The demand for electricity in Pakistan

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Abstract

This paper examines the patterns of electricity demand in Pakistan over the period 1970–2006 using autoregressive distributed lag technique to cointegration. Long run and short-run price and income elasticities are examined for the national level and for the three major consumer's categories—households, industry and agriculture. The overall results suggest that income and price elasticities possess expected signs at aggregate and disaggregate levels in the long run as well as in the short run. The error correction terms possess expected negative signs and are highly significant with reasonable magnitudes. Furthermore, the estimated long run and short-run electricity demand functions remains stable over the sample period. The results thus convey important information to the agents operating in the electricity market regarding the pricing policies and helps in planning the future strategy of electricity demand management.

1. Introduction

It is now well recognised that energy plays a crucial role in enhancing socio-economic development. Energy has become an engine of economic growth at local and global levels. It is needed worldwide for fostering and sustaining development process. Given world economic growth coupled with an increase in population, the demand for energy is bound to increase, and meeting this demand poses serious challenges at the global level. In the coming decades, the demand for energy is expected to grow more rapidly in developing countries. Though the developing countries currently consume a limited share of the world's commercial energy, faster income growth of their economies suggests that soon they will be consuming a major share of world's energy production (Dahl, 1994). The International Energy Agency has predicted that developing countries would increase their share of global oil consumption from 20.5 per cent in 1999 to 35.8 per cent in 2020 (IEA, 2002). Total world consumption of marketed energy is expected to grow by 57 per cent from 2004 to 2030. Global energy consumption is expected to rise from 447 quadrillion British thermal units (QBtu) in 2004 to 559 QBtu in 2015 and then to 702 QBtu till 2030 (Raiz, 2008). The share of developing countries in the world's energy consumption in

1971 was only 15 per cent, which increased to 27 per cent in 1991 and was always expected to increase further; for example, to 40 per cent by the year 2010 (Schneider, 1994). Today, the share of developing countries in the world energy demand is 30 per cent and is expected to increase more than 40 per cent by the year 2030 due to high population growth and the execution of various development programmes during the coming three decades (Raiz, 2008). To meet the future energy challenges, developing countries lack necessary resources such as infrastructure, institutional framework and well-defined long-term plans. Therefore, extensive investment is needed in new generation capacity to meet the growing needs of electricity and other forms of energy in developing countries (Levine *et al.*, 1995).

The central thrust of Pakistan's energy policy has been on augmenting the country's energy system since its independence in 1947.[1] There has been substantial expansion of energy sector as a result of planning and public investment. However, despite the increase in production capacity of energy sector, Pakistan still suffers from energy shortage. This situation poses constraints on the growth of the economy and social sector development. Being a developing country, Pakistan faces the challenge of how to fuel the growth of industry and agriculture sectors for meeting growth targets and providing energy at affordable prices to poor households, especially to those living in the rural areas.[2] The availability of energy at affordable prices is a critical factor that determines a whole array of productive activities and leads to increased economic growth and reduces poverty (Siddiqui, 2004).[3] At national level, efforts are being made to utilise the existing energy resources more efficiently through the improvements in technology and controlling cost of energy and its wastage (Siddiqui, 2004; Raiz, 2008).[4]

Today, the energy sector in Pakistan faces serious challenges, namely, how to expand and improve the delivery of energy services to different sections of the society and economy in an environmentally and socially acceptable manner. This is indeed a big challenge and it will require a package of strategies designed to meet the country's energy needs. The second main challenge is the lack of Research and Development in the energy sector. It is now well documented in the literature that technological advancement enhances energy-related benefits and reduces costs and risks. Research on energy-related issues is likely strengthening the technological base, capabilities and innovation capacity in the country, which in turn enhances competitiveness.

The third challenge is the price distortions arising from the administrated energy prices. The energy-pricing policies have a direct impact on the development of the energy sector, because the viability of the public sector, as well as private sector participation, hinges upon the pricing policies vis-à-vis energy sector. In Pakistan, energy prices are highly subsidised and non-transparent for some sectors and compensated by overpricing from others.[5] The industrial sector is cross-subsidizing the energy supplied to the other sectors. The agriculture sector is the main beneficiary, and one-third of the energy supply is to the agriculture sector that earns very low revenue. The current electricity pricing policy is based on the principle to cover all operating and capital costs. Since March 2001, automatic tariff adjustment policy for fuel cost variations has been adopted and applied every 3 months (Malik, 2007). Furthermore, low-income groups do not receive subsidy benefits and are forced to use fuel such as dung, firewood and kerosene that are unsubsidised and their prices are higher than that of natural gas and electricity (Qureshi, 2007). This type of pricing mechanism is used as a social policy instrument to influence fuel consumption. So there is a need to review current subsidised and non-transparent pricing policies and rationalise tariff structure.

