK & USA (MWh)

If Pakistan is assumed to progress as a ‘Services Led’ economy of advanced countries with uninterrupted energy supply like the UK & USA, how much energy would it need per capita? In the last four decades, Pakistan’s overall energy consumption increased from 3.4

MWh to 5.8 MWh during 1973-2015 respectively, with an average value of 4.7 MWh. When Pakistan is compared with the UK and USA, where the ‘Services Sector’ contributes approximately 80.2% of the GDP (2016). The historic energy consumption per capita for the UK has been 32.3- 45.1 MWh and 79.1- 94.9 MWh for the USA. It is seen that the energy consumption per capita has a declining trend of these countries, but it is still much higher than in Pakistan during the last four decades.

The average energy consumption per capita of Pakistan, the UK and USA is 4.7, 41.1 and 88.9 MWh, respectively. If Pakistan is to progress like UK and USA, its average energy consumption would have been 32.3 MWh and 79.1 MWh if compared with UK and USA as of 2015, than Pakistan (188M) would have needed 522.1 MToe (405% more) and

**Table 2).**

In eighty’s similar trend is seen in the energy consumption, the residential sector being (56.4-60.4%) the largest consumer, while industry was (19.5-20.2%) in second and transport (9.8-11.2%) as

1278.7 MToe (993% more). when compared with UK and USA (2015) but it only used 77.7 MToe. The unfulfilled energy of 444.4 MToe and 1201 MToe was required if it had to be compared with UK and USA in 2015.

If we assume the current (2015) energy consumption of UK and USA as the future energy demand of Pakistan, then by 2050 Pakistan (305M) would be needing 847.1MToe and 2074.4MToe respectively. So, in the period of 35 years Pakistan need to grow its energy consumption by 658% and 1611% to meet the energy consumptions of UK and USA respectively.

**4.1.2 Overall Sectoral Energy Consumption of Pakistan, UK and USA**

Pakistan’s historic energy consumption: In seventy’s residential sector was the main consumer of energy in Pakistan, consuming 61.5%-62.2% of total energy. Industry and transport were the next largest consumers of energy, consuming 21.5-22.2% and 6.4-6.9% respectively (

the third largest consumer of energy. The gradual decrease in the consumption of energy by the residential sector is seen through the 1990s, 2010’s and in the year 2015, it consumed 50% of energy, but it is still the largest consumer of overall energy by sector. There is not much increase or decrease in the

energy consumption of the industrial sector, it remained as second largest consumer with an average of 27.7% in the last four decades. The transport sector has shown some growth as the third largest

consumer and the maximum energy consumed in 2015 was 17.8%; its average consumption during the last four decades is 12.7%. (

Table 2).

The historic sectoral energy consumption analysis of Pakistan shows that the residential sector remained

the main consumer, with the average usage of 54.8% in the last four decades.

Table 2 Pakistan's overall Historic Sectoral Energy Consumption (Pedia 2015)

Year	Pakistan Total Energy (Mtoe)	Pakistan Industry (Mtoe)	Industry %	Pakistan Commerce & services (Mtoe)	Com. Ser. %	Pakistan Transport (Mtoe)	Transport %	Pakistan Residential (Mtoe)	Residential %	Pakistan Energy Per Capita (Toe)	Per Capita of energy (MWh)
1973	16.9	3.6	21.5	0.8	4.6	1.1	6.4	10.5	62.2	0.3	3.4
1975	18.5	4.1	22.2	0.8	4.6	1.3	6.9	11.4	61.5	0.3	3.5
1980	22.5	4.4	19.5	0.9	3.8	2.2	9.8	13.5	60.0	0.3	3.7
1985	28.9	5.8	20.2	1.0	3.5	3.2	11.2	16.3	56.4	0.4	4.1
1990	36.2	7.9	21.9	0.8	2.2	4.5	12.4	20.0	55.3	0.4	4.7
1995	44.5	10.5	23.6	1.1	2.4	6.6	14.8	23.5	52.8	0.4	5.1
2000	51.1	11.2	21.8	1.3	2.5	8.4	16.4	26.7	52.4	0.5	5.3
2005	62.4	17.1	27.4	1.8	2.9	9.1	14.5	30.2	48.3	0.5	5.7
2010	70.0	17.8	25.5	2.1	3.1	11.5	16.5	34.3	49.0	0.5	5.8
2015	77.7	18.5	23.8	2.4	3.0	13.9	17.8	38.9	50.0	0.5	5.8
Average	42.9	10.1	22.7	1.3	3.3	6.2	12.7	22.5	54.8	0.4	4.7

The sectoral energy consumption of the UK shows different trends when compared with Pakistan. The average percentages of energy consumption by

industry, transport and residential sectors of the UK are 25.2%, 26.1% and 27.9% respectively in the last four decades. (

Table 3). By looking at these percentages we see there is no specific sector which is largely consuming overall energy as seen in Pakistan, where domestic sector has consumed 50.8% average energy in the same time period. Services and commercial sectors of UK consumed average energy of 10.7%, whereas Pakistan consumed 3.3% average energy.

look at the domestic sector energy consumption of service-led economies. The UK's economy is dependent more on services, and an increasing trend (9.4% to 12.9%) can be seen in the energy consumption of the services sector. The industrial sector has a decreasing trend of energy consumption; in the last four decades, it has decreased from 36.6% to 18.1% (1971-2015). The energy consumption by the transport sector has increased gradually in the same period.

Historically, in Pakistan, most of the energy is consumed by the domestic sector; it is important to

Table 3 UK's overall Historic Sectoral Energy Consumption (Gov. 2015)

Year	UK Total Energy	U.K Industry (Mtoe)	Industry %	U.K Commerce & services	Com. Ser. %	U.K Transport (Mtoe)	Transport %	U.K Residential (Mtoe)	Residential %	U.K Energy Per	Per Capita of energy

	(Mtoe)			(MToe)							Capita (Toe)	(MWh)
1973	143.2	52.4	36.6	13.4	9.4	27.6	19.3	33.7	23.5	3.9	45.1	
1975		133.3	46.7	35.0	11.9	8.9	26.4	19.8	33.4	25.1	3.6	41.3
1980		131.2	39.3	30.0	12.6	9.6	30.4	23.2	35.9	27.4	3.5	40.9
1985		133.2	34.5	25.9	13.8	10.4	32.9	24.7	38	28.5	3.6	41.3
1990		138.2	32.2	23.3	12.8	9.3	39.2	28.4	37.3	27.0	3.6	41.9
1995		143.8	31.7	22.0	16.3	11.3	39.7	27.6	39.3	27.3	3.7	43.4
2000		150.6	33.9	22.5	16.8	11.2	41.8	27.8	43	28.6	3.8	44.1
2005		148.7	30.9	20.8	16.7	11.2	42.7	28.7	44.2	29.7	3.7	42.9
2010		138.2	25.1	18.2	17.5	12.7	40.4	29.2	45.4	32.9	3.3	37.8
2015		125.3	22.7	18.1	16.2	12.9	40.2	32.1	36.5	29.1	2.8	32.3
Average		138.6	34.9	25.2	14.8	10.7	36.1	26.1	38.7	27.9	3.5	41.1

The transport sector of the USA is the main consumer of energy, consuming 36.7% average energy over the last four decades. The industrial sector is the second largest sector, consuming 22.9% (Table 4). Industrial sector of USA has decreasing trend of energy consumption while transport sector has an ascending trend. Residential sector consumed more or less same percentage of overall energy during 1972-2015.

Comparing Pakistan with the USA shows residential sector of Pakistan mostly consumes available energy (average 54.8% in the last four decades), whereas the

average energy. The residential sector of the USA is only consuming 17.3% average energy. There is an increasing trend of energy consumption by the commercial and services sector (11.3-13.7%). (

USA's residential sector only consumed 17.3% average energy in the same period. Services-led economies of the UK and USA show that the percentage usage of energy by commercial, services and transport sectors is an increasing trend. If Pakistan becomes a service-led economy, it will have to focus more on the services and transport sectors. Pakistan's per capita energy consumption has to increase from 0.4 Toe to 3.5 Toe and 7.6Toe, if it is to be compared with the UK and USA, respectively, and this can be the future energy forecast for Pakistan per capita.