The energy demand literature suggests that income and price elasticities have been used to understand demand patterns and to undertake other activities such as forecasting, demand management and policy analysis (Bose and Shukla, 1999). Reliable income and price elasticities are more relevant in designing public policies on restructuring because price is the major component of reform (Narayan and Smyth, 2005). This information is also important in formulating appropriate income and pricing policies. In this context, the accurate estimates of income and price elasticities for the different sectors would be very valuable (Bose and Shukla, 1999).

Extensive research work has been carried out to examine the determinants of electricity demand in both developed and developing countries. For example, studies by Edmonds and Reilly (1985), Ibrahim and Hurst (1990), Pourgerami and von Hirschhausen (1991), Donatos and Mergos (1991), Ang *et al.* (1992), Balabanoff (1994), Silk and Joutz (1997), Brenton (1997), Pesaran *et al.* (2001), Bose and Shukla (1999), Hunt *et al.* (2000), Akmal and Stern (2001), Filippini and Pachauri (2004), Holtedahl and Joutz (2004), Narayan and Smyth (2005), De Vita *et al.* (2006), Yoo *et al.* (2007) and Ziramba (2008). These studies suggest the price elasticity of demand is negative and long-term price and income elasticities are greater than short-run elasticities. Furthermore, income elasticity of electricity used for residential purpose is positive. However, there is very little analytical work available for Pakistan *inter alia* by Riaz (1984), Iqbal (1983, 1986), Chisti and Mahmud (1990), Burney (1990), Siddiqui and Haq (1999), Ahmad (2000) and Looney (2007). Siddiqui and Haq (1999) examine electricity demand function at aggregate and disaggregate levels. They conclude that at aggregate level, output, price and number of consumers are the major determinants of electricity demand. The results of these studies are spurious because of the use of traditional estimation techniques. The present study is an improvement over the previous studies in terms of longer span of data series and estimation technique, such as cointegration, which addresses the issue of spurious regression and boosts the reliability of results.

The main purpose of this paper is to examine the determinants of demand for electricity in Pakistan at aggregate as well as disaggregate levels over the period 1970–2006 within the framework of autoregressive distributed lag (ARDL) approach to cointegration.

This study makes two main contributions in the existing literature. First, we formulate the electricity demand function for both aggregate and disaggregate levels by introducing average weather conditions along with the real income and real price of electricity—this formulation is quite different from the earlier studies carried out in Pakistan. Second, we implement ARDL technique to cointegration, which estimates the long run and short-run relationships simultaneously.

The rest of the paper is organised as follows. An overview of the energy market in Pakistan is given in Section 2. Section 3 contains a brief overview of the electricity sector in Pakistan. Section 4 deals with the model specification, methodology and data issues. Empirical results are presented in Section 5, while concluding remarks along with some policy implications are given in the final section.

2. An overview of energy market in Pakistan

All economies need an ever-increasing supply of energy for their socio-economic development. Pakistan has been facing severe imbalance between energy demand and energy supply. During the past 25 years, energy supply in Pakistan has been increased by around 40 times, but still the demand outstrips supply. With the increase in economic activities, per capita energy consumption had also been increased. Industrialisation, growth in agriculture and services sectors, urbanisation, rising per capita income and rural electrification has resulted in a phenomenal rise in energy demand (National Bank of Pakistan, 2008). Inefficient use of energy and its wastages has further widened the demand–supply gap and exerts strong pressure on the energy resources in the country.

The annual growth of primary energy supply increased from 3.17 per cent to 4.3 per cent during the years 1997–1998 and 2006–2007. The share of natural gas reached to 48.5 per cent, followed by oil (30.0 per cent), hydroelectricity (12.6 per cent), coal (7.3 per cent), nuclear electricity (0.9 per cent), liquefied petroleum gas (LPG) (0.5 per cent) and imported electricity by 0.1 per cent during the year 2006–2007. **Table 1** presents the shares of primary energy supply in Pakistan.

It can be clear from Table 1 that energy production in Pakistan is highly dependent on oil and gas, which together contribute more than 77 per cent of the total primary energy supplied. The average share of gas and oil are, respectively, 44.36 per cent and 32.58 per cent during the period 1997–1998 until 2006–2007. The remaining sources of energy supply consist of hydroelectricity and coal, and their shares in total energy supply are around 12 per cent and 6 per cent, respectively, during the corresponding period. During 2006–2007, total primary energy supply was 60,387,776 tons of oil equivalent (TOE). However, the energy supply for the final consumption is equal to 36,005,255 TOE. **Table 2** provides the details of primary energy balance sheet for the years 2005–2006 and 2006–2007.

Table 1 Percentage share of primary energy supply (in TOE)

Source/year	Oil	Gas	LPG	Coal	Hydroelectricity	Nuclear electricity	Imported electricity*	Total	Annual growth (%)
1997–1998	43.5	37.6	0.4	5.1	13.1	0.2	0.0	100.0	3.17
1998–1999	42.7	38.7	0.4	5.1	12.8	0.2	0.0	100.0	3.93
1999–2000	43.4	40.5	0.5	4.7	10.7	0.2	0.0	100.0	3.48
2000–2001	43.4	41.4	0.3	4.5	9.2	1.1	0.0	100.0	2.83
2001–2002	40.8	42.7	0.4	4.9	10.0	1.2	0.0	100.0	1.53
2002–2003	38.3	43.8	0.4	5.4	11.3	0.9	0.0	100.0	4.38
2003–2004	29.9	49.7	0.4	6.5	12.7	0.8	0.0	100.0	8.02
2004–2005	29.4	50.3	0.4	7.6	11.0	1.2	0.0	100.0	9.25
2005–2006	28.4	50.4	0.4	7.0	17.7	1.0	0.1	100.0	4.18
2006–2007	30.0	48.5	0.5	7.3	12.6	0.9	0.1	100.0	4.33
Average	32.58	44.36	0.37	5.8	12.11	0.77	0.1	100.0	4.51

Source: Pakistan Energy Yearbook 2003, 2005, 2006 and 2007.
* Indicates the Water and Power Development Authority-imported electricity from Iran since October 2002.
LPG, liquefied petroleum gas; TOE, tonne of oil equivalent.

Table 2 Primary energy balance sheet

Energy supplies	2005–2006 Total energy (in TOE)	2006–2007 Total energy (in TOE)
Net primary energy supplies	57,855,120	60,387,776
Energy transformed	–16,828,316	–17,910,766
Transport and distribution losses	–2,214,302	–2,226,442
Auxiliary consumption of energy sector	–698,606	–746,904
Consumption of non-energy uses	–4,036,832	–3,792,693
Spare by-product electricity from PASMIC	–16,551	–11,157
Statistical differences	–114,826	305,442
Final energy supply for use	33,945,689	36,005,255
Sectoral uses of final energy		
Domestic	7,054,587	7,605,145
Commercial	1,247,992	1,377,247
Industrial	14,654,360	15,792,049
Agriculture	732,699	767,266
Transport	9,493,667	9,721,183
Other Government	762,384	742,364

Source: Pakistan Energy Yearbook 2006 and 2007.
TOE, tons of oil equivalent; PASMIC, Pakistan Steel Mills Corporation.

It is now globally recognised that energy plays an important role in the production process. In Pakistan, agriculture, industry, trade and services sectors have been growing rapidly over the past few years. Given the pace of economic growth, energy demand is expected to increase. During the 1980s, about 86 per cent of the energy demand was met by domestic sources of energy, and the remaining 14 per cent gap was filled by the imports. Since then, the demand–supply gap has been widening and reached around 47 per cent by the end of 2000 (State Bank of Pakistan, 2006). At present, Pakistan meets 75 per cent of its energy needs by domestic resources including gas, oil and hydroelectricity production. However, to sustain the economic growth rate of over 7 per cent over the next 25 years, Pakistan needs to expand its energy resource base. **Table 3** highlights the percentage share of the source-wise energy consumption in Pakistan during the period 1997–1998 until 2006–2007.

Table 3 suggests that the average percentage share of oil in energy consumption was 40.9 per cent during 1997–1998 until 2004–2005, followed by gas (34.6 per cent), electricity (15.7 per cent), coal (7.5 per cent) and LPG (1.3 per cent) during the same period. Significant changes took place among the intersectoral patterns of energy consumption. The change in pattern is evident from the data presented in **Table 4**.

Table 3 Energy consumption by source in Pakistan (in % of total TOE)

Source/year	Oil	Gas	LPG	Coal	Electricity	Annual growth (%)
1997–1998	46.9	31.3	0.9	5.4	15.5	3.2
1998–1999	47.7	31.0	1.0	5.7	14.6	3.3
1999–2000	47.3	32.0	1.0	5.0	14.7	4.9
2000–2001	45.9	32.2	1.1	5.1	15.7	–0.1
2001–2002	43.3	33.5	1.3	5.8	16.1	1.4
2002–2003	41.3	34.6	1.3	6.4	16.3	2.8
2003–2004	38.5	34.8	1.3	9.3	16.2	10.2
2004–2005	36.5	36.2	1.4	10.3	15.6	10.9
2005–2006	32.0	39.3	1.8	10.6	16.2	5.7
2006–2007	29.4	40.8	1.8	11.5	16.4	6.1
Average	40.9	34.6	1.3	7.5	15.7	4.7

Source: Pakistan Energy Yearbook 2003, 2005, 2006 and 2007.
TOE, tons of oil equivalent; LPG, liquefied petroleum gas.