Table 4 USA's overall Historic Sectoral Energy Consumption (Post 2015)

Year	USA Total Energy (Mtoe)	USA Industry (MToe)	Industry %	USA Commerce +services (MToe)	Com. & Ser. %	USA Transport (MToe)	Transport %	USA Residential (MToe)	Residential %	USA Energy Per Capita (Toe)	Per Capita of energy (MWh)
1973	1314	394	30.0	148	11.3	414.0	31.5	238	18.1	8.2	94.9
1975	1228	327	26.6	142	11.6	409.0	33.3	230	18.7	7.7	89.1
1980	1310	387	29.5	142	10.8	425.0	32.4	216	16.5	7.9	92.1
1985	1270	344	27.1	148	11.7	442.0	34.8	207	16.3	7.4	86.5
1990	1293	284	22.0	158	12.2	487.0	37.7	209	16.2	7.7	89.0
1995	1376	273	19.8	173	12.6	527.0	38.3	248	18.0	7.8	90.1
2000	1549	332	21.4	193	12.5	587.0	37.9	263	17.0	8.1	93.6
2005	1562	277	17.7	201	12.9	623.0	39.9	272	17.4	7.8	91.1

2010	1514	270	17.8	207	13.7	595.0	39.3	270	17.8	7.2	83.2
2015	1519	262	17.2	208	13.7	630.0	41.5	261	17.2	6.8	79.1
Average	1393.5	315.0	22.9	172.0	12.3	513.9	36.7	241.4	17.3	7.6	88.9

4.1.3 Domestic per Capita Electrical Energy consumption of Pakistan, UK and USA

Historically, the domestic sector of Pakistan has been using only 0.01 MWh (1973) either because of the non-availability of energy or the usage patterns. Currently, it is using 0.23 MWh (2015), which is much lower than the UK (1.83

MWh) and USA (4.84 MWh). This historic difference in the domestic energy consumption per capita indicates that there lies huge possibility of growth in its consumption, provided energy access to the domestic sector of Pakistan *Figure 5*.

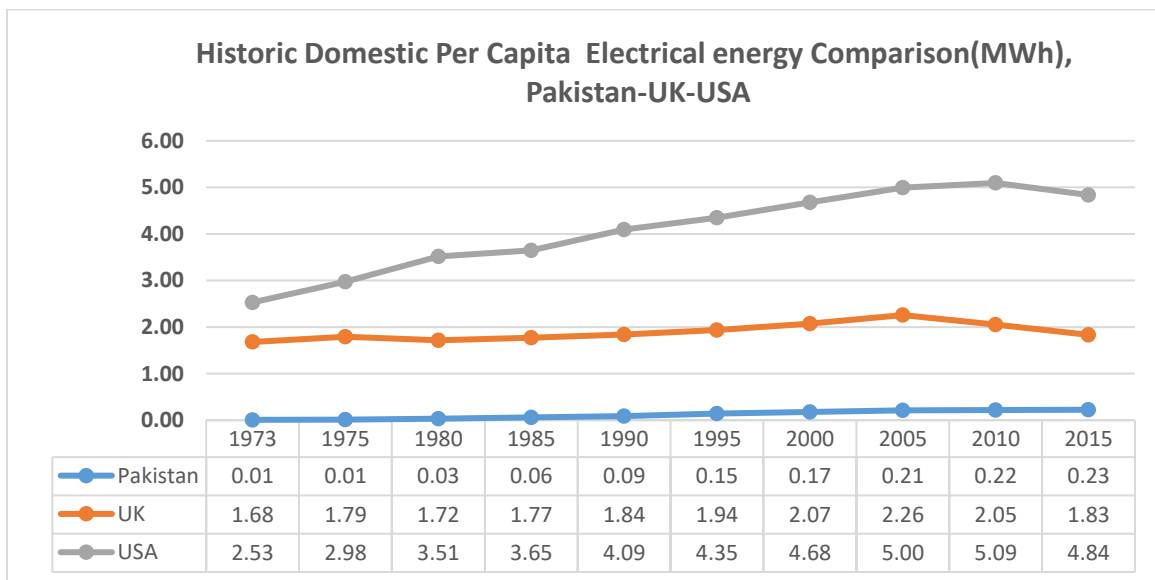


Figure 5 Total Historic domestic Electrical Energy Consumption Comparison of Pakistan with Services Led Economies per capita, UK & USA (MWh)

The energy consumption of the domestic sector of Pakistan is increasing gradually from 0.01 to 0.23 MWh per capita in the last four decades (1973-2015). The declining energy consumption trend is seen in the UK and the USA in recent years. Historically, in the UK, it went up to 2.26 MWh (2005) from 1.68 MWh (1973) but declined in the year 2015, consuming 1.83 MWh. Similarly, in the USA, it consumed a maximum of 5.09 MWh in 2010, and it was 2.53 MWh in 1973, while consumption was on decline in 2015, when it consumed 4.84 MWh per capita.

If the current (2015) consumption of the UK and USA is taken as the future demand of the domestic sector of Punjab, Pakistan, then it would have needed (with a population of 101.4M) 185560GWh

and 490776GWh of electrical energy, respectively, while it only consumed 23,322GWh.

By the year 2050, if compared with the current consumption of the UK and USA (with uninterrupted electrical energy supply), Punjab's domestic sector would need (with a population of 177M) 323910 GWh and 856680 GWh respectively.

4.2 Industry-led Economy, Pakistan is Compared with Kuwait, Oman

4.2.1 Overall Energy consumption per capita of Pakistan, Kuwait and Oman

Kuwait and Oman are mostly industry-led economies of the world, contributing 60.6% and 65% of GDP (2016). In forty years, Pakistan's energy consumption per capita has increased from 3.4 MWh to 5.8

MWh, with an average rate of 4.7 MWh, whereas the industry-led economy of Kuwait has historically grown from 89.4 MWh to 103.5 MWh, with an average value of 97.3 MWh. Oman’s energy

consumption was 1.4 MWh in 1973 and grew to 65.7 MWh in 2015, with an average growth of 31.7 MWh. (Figure 6)

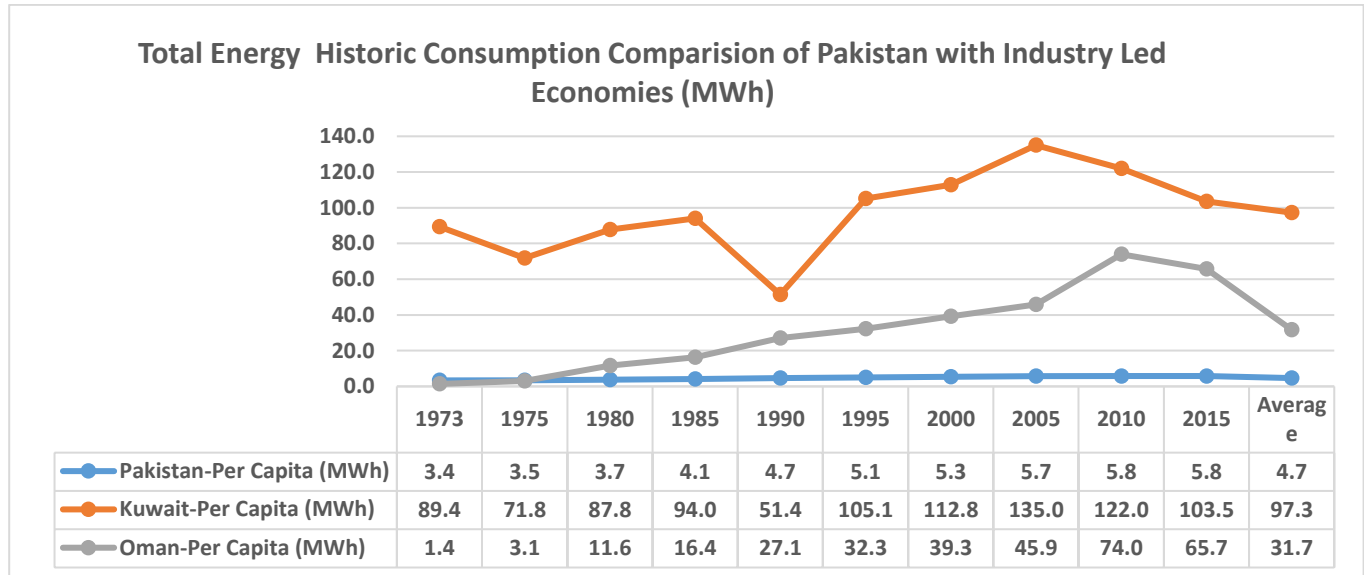


Figure 6 Total Historic Energy Consumption Comparison of Pakistan with Industry-Led Economies per capita, Kuwait & Oman (MWh)

Kuwait has an unusual trend of energy consumption, while Oman’s energy consumption has increasing trend like Pakistan. Both industrial-led economies of Kuwait (97.3 MWh) and Oman (31.7 MWh) use much higher average energy per capita than Pakistan (4.7 MWh).