Table 4 Energy consumption by sector (% of total energy)

Sector/year	Domestic	Commercial	Industrial	Agriculture	Transport	Other government	Annual growth
1997–1998	22.9	2.9	34.4	3.5	33.5	3.2	3.2
1998–1999	22.2	3.1	34.4	3.0	34.4	3.0	3.3
1999–2000	22.6	3.1	34.4	2.7	34.8	2.7	4.9
2000–2001	23.1	3.1	34.1	2.6	34.4	2.7	–0.1
2001–2002	23.0	3.2	34.4	2.7	33.6	3.1	1.4
2002–2003	23.2	3.2	35.4	2.6	33.3	2.2	2.8
2003–2004	21.7	3.2	38.3	2.5	32.0	2.3	10.2
2004–2005	21.2	3.4	39.8	2.2	31.4	2.1	10.8
2005–2006	20.8	3.7	43.2	2.5	28.0	2.3	5.7
2006–2007	21.1	3.8	43.9	2.1	27.0	2.1	6.1
Average	22.2	3.3	37.2	2.6	32.2	2.5	4.7

Source: Pakistan Energy Yearbook (various issues).

It is evident from Table 4 that on average, the industrial sector consumed 37.3 per cent of energy, followed by the transport sector with share 32.2 per cent and domestic sector with share 22.2 per cent. The agriculture sector, government and the commercial sector, respectively, consumed 2.6, 2.5 and 3.3 per cent. Though the annual growth rate of energy consumption has come down from 10.8 per cent in 2004–2005 to 6.1 per cent at the end of

2006–2007, still at present, Pakistan faces a deep energy crisis due to demand–supply gap. To steer the economy out of this crisis and to meet the future challenges, there is an urgent need to expand and upgrade the domestic resource base, accelerate exploitation and exploration of additional indigenous resources, increase the share of coal and hydroelectric in the energy mix, promote alternative renewable energy sources, improve energy efficiency and conversation, promote public private partnership in the energy sector and insure the necessary human resource development.

The per capita consumption of energy by different sources of energy is reported in **Table 5**. In is clear from Table 5 that per capita consumption of oil during 1997–1998 and 2003–2004 fell from 4.0 kg to 1.6 kg, whereas per capita consumption of natural gas stood constant at 1.0 million Btu. The per capita consumption of LPG and electricity shows an increasing trend.

Pakistan's economy has been growing at an average of 7.6 per cent per year over the last 3 years. To sustain future growth over 7 per cent, the demand for energy is expected to grow at 1.2 times the economic growth rate, amounting to over 8 per cent growth per year (ISSI, 2007b).[6] However, the gap between energy consumption and energy production has been widening year by year and creating an alarming situation for the country (Looney, 2007). It is clear from **Fig. 1** that the gap between supply and demand of energy has increased overtime. The average supply and demand of energy is equal to 0.90 QBtu and 1.38 QBtu for the period 1980–2005. According to Pakistan's Energy Security Plan (2005–2030), the total primary energy consumption in Pakistan is expected to increase sevenfold from 55 million TOE (MTOE) to 360 MTOE, and over eightfold increase in the requirement of power by 2030 (ISSI, 2007b). Thus, the country would be facing the shortage of more than 31 per cent of energy in the future.

In Pakistan, the current energy crisis stems from the decline in hydro sources of energy and over-reliance on the expansive source of electricity. Presently, oil-based thermal plants account for 68 per cent of generating capacity, hydroelectric plants for 30 per cent and nuclear plants for only 2 per cent (Looney, 2007). This has led to huge generation costs, which in turn adversely affect the economy over the past 8 years. Rise in the oil prices are pushing the electricity tariff to very high rates. As a result, manufacturing costs and inflation are at the rising trend, export competitiveness is eroded and the pressure on the balance of payments is increasing. These factors adversely affect the present growth trajectory of the economy (Omar, 2005; Looney, 2007; National Bank of Pakistan, 2008).

Among all sources of energy, electricity is a very important source of power. Consumption of electricity by households sectors, industrial sector and agriculture sector occupies an important role among other sources of energy. Khagram (2004) argues that electricity is the cheapest and cleanest source of energy. It also has massive implications for infrastructure requirements to meet the growing electricity demand in the future.[7] Presently, annual demand for electricity is increasing by around 10 per cent per annum, and the shortage of

Table 5 Per capita household energy consumption

Parameter	1997–1998	1998–1999	1999–2000	2000–2001	2001–2002	2002–2003	2003–2004
Population (in million)	113	133	136	140	143	147	150
Oil (kg)	4.0	3.8	3.6	3.3	2.4	2.0	1.6
Gas (MMBtu)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
LPG (kg)	1.2	1.2	1.3	1.4	1.8	1.8	1.9
Electricity (kWh)	114	146	157	163	162	161	172

Source: Household Use of Commercial Energy (Report No. 320/06, World Bank).
MMBtu, million British thermal units; LPG, liquefied petroleum gas.

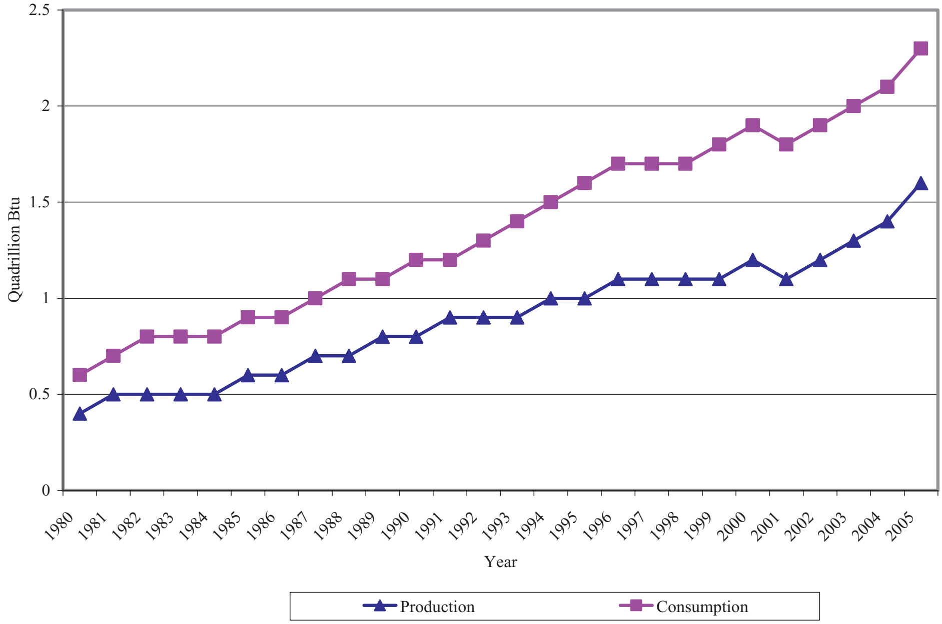


Figure 1 Energy production and consumption since 1980–2005 [in quadrillion British thermal units (Btu)].

electricity power ranges between 1500 megawatts (MW) to 2300 MW during the peak summer. The need of electrical power will keep on increasing year after year because of the expansion of economic activities, increase in population, overall development and high consumption. In this situation, the analysis of the electricity demand carries useful implications for Pakistan. On one hand, it provides information regarding income and price elasticities of electricity demand, which are more relevant for designing the pricing policies. On the other hand, ever increasing demand for electricity stimulates the government and policy makers to reformulate the future water and other resource management strategies.

3. Overview of electricity sector in Pakistan

At the time of independence in 1947, the power generation capacity of Pakistan was only 60 MW for a population of 31.5 million, with a per capita consumption of 4.5 units. However, the power sector gained momentum in 1970, and the installed capacity rose from 636 MW in 1970 to 1331 MW in 1975. In 1980, the system capacity touched 3000 MW, and thereafter it rapidly grew to over 8000 MW by 1990–1991 (Government of Pakistan, 2008).

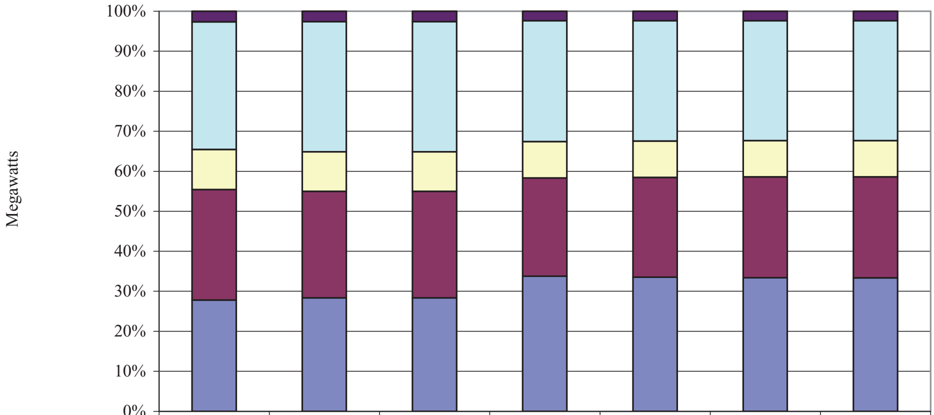
Table 6 (a) Power plants and grid of utilities (in MW). (b) Electricity generation (in million kWh)