If Pakistan progress as an industry-led economy, its per capita energy consumption could be 103.5MWh and 64.7MWh when compared with Kuwait and Oman as of 2015, than Pakistan with the population of 188M (2015), would have needed 1673Mtoe(1300%) and 1062 Mtoe (825%) respectively.

If we assume the current (2015) energy consumption of Kuwait and Oman as the future energy demand of Pakistan, then by 2050, with a population of 305M, it would need 2714 MToe and 1723 MToe, respectively. So, Pakistan needs to grow its energy

consumption by 2108% and 1338.8% to match the current energy consumption of Kuwait and Oman per capita, respectively, as an ‘Industrial Led Economy’(Figure 6).

#### 4.2.2 Overall Sectoral Energy Consumption, Pakistan, Kuwait and Oman

The industrial sector of Kuwait has been the main consumer of energy, consuming an average of 34.1 % ( 1973-2015), transport being the second (average 25.6%) and the residential sector (average 13.6%) remained the third largest consumer. Historically, the industrial sector consumed 27-42.9% of energy, it did not show a constant increasing or decreasing trend, but still this sector remained the largest consumer of energy (

consumed an average 13.6% of energy in the last four decades (1973-2015).

Table 5). When comparing with Pakistan, where the residential sector is the largest consumer of average energy (54.8%) while Kuwait’s residential sector only

Table 5 Kuwait's overall Historic Sectoral Energy Consumption

Year	Kuwait Total Energy (Mtoe)	Kuwait Industry (MToe)	Industry %	Kuwait Commerce +services (MToe)	Com. & Ser. %	Kuwait Transport (MToe)	Transport %	Transport	Kuwait Residential (MToe)	Residential %	Kuwait Energy Per Capita (Toe)	Per Capita of energy (MWh)
1973		3.93	1.3	33.1	0.01	0.3	0.8	19.1	0.28	7.1	7.7	89.4
1975		3.49	1.11	31.8	0.01	0.3	0.7	19.8	0.29	8.3	6.2	71.8
1980		6.25	1.69	27.0	0.1	1.6	1.8	28.6	0.47	7.5	7.6	87.8
1985		8.12	2.23	27.5	0.02	0.2	3.1	37.6	1.16	14.3	8.1	94.0
1990		3.96	1.7	42.9	0.02	0.5	1.0	24.5	0.88	22.2	4.4	51.4
1995		7.04	2.5	35.5	0.22	3.1	1.8	25.9	1.17	16.6	9.0	105.1
2000		8.14	3.19	39.2	0.57	7.0	2.1	25.3	1.27	15.6	9.7	112.8
2005		12.17	4.79	39.4	0.77	6.3	2.8	22.8	1.81	14.9	11.6	135.0
2010		15.05	4.18	27.8	1.13	7.5	4.2	28.0	2.25	15.0	10.5	122.0
2015		17.6	6.5	36.9	1.32	7.5	4.3	24.4	2.62	14.9	8.9	103.5
Average		8.6	2.9	34.1	0.4	3.4	2.2	25.6	1.2	13.6	8.4	97.3

Pakistan’s industrial sector consumed an average of 22.7% of energy while Kuwait’s industrial sector consumed 34.1% in the same period, of the total country’s energy. The transport sector of Kuwait consumed double the percentage of (average 25.6%) country’s energy than Pakistan (average 12.7%).

If Pakistan is to compare with the industry-led economy of Kuwait, then more of its resources would be consumed by the industry and transport sectors. Pakistan, with its current usage of an average of 54.8% of energy by the residential sector, is not fulfilling its demand, and still there are energy crisis in the domestic sector of Pakistan. The industrial and transport sector would require additional energy

if it will make progress like Kuwait. The commercial and service sectors of Pakistan and Kuwait more or less consuming the same amount of average energy, 3.3% and 3.4% respectively.

Oman’s industrial sector consumed the largest amount of energy (51.2%) in 2015, the transport sector consumed 21.7%, and the residential sector consumed only 8% of energy in the same year. Historic values of sectoral energy consumption show that industrial energy consumption is increasing yearly. While the transport sector has a reverse trend in energy consumption. In 1973, industry consumed 12.5% and the transport sector consumed 50% of energy, while in the year 2015, it showed an opposite trend, the industrial sector consumed 51.2% and the transport sector consumed 21.7% of energy

Table 6.

Table 6 Oman's overall Historic Sectoral Energy Consumption

Year	Oman Total Energy (Mtoe)	Oman Industry (MToe)	Industry %	Oman Commerce +services (MToe)	Com. & Ser. %	Oman Transport (MToe)	Transport %	Transport	Oman Residential (MToe)	Residential %	Oman Energy Per Capita (Toe)	Per Capita of energy (MWh)
1973	0.08	0.01	12.5	0	0.0	0.0	50.0	0	0.0	0.0	0.1	1.4
1975	0.2	0.02	10.0	0	0.0	0.1	45.0	0.01	5.0	0.3	3.1	
1980	0.55	0.01	1.8	0.02	3.6	0.2	40.0	0.03	5.5	1.0	11.6	
1985	1.39	0.33	23.7	0.07	5.0	0.4	30.2	0.14	10.1	1.4	16.4	

1990	1.84	0.74	40.2	0.11	6.0	0.6	31.5	0.22	12.0	2.3	27.1
1995	2.53	1.01	39.9	0.15	5.9	0.8	29.6	0.31	12.3	2.8	32.3
2000	3.05	1.1	36.1	0.21	6.9	0.9	29.5	0.36	11.8	3.4	39.3
2005	4.98	1.57	31.5	0.3	6.0	1.2	24.9	0.51	10.2	4.0	45.9
2010	12.26	5.47	44.6	0.51	4.2	2.8	22.5	0.81	6.6	6.4	74.0
2015	20.43	10.45	51.2	0.86	4.2	4.4	21.7	1.37	6.7	5.7	65.7
Average	4.7	2.1	29.2	0.2	4.2	1.1	32.5	0.4	8.0	2.7	31.7

Table 6).

Comparing with Pakistan, where residential sector is the main consumer of energy (average 54.8%), IF Pakistan progress as an industrial led economy like Oman, most of its energy would be going to industry and transport, and its per capita energy consumption by domestic sector will also increase, while overall energy per capita would increase from 4.7MWh to 31.7Mwh, if compared with Oman.

#### 4.2.3 Domestic Per Capita Electrical Energy Consumption of Pakistan, Kuwait and Oman

Historically, per capita electrical energy consumption by the domestic sector of Kuwait

Residential sector consumed between 5-12% of total energy in the last four decades (average 8%) ( remained increasing, starting from 3.7 MWh in 1973 till 2005, when it was 11.51 MWh. After this, there is seen decline in the energy consumption, and by the year 2015, it was 9.82 MWh. Kuwait is one of those countries whose domestic sector is nearly consuming all electrical energy as a source of domestic energy, as a result, its consumption per capita is very high. Oman’s domestic sector started using electrical energy in 1975; since then, its usage has increased, and by 2015, it consumed 3.11 MWh per capita.

Compared to the industry led economies of Kuwait and Oman, the current energy consumption (2015) of these countries can be predicted as future energy demand of domestic sector of Punjab and Pakistan. Kuwait is an exceptional example where all of the domestic energy would be fulfilled by electrical source.

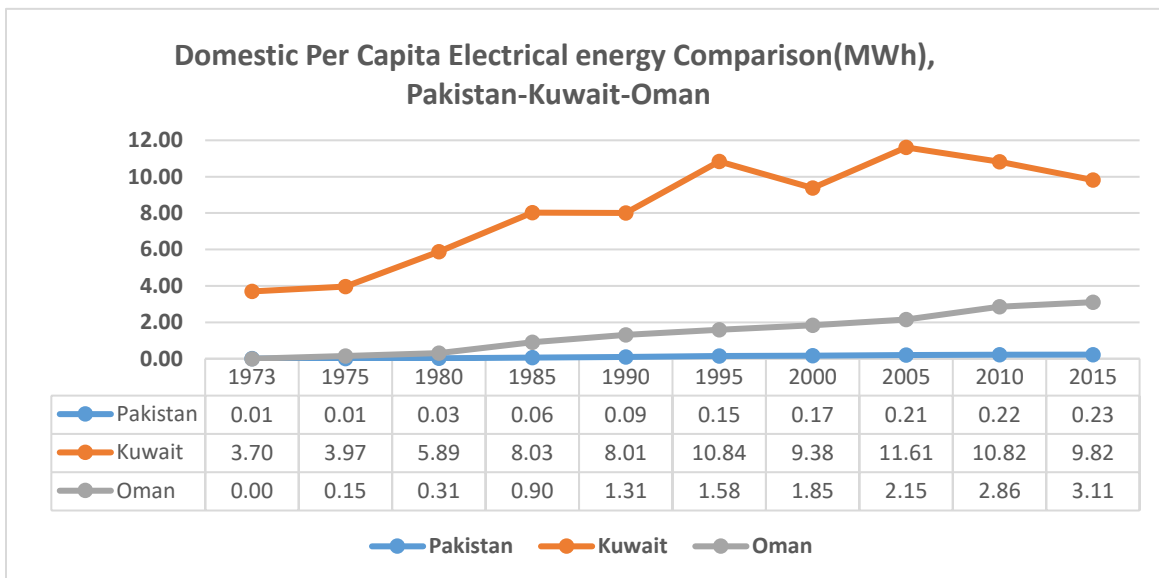


Figure 7 Total Historic domestic Electrical Energy Consumption Comparison of Pakistan with Industry Led Economies per capita, Kuwait & Oman (MWh)

As of 2015, if compared with Kuwait and Oman, Punjab would have needed 995748GWh and 315354GWh of electrical energy (but Punjab consumed 23322MWh), and by the year 2050, it would need 1738140GWh and 550470GWh respectively. Compared with Kuwait is a case where all domestic sector energy is shifted to electrical energy.

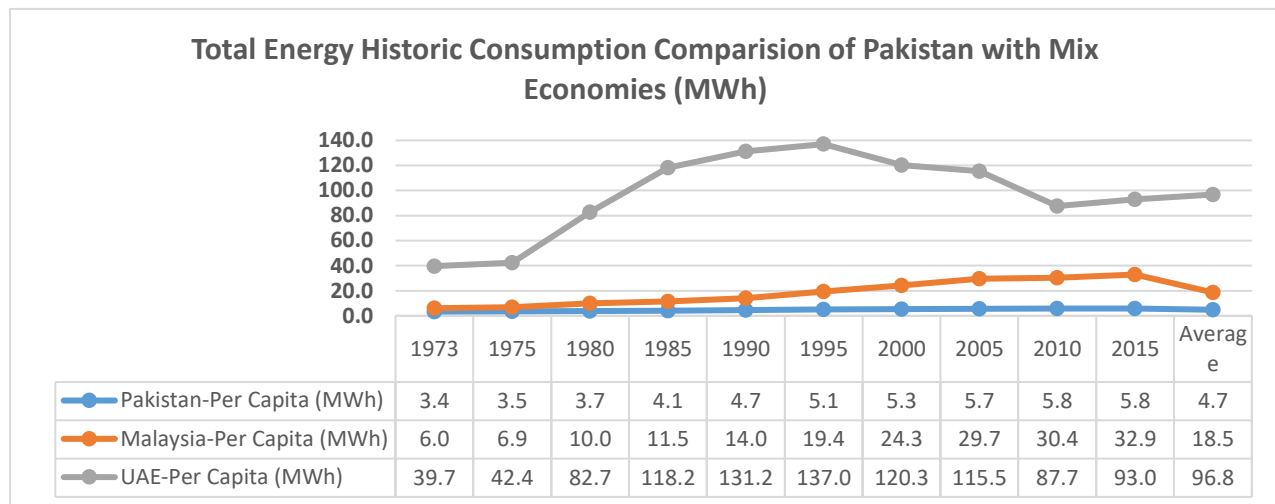
**4.3 Mix Economy (Services & industrial sector) Pakistan is compared to the UAE & Malaysia**

**4.3.1 Overall Energy consumption per capita, Pakistan, Malaysia and UAE**

UAE and Malaysian economies are mostly dependent on their Industrial and Services

Sectors (Figure 8). The average energy consumption of Pakistan per capita is 4.7 MWh in the last four decades (1973-2015), while Malaysian and UAE average energy consumptions are 18.5 MWh and 96.8 MWh, respectively, which are much higher than Pakistan.

Malaysia's per capita energy consumption increased from 6 MWh to 32.9 MWh from 1973 to 2015, and the UAE's from 39.7 MWh to 93 MWh. UAE energy consumption has been decreasing in the last few years, while Pakistan's consumption increased from 1971 to 2015.



**Figure 8 Total Historic Energy Consumption Comparison of Pakistan with Mix Economies per capita, Malaysia & UAE (MWh)**

If Pakistan makes progress as a mixed economy, then its future energy consumption per capita can be compared with the current energy consumption of Malaysia and the UAE. In that case, it would need 32.9 MWh and 93 MWh, respectively, as of 2015. Having a population of 188M, it would have needed 531 Mtoe (412% more of current use) and 1503 Mtoe (1168% more of current use) when compared with Malaysia and the UAE, respectively.

If the current energy consumption of Malaysia and UAE is taken as the future energy demand of Pakistan per capita by the year 2050(305M), it would need 862.8 MToe (670) and 2439 MToe (1895%) to meet the current consumption of Malaysia and UAE.

**4.3.2 Overall Sectoral Energy Consumption, Pakistan, Malaysia and UAE**

Historically, the industrial sector of the UAE has been the largest consumer of energy, consuming an average of 60.9% of energy from 1973 to 2015. There is a decreasing trend of utilization by the industry, but still, it is the leading end user of energy, consuming 57.8% of total energy

in 2015. The commercial and services sectors have an increasing trend of energy consumption, which consumed 1.8% in 1973 and 6.0% in 2015. Transportation is the second greatest end user of energy with an average value of 27.5% from 1973-2015 (

Table 7).

Table 7 UAE's overall Historic Sectoral Energy Consumption

Year	UAE Total Energy (Mtoe)	UAE Industry (Mtoe)	Industry %	UAE Commerce +services (Mtoe)	Com. & Ser. %	UAE Transport (Mtoe)	Transport %	UAE Residential (Mtoe)	Residential %	UAE Energy Per Capita (Toe)	Per Capita of energy (MWh)	
1973	1.13	0.82	72.6	0.02	1.8	0.3	23.0	0.03	2.7	3.4	39.7	
1975	1.61	0.97	60.2	0	0.0	0.6	34.2	0.05	3.1	3.7	42.4	
1980	5.57	2.75	49.4	0.19	3.4	2.3	41.3	0.24	4.3	7.1	82.7	
1985	10.65	6.35	59.6	0.35	3.3	3.1	29.0	0.5	4.7	10.2	118.2	
1990	16.18	10.71	66.2	0.48	3.0	3.7	23.0	0.74	4.6	11.3	131.2	
1995	21.55	14.77	68.5	0.71	3.3	4.3	20.1	1.02	4.7	11.8	137.0	
2000	23.04	14.2	61.6	0.9	3.9	7.9	34.4	1.28	5.6	10.3	120.3	
2005	27.71	14.92	53.8	1.68	6.1	7.6	27.3	1.67	6.0	9.9	115.5	
2010	45.18	26.64	59.0	2.43	5.4	10.5	23.2	2.87	6.4	7.5	87.7	
2015		53.15	30.71	57.8	3.2	6.0	10.4	19.6	3.64	6.8	8.0	93.0
Average		20.6	12.3	60.9	1.0	3.6	5.1	27.5	1.2	4.9	8.3	96.8

The residential sector has an increasing trend of energy consumption, it consumed 2.7-6.8% in the last four decades, and it is not the main consumer of energy. UAE's sectoral analysis shows industry & transport are the main consumers of energy, while in Pakistan, its residential sector (average 54.8%)

The sectoral energy consumption pattern of Malaysia shows that industrial consumption is decreased it (Table 8) commercial and services sector has an increasing trend of energy consumption, consuming 8.6% (2015) of total energy

Table 8.

Comparing Pakistan with the mixed economy of Malaysia, it needs to increase its energy consumption by the industry, transport and services sectors, while at present (2015), half of its energy (54.8%) is being

Table 8.