(a)	Installed capacity (2006)				Installed capacity (2007)			
Utilities	Thermal	Hydro	Nuclear	Total	Thermal	Hydro	Nuclear	Total
WAPDA	4,900	6499	325	11,724	4900	6479	325	11,704
KESC	1756	—	137	1893	1756	—	137	1893
IPPs	5833	—	—	5833	5822	—	—	5822
Total	12,489	6499	462	19,450	12,478	6479	462	19,420
(b)	Electricity generation (2005–06)				Electricity generation (2006–07)			
Utilities	Thermal	Hydro	Nuclear	Total	Thermal	Hydro	Nuclear	Total
WAPDA	22,508	30,862	2341	55,711	21,597	31,953	2099	55,649
KESC	9130	—	143	9273	8169	—	189	8358
IPPs	28,645	—	—	28,645	34,206	—	—	34,206
Total	60,283	30,862	2,484	93,629	63,972	31,953	2288	98,213

Source: Pakistan Energy Yearbook 2006 and 2007.
MW, megawatts; WAPDA, Water and Power Development Authority; KESC, Karachi Electricity Supply Corporation; IPP, Independent Power Plants.

At present, electricity demand is 13,021 MW, which is expected to increase in the coming years. Responsibility for the generation and supply of electricity rests with two utilities—the Pakistan Water and Power Development Authority (WAPDA) and the Karachi Electricity Supply Corporation (KESC). WAPDA supplies electricity throughout the country while KESC is responsible for supplying electricity to Karachi and its adjoining areas. The Pakistan Atomic Energy Commission owns nuclear power plants, which are connected to WAPDA and KESC networks. The Independent Power Plants (IPPs) are connected to the national grids at various locations. The total installed generation capacity is around 19,420 MW and the customer base is about 17.73 million in 2007–2008 (Government of Pakistan, 2008). **Table 6** and **Fig. 2** provides the full description of installed capacity of electricity and electricity generation by source.

The current installed capacity of electricity is about 19,420 MW. During the year 2006–2007, the power system generated 98,213 million kWh of electricity (Table 6) of which 64.3 per cent comes from thermal plants, while hydroelectricity and nuclear power account for 33.4 and 2.4 per cent, respectively. Pakistan's total generation capacity has increased rapidly due to the establishment of IPPs; this almost eliminated the power shortage in the 1990s. The supply of hydroelectricity is season dependent and decreases by about 3000–4000 MW when the water level in the dams gets low during winter. The effective generating capacity of WAPDA's power plants has decreased slightly. In the past several years, the installed capacity has been insufficient to meet the demand. Current



	2001	2002	2003	2004	2005	2006	2007
Nuclear	462	462	462	462	462	462	462
Thermal (IPPs)	5583	5795	5794	5808	5832	5833	5822
Thermal (KESC)	1756	1756	1756	1756	1756	1756	1756
Thermal (WAPDA)	4830	4735	4735	4735	4835	4900	4900
Hydel (WAPDA)	4867	5051	5051	6496	6499	6499	6479

Year

Figure 2 Installed capacity of electricity by source.

supply is estimated at 15,055 MW against demand of more than 17,600 MW. A deficit of 2500 MW was recorded through load shedding, which reduced the industrial growth and adversely affected the economy. Many villages do not enjoy access to electricity, and only 60 per cent of the population are connected to the national grid.

The percentage share of electricity consumption by different sectors of the economy is shown in **Figs. 3 and 4** covering the periods 1970–2000 and 2001–2006, respectively. Figure 3 shows that during the period 1970–2000, the industrial sector consumed 35 per cent of electricity, followed by households (33 per cent), agriculture sector (17 per cent), 8 per cent by bulk and the commercial sector by 6 per cent. However, during 2001–2006, the electricity consumption of households dramatically increased to 47 per cent. During the same period, the industrial and agriculture sectors consumption reduced to 33 and 11 per cent, respectively. Commercial sector consumption remained at 6 per cent while bulk share in consumption reduced to 6 per cent.

Similarly, during 2006–2007, household electricity consumption remained dominant (46 per cent), followed by industrial sector (29 per cent), agriculture sector (11 per cent), commercial sector (7 per cent), bulk supplies (6 per cent) and street lights (1 per cent) (Hydrocarbon Development Institute of Pakistan, 2007). Thus, the huge increase in household consumption of electricity is the major reason for the demand–supply gap.