Table 8 Malaysia's overall Historic Sectoral Energy Consumption

Year	Malaysi a Total Energy (Mtoe)	Malaysi Industr y (Mtoe)	Industr y %	Malaysia Commerc e +services (Mtoe)	Com . & Ser. %	Malaysia Transport (Mtoe)	Transport %	Malaysia Residential (Mtoe)	Residential %	Malaysian Energy Per Capita	Per Capita of energy

was 41.8% in 1973 while only consumed 29.4% in 2015. The residential sector has a similar trend; it consumed 20.6% in 1973 and only 7.78% in 2015. Whereas the transport sector has an increasing trend of energy consumption, it consumed 34.1% in 1973 and

40.9% in 2015. (

consumed by the domestic sector. If Pakistan makes progress as a mixed economy and increases its standard like Malaysia, it needs to increase its average energy consumption from 4.7 MWh to 18.5 MWh

		(MToe)								(Toe)	(MWh)
1973	4.57	1.91	41.8	0.16	3.5	1.6	34.1	0.94	20.6	0.5	6.0
1975	5.39	2.3	42.7	0.2	3.7	1.7	32.1	1.14	21.2	0.6	6.9
1980	7.17	3.06	42.7	0.2	2.8	2.1	29.8	1.4	19.5	0.9	10.0
1985	9.46	3.72	39.3	0.45	4.8	3.1	32.7	1.62	17.1	1.0	11.5
1990	13.91	5.57	40.0	0.79	5.7	4.9	35.1	1.83	13.2	1.2	14.0
1995	22.53	8.65	38.4	1.32	5.9	6.9	30.6	2.23	9.9	1.7	19.4
2000	29.76	11.75	39.5	2.21	7.4	10.8	36.3	2.65	8.9	2.1	24.3
2005	38	15.95	42.0	2.95	7.8	13.7	36.0	3.13	8.2	2.6	29.7
2010	42.48	14.93	35.1	4.3	10.1	14.9	35.1	3.57	8.4	2.6	30.4
2015	51.59	15.19	29.4	4.46	8.6	21.1	40.9	3.99	7.7	2.8	32.9
Average	22.5	8.3	39.1	1.7	6.0	8.1	34.3	2.3	13.5	1.6	18.5

4.3.3 Domestic Per Capita Electrical Energy Consumption of Pakistan, Malaysia and UAE

Malaysia and the UAE, having mixed economies, consumed 1 MWh and 3.86 MWh of domestic energy per capita by 2015.

Historically, Malaysian energy consumption of the domestic sector is increasing, while UAE’s energy consumption trends show that it was maximum in 2005(4.41 MWh) and then decreased to 3.86 MWh in 2015 *Figure 9*.

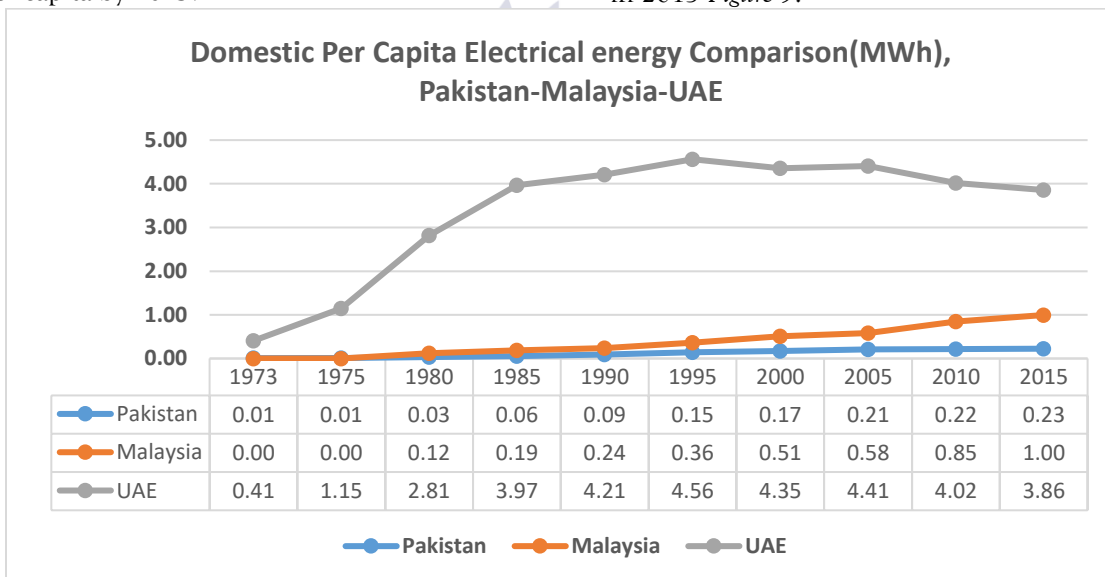


Figure 9 Total Historic Domestic Electrical Energy Consumption Comparison of Pakistan with Mix Economies per capita, Malaysia & UAE (MWh)

When the current energy consumption (2015) of Malaysia and UAE of mix economies are compared with Punjab’s domestic sector with population of 101.4M, would have needed 101400GWh and 391404GWh of electrical energy respectively.

By the year 2050, if the current utilization of Malaysia and UAE is counted as the future

demand of Pakistan, then Panjab’s domestic sector with a population of 177M would need 177000 GWh and 683220 GWh respectively.

4.4 Pakistan is compared with the Neighbouring Countries of China, India, & Iran

4.4.1 Overall Energy consumption per capita, Pakistan, India, China and Iran

In the neighbouring countries, Pakistan is compared with India, China and Iran. It is seen how much future energy Pakistan would need if it is compared with developed and developing countries in the regional context. China and Iran have grown their

per capita energy consumption from 5.6- 25.2 MWh and 7.8-34.8MWh respectively. China and Iran have approximately 51% and 40% shares of the industrial and services sector in the GDP (2016). They are consuming about twice as much energy by the industrial sector. India’s industrial sector consumes 50% more energy per capita as compared to Pakistan (Figure 10).

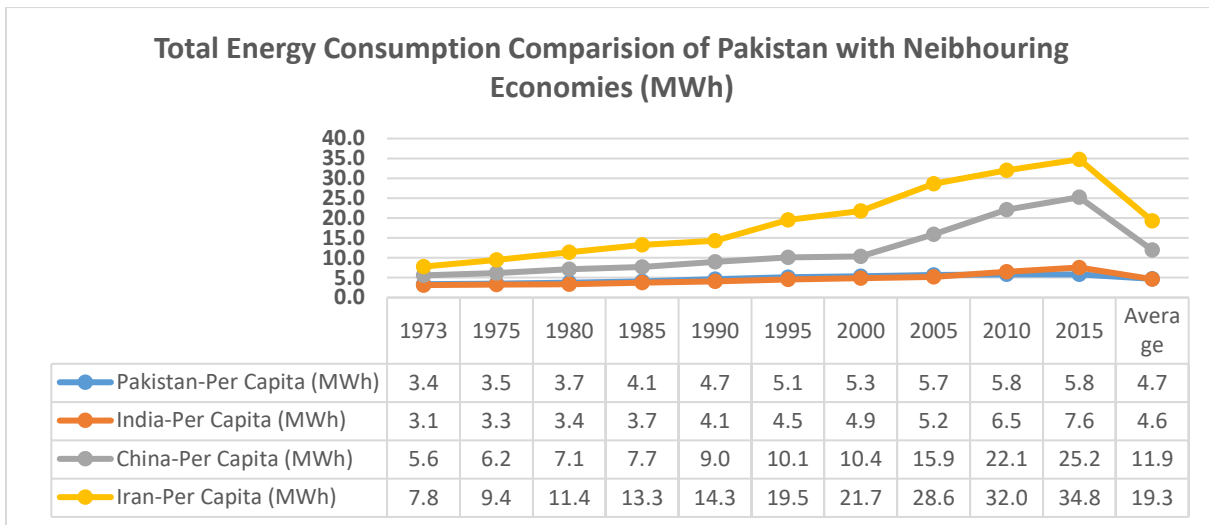


Figure 10 Total Historic Energy Consumption Comparison of Pakistan with Neighbouring Economies per capita, India, China & Iran (MWh)

The average energy consumption of Pakistan, India, China and Iran during the last four decades is 4.75, 4.6%, 11.9% and 19.3% respectively (2015).

If Pakistan is to make progress like China and Iran, it would need 407.1 MToe (316%) and 562.5 MToe (437%) as of 2015, more energy as compared to its current consumption per capita (77.7 MToe). If the current (2015) energy consumption of China and Iran is taken as the future energy demands of Pakistan per capita, then by 2050 (305M), Pakistan would need 660 MToe (512%) and 912 MToe (708.6%), as of its current energy consumption of 77.7 MToe.

Table 9).

Table 9 India's overall Historic Sectoral Energy Consumption

Year	India Total Energy (Mtoe)	India Industry (MToe)	Industry %	India Commerce +services (MToe)	Com. & Ser. %	India Transport (MToe)	Transport %	India Residential (MToe)	Residential %	India Per Capita Energy	Per Capita of energy
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India’s per capita consumption of energy (7.6 MWh) is slightly above that of Pakistan (5.8 MWh) as of 2015

4.4.2 Overall Sectoral Energy Consumption, Pakistan, India, China and Iran

Historic sectoral energy consumption patterns of India are somewhat similar to Pakistan, the residential sector being the largest consumer (47.6%), the industrial sector (27.3%) the second largest consumer and the transport sector (10.3%) the third largest sector from 1973 to 2015 (

										(Toe)	(MWh)
1973	143.3	33.9	23.7	6.2	4.3	12.5	8.7	83.2	58.1	0.3	3.1
1975	152.3	37.4	24.6	6.4	4.2	14.2	9.3	86.8	57.0	0.3	3.3
1980	173.7	41.4	23.8	2.3	1.3	16.6	9.6	97.7	56.2	0.3	3.4
1985	204.1	53.5	26.2	8.2	4.0	16.3	8.0	108.1	53.0	0.3	3.7
1990	243.2	66.7	27.4	9.2	3.8	20.9	8.6	119.7	49.2	0.4	4.1
1995	278.3	72.8	26.2	10.5	3.8	26.0	9.3	129.4	46.5	0.4	4.5
2000	315.4	83.4	26.4	10.7	3.4	32.0	10.1	141.5	44.9	0.4	4.9
2005	361.2	100.9	27.9	12.7	3.5	38.8	10.7	154.6	42.8	0.5	5.2
2010	480.4	159	33.1	18	3.7	64.2	13.4	170.9	35.6	0.6	6.5
2015	577.6	195.3	33.8	22.6	3.9	89.0	15.4	190.6	33.0	0.7	7.6
Average	293.0	84.4	27.3	10.7	3.6	33.1	10.3	128.3	47.6	0.4	4.6

While China’s industrial sector is the main consumer of average energy (40.9%) residential sector is the second largest (38.3%), and the (Table 10).

transport sector consumes an average of 8.2% in the last four decades (

Table 10 China's overall Historic Sectoral Energy Consumption

Year	China Total Energy (Mtoe)	China Industry (MToe)	Industry %	China Commerce +services (MToe)	Com. & Ser. %	China Transport (MToe)	Transport %	China Residential (MToe)	Residential %	China Energy Per Capita (Toe)	Per Capita energy (MWh)
1973	364	117	32.1	5	1.4	16.0	4.4	205	56.3	0.5	5.6
1975	410	143	34.9	5	1.2	19.0	4.6	218	53.2	0.5	6.2
1980	487	182	37.4	5	1.0	23.0	4.7	241	49.5	0.6	7.1
1985	563	200	35.5	7	1.2	29.0	5.2	269	47.8	0.7	7.7
1990	654	234	35.8	12	1.8	34.0	5.2	291	44.5	0.8	9.0
1995	780	330	42.3	19	2.4	46.0	5.9	295	37.8	0.9	10.1
2000	780	298	38.2	23	2.9	87.0	11.2	279	35.8	0.9	10.4
2005	1185	571	48.2	39	3.3	139.0	11.7	284	24.0	1.4	15.9
2010	1580	851	53.9	56	3.5	205.0	13.0	281	17.8	1.9	22.1
2015	1904	967	50.8	77	4.0	298.0	15.7	312	16.4	2.2	25.2
Average	870.7	389.3	40.9	24.8	2.3	89.6	8.2	267.5	38.3	1.0	11.9

Iran’s industrial, transport and residential sectors have had similar average consumption of energy

since 1973, consuming 23.8%, 25% and 26% respectively. There is no one sector which

is distinctly consuming the largest amount of energy (Table 11).

Table 11 Iran's overall Historic Sectoral Energy Consumption

Year	Iran Total Energy (Mtoe)	Iran Industry (MToe)	Industry %	Iran Commerce & services (MToe)	Com. Ser. %	Iran Transport (MToe)	Transport %	Iran Residential (MToe)	Residential %	Iran Energy Per Capita (Toe)	Per Capita of energy (MWh)
1973	16.6	4.7	28.3	1.5	9.0	3.4	20.5	3	18.1	0.7	7.8
1975	21.7	5.6	25.8	1.9	8.8	5.0	23.0	4.2	19.4	0.8	9.4
1980	27.7	6.8	24.5	2.9	10.5	7.1	25.6	6.3	22.7	1.0	11.4
1985	44.3	10.2	23.0	4.2	9.5	11.6	26.2	11.6	26.2	1.1	13.3
1990	54.7	14.2	26.0	4.2	7.7	13.0	23.8	12.6	23.0	1.2	14.3
1995	77.9	18.1	23.2	6.1	7.8	18.5	23.7	23.3	29.9	1.7	19.5
2000	94.7	18.5	19.5	7.5	7.9	25.5	26.9	29.6	31.3	1.9	21.7
2005	126.8	25.3	20.0	9.9	7.8	35.3	27.8	39.7	31.3	2.5	28.6
2010	158.3	38.5	24.3	11.1	7.0	40.0	25.3	46.5	29.4	2.8	32.0
2015	175.7	40.9	23.3	10.8	6.1	46.8	26.6	50.8	28.9	3.0	34.8
Average	79.8	18.3	23.8	6.0	8.2	20.6	25.0	22.8	26.0	1.7	19.3

In the neighbouring countries of Pakistan, India has similar energy consumption trends by different sectors, while China's industry is consuming more percentage of energy, Iran's sectoral consumption trend are different in a way that its transport sector is consuming more energy and residential sector is consuming less percentage of energy, while industrial sector consumed similar amount of average energy since 1973 till 2015.

#### 4.4.3 Domestic Per Capita Electrical Energy Consumption of Pakistan, India, China and Iran

In the regional context of Pakistan, India's domestic sector has consumed 0.19 MWh per capita, which is less than Pakistan, which consumed 0.23 MWh by year 2015. While China and Iran consumed 0.61 MWh and 1.08Mwh respectively, during the same year *Figure 11*.

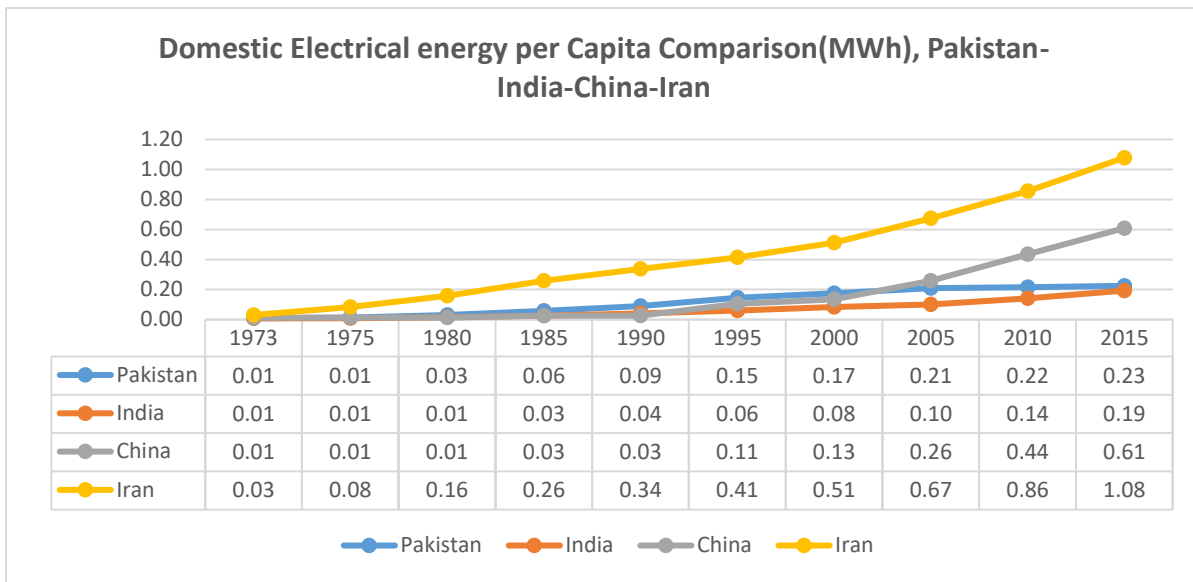


Figure 11 Total Historic Domestic Electrical Energy Consumption Comparison of Pakistan with Neighbouring Economies per capita, India, China & Iran (MWh)

Historically, Pakistan, India and China have shown an increasing trend of electrical energy consumption. In 1973, Pakistan, India and China’s domestic sectors were consuming the same amount of energy per capita. China’s energy consumption increased after 2005, with a huge increase. Historically, Iran has been consuming more domestic electricity compared with the other three countries.

If the current energy (2015) consumption of China and Iran is taken as the future energy demand of

Pakistan, then by the year 2050, Punjab’s domestic part will require (population 177M) 107970 GWh and 191160 GWh of electrical energy, respectively.