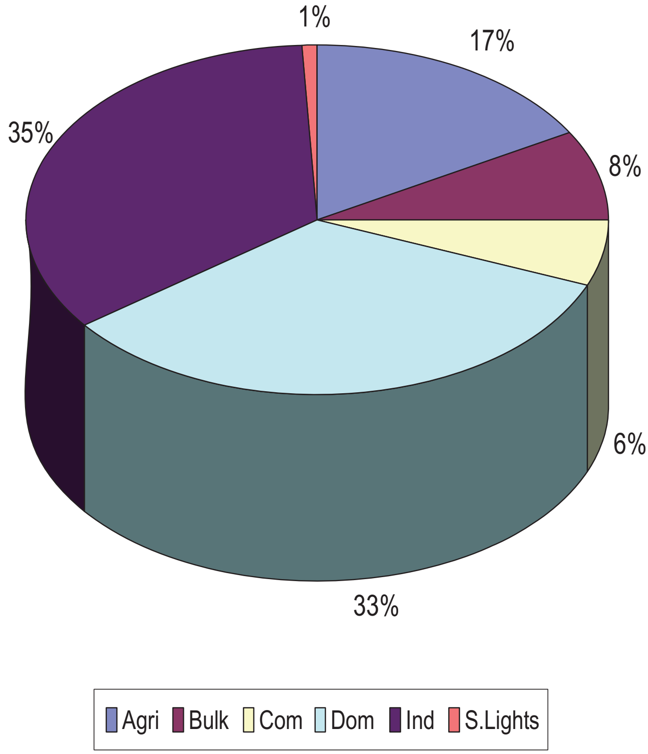


Figure 3 Sectoral consumption of electricity from 1970–2000.

The total installed power generation capacity is insufficient to meet the growing needs of the country and has hit the economy badly. The growing electricity demand–supply gap has forced the authorities to resort to load shedding for very long duration. This has adversely affected the public, businesses and trading communities. To tackle the power crisis, the government has to come up with mega hydroelectric projects and encourage domestic and foreign investors to invest in the energy sector and extend and improve the nuclear power generation.[8]

4. Model, methodology and data

Following Bentzen and Engsted (1993), Beenstock *et al.* (1999), Clements and Madlener (1999), Silk and Joutz (1997), Al-Faris (2002), Narayan and Smyth (2005), De Vita *et al.* (2006), Dergiades and Tsoulfidis (2008) and Ziramba (2008), we specify the following electricity demand function for Pakistan:

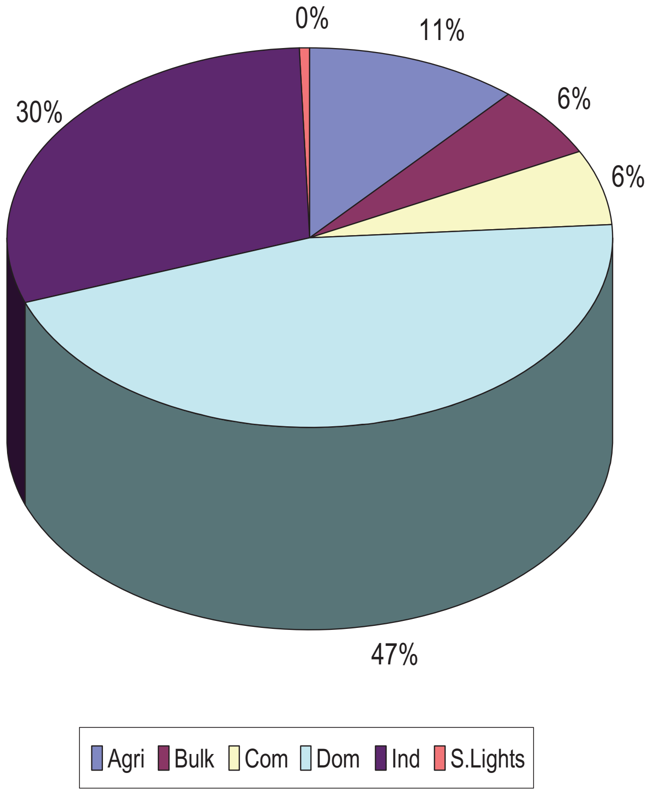


Figure 4 Electricity consumption by sectors from 2001–2006.

$$ed_t^j = \beta_0 + \beta_1 ry_t^j + \beta_2 ep_t^j + \beta_3 cus_t^j + \beta_4 temp_t + \varepsilon_t \quad (1)$$

where ed_t, ry_t, ep_t, cus_t and $temp_t$ are, respectively, electricity demand, real income, real price of electricity, number of customers and temperature at time t. ε_t is the random term assumed to be white noise and normal and identically distributed.[9] $j = T, H, A, I, C$ denotes the aggregate electricity demand, households electricity demand, agriculture sector demand, industrial sector demand and commercial sector demand, respectively. The lowercase letters represent the logarithmic values of the variables included in Equation (1). According to economic theory, higher income is expected to increase electricity consumption through greater economic activities and increased purchases of electrical equipment, so $\beta_1 > 0$. A rise in electricity prices leads to fall in electricity demanded, therefore, $\beta_2 < 0$. Similarly, the higher the number of customers, the higher will be the demand for electricity, hence $\beta_3 > 0$. The expected sign of $\beta_4 > 0$ because as the temperature changes, the use of electricity also increases because of greater use of appliances such as air conditioners and heaters.[10]