**4.5 Pakistan and Worldwide Energy Claims**

In the rapidly growing economies, the world GDP will be twice in 2040 due to the progress of underdeveloped countries, with the uplifting of 2.5 billion unprivileged people (Energy 2018). By 2035, 1751 Mtoe would be the global energy usage, the Middle East 1144 Mtoe and Asia 7684 Mtoe (Newell, Richard and Qian 2016). If the average growth rate were 3.4%, the world energy usage would rise by 30% by 2040.

Pakistan, being part of Asia (as a major future consumer), would have higher energy demands, while China & India are at the lead, whereas there would be a decline in the usage of Japan, Europe and the USA (WEO 2017).

Due to population increase and richness shortly, the building sector energy would mainly be utilised (90%) by Africa (14%), Asia(66%) and the Middle East(13%) (Energy 2018). 2/3 of the energy demand increase in 2040 is in Asia, and the overall increase in primary energy consumption would be up to 17983 Mtoe in 2040 than its value in 2016 (13276 Mtoe) (Energy 2018).

It is seen that the future increase in energy demand of the world is mainly in the Asia and middle east, there is not much increase in the US rather Europe is going to decrease its energy demand by 2040 (Figure 12&Figure 13). Pakistan is among those developing and prospering countries in the south Asia whose energy demand is going to increase in the future, and as predicted average increase of 30% till 2040, it would need 123.5 Mtoe, but the actual value may be much higher, as predicted by this research work Figure 13.

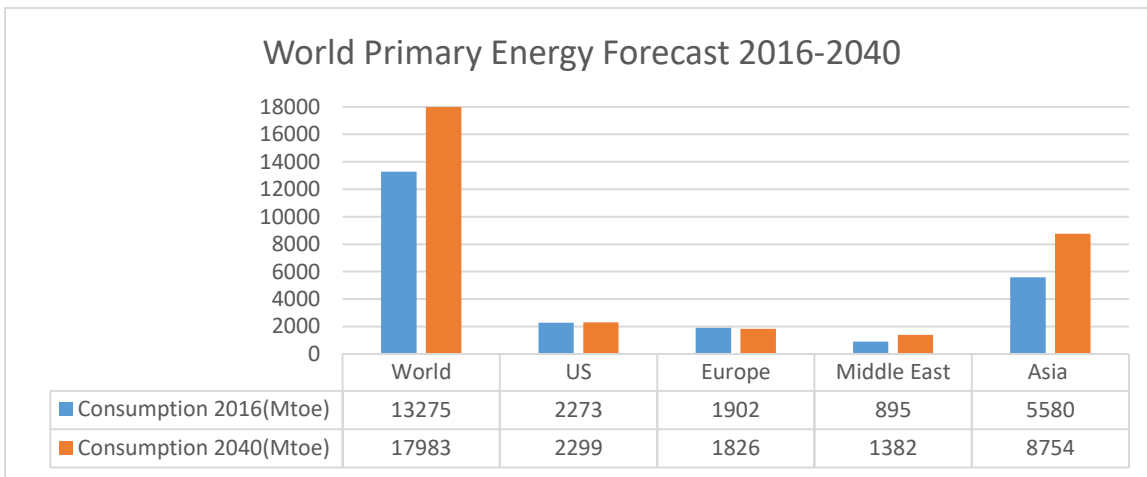


Figure 12 World Energy consumption forecast 2016-20140 source: (Energy 2018)

While comparing the energy consumption of two time periods of 1990-2016 & 2016-2040, the decreasing trend is seen in all parts of the

world. The overall energy required is increasing, but between the two time periods it is decreasing. (Figure 13)

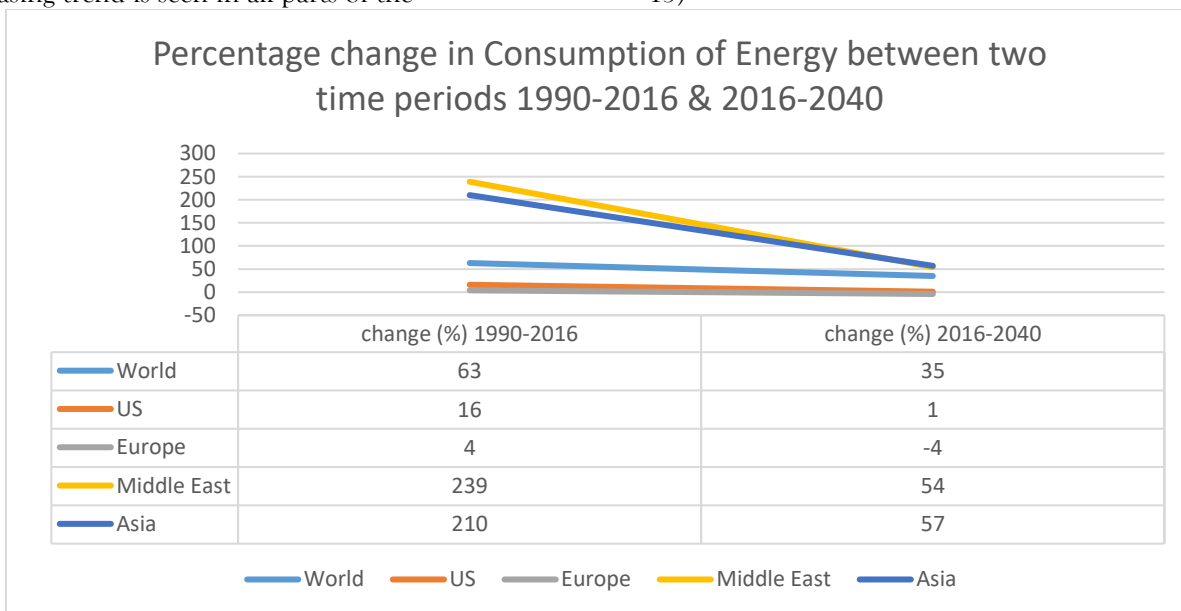


Figure 13 Percentage change in the energy consumption between two time periods 1990-2016 & 2016-2040 source: (Energy 2018)

**Discussion**

Based on the assumptions made in this research paper that if Pakistan make progress like other developed and developing countries, how much its energy consumption per capita should have been in 2015 and what it should be in the year

2050. The energy consumption per capita of different economies in the year 2015 is taken as the future energy consumption value and demand for Pakistan, as these economies have uninterrupted and advanced energy supply per capita in the year. In the projection for future energy demand, the per capita values of these compared economies in 2015 are taken, while the population projection of Pakistan in 2050 is multiplied by the per capita value of 2015.

So, the future demand is the reflection of energy consumption per capita of the compared economies in 2015.

The projected values show that when compared with services-led economies like the UK & USA, Pakistan was deficient of 444.4 Mtoe and 1201 Mtoe,

respectively, in 2015, while it only consumed 77.7 Mtoe.

**Table 12.** If the current (2015) energy consumption of the UK and USA is estimated as the future energy demand per capita of Pakistan with a population of 305M, then in the year 2050, it would need 847.1 Mtoes and 2074.4 Mtoe, respectively.

Comparing Pakistan with Kuwait & Oman, the industry-led economies, shows that in 2015, it was deficient of 1595.3 Mtoe and 984.3 Mtoe, respectively. Projecting these values of energy consumption per capita in 2050, Pakistan would require 2714 Mtoe and 1723 Mtoe when compared with Kuwait and Oman, respectively

**Table 12.** Pakistan would have needed 453.3 Mtoe and 1,425.3 Mtoe more energy in 2015 if it were to be compared with the mixed economies of Malaysia and the UAE,

respectively. Compared with the current (2015) consumption values of Malaysia and UAE per capita, Pakistan would need 862.8 Mtoe and 2439 Mtoe in the year 2050 with its population of 305 M

Table 12.



**Table 12** Compared Economies in 2015 & 2050, Pakistan's overall energy requirement per capita, while it consumed 77.7 MToe (2015)

Compared Countries	Pakistan's current energy Requirement (per capita)(2015-P-188M)	Pakistan's increase in energy, (per capita) as of 2015 consumed energy, (per capita)	Pakistan's % energy Requirement (2050-P-305M)(per capita)	Pakistan's % increase as of 2015 consumed energy by 2050 (per capita)
<b>When compared with service-led economies, while Pakistan consumed only 77.7 Mtoe (2015)</b>				
UK	522.1	572	847.1	990.2
USA	1278.7	1545	2074.4	2569.8
<b>When compared with industry-led economies, while Pakistan consumed only 77.7 Mtoe (2015)</b>				
Kuwait	1673	2053.2	2714	3393
Oman	1062	1266.8	1723	2117.5
<b>When compared with Mixed Economies, while Pakistan consumed only 77.7 Mtoe (2015)</b>				
Malaysia	531	583.4	862.8	1010.4
UAE	1503	1834.4	2439	3039
<b>When compared with Neighbouring Economies, while Pakistan consumed only 77.7 Mtoe (2015)</b>				
India	126.1	62.3	199.3	156.5
China	407.1	424	660	749.4

Iran	562.5	624	912	1073.7
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Among the neighbouring countries of India, China and Iran, Pakistan was deficient of 48.4 Mtoe, 329.4 Mtoe and 484.8 Mtoe, respectively, in 2015. With the same per capita values of

these countries (as of 2015), the projected energy requirement of Pakistan in 2050 would be 199.3 Mtoe, 660 Mtoe and 912 Mtoe if compared with India, China and Iran, respectively

Table 12.

The electricity usage of the domestic sector of Punjab is compared with developed and developing countries. To see if there would be uninterrupted power/energy supply available, how much it should be, per capita, adding up to make the complete demand by the domestic sector? Punjab is the largest province of Pakistan w.r.t population, comprising about 56%.

Table 13. Punjab domestic sector would require, till 2050, 323910GWh and 856680GWh if compared with the UK and USA, respectively (current demand of 2015), with its 177 M Population. Punjab’s per capita electricity usage was 972426 GWh and 292032 GWh less in 2015, when

When we compare Punjab with the UK & USA, service-led economies, Punjab’s domestic sector was deficient of 162238GWh and 467454GWh respectively in total, when per capita electrical energy consumed by the UK and USA is adopted for Punjab with 101.4M residents compared with that of Kuwait & Oman, industry-led economies, respectively. Further, in 2050, Punjab would need 1738140GWh and 550470GWh when compared with the current (2015) per capita domestic electricity usage of Kuwait and Oman, respectively

Table 13.

Table 13 Punjab’s overall domestic electrical energy requirement (based on per capita value), when compared with different economies of the world in 2015 and 2050, while it consumed 23322 GWh in 2015

Compared Countries	Punjab’s current domestic electrical energy Requirement (GWh)(2015-P-101.4M)(per capita)	Punjab’s % increase as of 2015(23322GWh) consumed energy,(per capita)	Punjab’s future domestic electrical Requirement (GWh)(2050-P-177M) (per capita)	Punjab’s % increase as of 2015 consumed energy by 2050 (per capita)
<b>When compared with service-led economies, while Punjab consumed only 23322 GWh (2015)</b>				
UK	185560	695	323910	1288
USA	490776	2004	856680	3573
<b>When compared with industry-led economies, while Punjab consumed only 23322 GWh (2015)</b>				
Kuwait	995748	4169.6	1738140	7352.8
Oman	315354	1252.2	550470	2260.3
<b>When compared with Mixed Economies, while Punjab consumed only 23322 GWh (2015)</b>				
Malaysia	101400	334.8	177000	659
UAE	391404	1578.3	683220	2829.5
<b>When compared with Neighbouring Economies, while Punjab consumed only 23322GWh (2015)</b>				
China	61854	165.2	107970	363
Iran	109512	369.6	191160	720

Punjab, when compared with Malaysia & the UAE, the domestic sector would have consumed 101400GWh and 391404GWh of electricity per capita, respectively, in 2015. In future, if the per capita consumption of Malaysia and UAE is taken from 2015 as the future need of Punjab's domestic sector, then it would be needed 177000GWh and 683220GWh respectively.

Table 13. India is discussed as its electricity usage per capita is less than Pakistan.

According to the analysis and results of this research, we can divide the compared countries into three groups, i.e., as per their per capita energy consumption values.

Upper consumers, like the USA, Kuwait, Oman and UAE

Medium consumers, like the UK, Malaysia and Iran  
 lower consumers like China, India and Pakistan

Comparing Punjab's domestic electrical energy needs with China and Iran shows that it was deficient of 38532 GWh and 86190 GWh, respectively, in 2015. The future need of the Punjab domestic electrical energy sector would be 107970 GWh and 191160 GWh, respectively, when per capita current consumption (2015) of China and Iran is projected as the future need of Punjab by 2050

In future, if Pakistan is to make progress like these economies of the world, on average, it must be capable of making available 2237.5 Mtoe, 874 Mtoe, and 429.5 Mtoe when compared with upper, medium and lower consumers, respectively, by 2050. (Current 2015 Pakistan uses 77.7 Mtoe)Figure 14. Similarly, the domestic sector of Punjab would need on average 957127.5 GWh, 230690 GWh and 107970 GWh, if compared with upper, medium and lower consumers, respectively, by 2050. (Current domestic sector of Punjab consumed 23322 GWh in 2015)

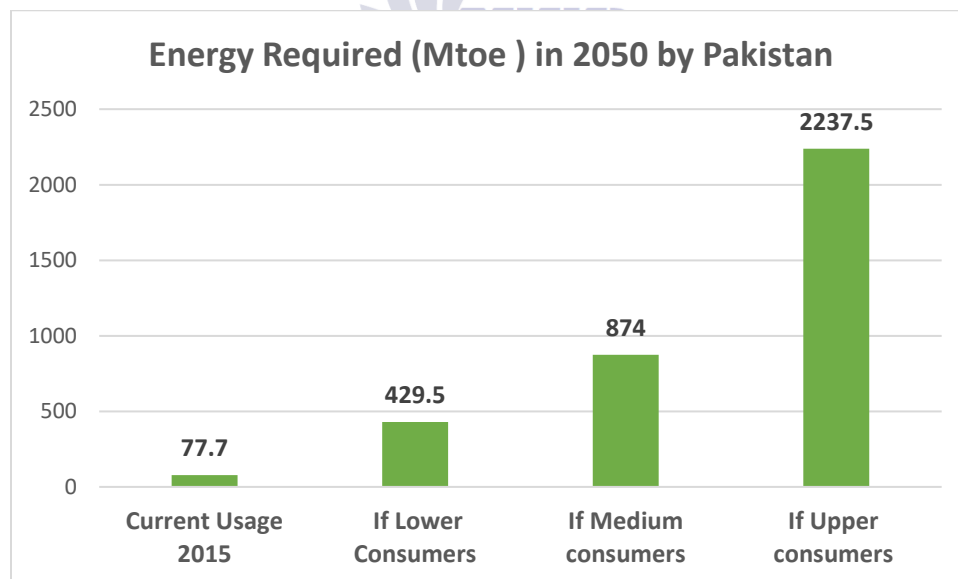


Figure 14 Energy Required by Pakistan if it develops under different Scenarios by 2050

**Conclusion & Recommendations**

Pakistan is facing a severe energy crisis at present with its rapidly growing population, urbanization, more access to energy for every citizen, modernisation, and gradual GDP growth, it certainly requires a resilient solution of energy supplies for all

its economic sectors. Historically, energy demand forecasting made, and policies adopted to overcome the energy crisis were not fruitful. One of the reasons, among others, is the wrong estimation of ever-growing energy demand by different sectors, resulting

in insufficient supplies. The data required for forecasting at the sectoral or sub-sectoral level is not intensively available or reliable. Nevertheless, in this study triggered by the current energy crisis and Pakistan's inability to forecast energy demand, forecasting of all economic sectors is done and several scenarios are presented to predict, by making assumptions and comparing Pakistan with service led, industry led, mixed and other neighbouring economies at per capita level, with uninterrupted energy supplies to all economic sectors. The energy consumption per capita in 2015 by these developed economies is taken as pivotal to represent the future energy demand per capita of Pakistan till 2050.

Looking at the results of comparison with advanced and developed economies, we are certain that the per capita current energy consumption of Pakistan is far less, implying a colossal possibility of its growth when energy is made available. According to the results, Pakistan would be consuming 2237.5 Mtoe, 874 Mtoe, and 429.5 Mtoe when compared with upper, medium and lower consumers, respectively, by 2050 if per capita consumption (in 2015) of these economies is taken as the future needs of Pakistan. Similarly, the domestic sector of Punjab would need on average 957127.5 GWh, 230690 GWh and 107970 GWh, if compared with upper, medium and lower consumers respectively by 2050. This study is a historical comparative analysis from 1973-2015 and a future energy forecast from 2015-2050 if Pakistan make progress like other developed and developing economies of the world. Pakistan is among the developing and prospering countries of South Asia, whose future energy demand is increasing.

Based on the overwhelming statistics presented here, we suggest that authorities should consider this new perspective and accommodate these new demand scenarios in the mitigation strategies and policies for addressing future needs. The road map for Pakistan regarding energy supply and demand, as followed by different economies, provides a way forward with predicted projections of demand per capita.

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