The dynamic electricity demand model is specified following the modelling approach proposed by Pesaran *et al.* (2001). Assume that:

$$z_t = (ed_t, ry_t, ep_t, cus_t, temp_t)' = (ed_t, x_t')'. \tag{2}$$

The unconditional error correction model of electricity demand can be written as:

$$\Delta ed_t^j = c_0 + c_1 t + \boldsymbol{\pi}_{ed} ed_{t-1}^j + \boldsymbol{\pi}_{edx,x} \mathbf{x}_{t-1}^j + \sum_{i=1}^{\rho-1} \boldsymbol{\psi}_i' \Delta \mathbf{z}_{t-1}^j + \boldsymbol{\omega}' \Delta \mathbf{x}_t^j + u_t. \tag{3}$$

Here Δ denotes the first difference operator. The parameters $\boldsymbol{\pi}_{ed}$ and $\boldsymbol{\pi}_{edx,x}$ are long-run multipliers. c_0 is the drift and t is the time trend. Lagged values of Δed_t and the current Δx_t and lagged values of Δz_t are used to model the short-run dynamic structure. To test the cointegration relationship between ed_t and x_t using bound testing procedure, we examine the joint hypotheses in Equation (3). The null hypotheses are:

$$H_0^{\pi_{ed}} : \boldsymbol{\pi}_{ed} = 0,\ H_0^{\pi_{edx,x}} : \boldsymbol{\pi}_{edx,x} = 0'$$

and the alternative hypotheses are:

$$H_1^{\boldsymbol{\pi}_{ed}} : \boldsymbol{\pi}_{ed} \neq 0,\ H_1^{\boldsymbol{\pi}_{edx,x}} : \boldsymbol{\pi}_{edx,x} \neq 0'.$$

This specification assumes that error terms, u_t's are white noise. In this regard, the ρ (order of vector autoregression) is very important and it should be selected carefully. The F-statistic is non-standard distribution and depends on the unit root properties of the data, that is, the variables included in the model are I (0) or I (1) and the number of regressors. The critical values for upper and lower bound are available in Pesaran and Shin (1999) and Pesaran *et al.* (2001). If the calculated F-stat lies above the upper bound, the hypothesis of no cointegration can be rejected.

Having identified the evidence of cointegration relationship, the next step is to select the optimal ARDL specification of Equation (1) on the basis of lag selection criteria such as the Akaike Information Criterion or Schwarz Bayesian Criterion (SBC).[11] A general representation of *ARDL* (p, q, r, s, m) model is given by:

$$ed_t^j = b_0 + \sum_{i=0}^{p} b_{1i} ed_{t-i}^j + \sum_{i=0}^{q} b_{2i} ry_{t-1}^j + \sum_{i=0}^{r} b_{3i} ep_{t-1}^j + \sum_{i=0}^{s} b_{4i} cus_{t-1}^j + \sum_{i=0}^{m} b_{5i} temp_{t-i} + \boldsymbol{\eta}_t. \tag{4}$$

The long-run multiplier can be obtained as:

$$\beta_0 = \left(b_0 \Big/ 1 - \sum_{i=1}^{p} b_{1i} \right) \text{ and } \beta_k = \left(b_n \Big/ 1 - \sum_{i=1}^{p} b_{1i} \right)$$

with $k = 1, \ldots, 4$ and $n = 2, \ldots, 5$.

Finally, the short-run dynamic coefficients for the optimal ARDL can be obtained by the estimation of following restricted error correction model:

$$\Delta ed_t^j = d_0 + \sum_{i=1}^{p} d_{1i} \Delta ed_{t-i}^j + \sum_{i=0}^{q} d_{2i} \Delta ry_{t-i}^j + \sum_{i=0}^{r} d_{3i} \Delta ep_{t-i}^j + \sum_{i=0}^{s} d_{4i} \Delta cus_{t-i}^j + \sum_{i=0}^{m} d_{5i} \Delta temp_{t-1} + \boldsymbol{\lambda} ec_{t-1} + \boldsymbol{\omega}_t \quad (5)$$

where ec_{t-1} is the error correction term and $\boldsymbol{\lambda}$ is the speed of adjustment towards the long-run equilibrium after a shock.

The study is based on the annual data covering the period 1970–2006. The data are collected from different sources. Gross Domestic Product at current factor cost is taken from the State Bank of Pakistan (2006) and *Pakistan Economic Survey* (various issues). The series of consumer price index is taken from *International Financial Statistics* (i.e. *IFS CD-ROM*). Data on temperature are taken from the *Pakistan Economic Survey* (various issues). Data on electricity consumption, number of customers and real prices (aggregate and disaggregate) are taken from *Water and Power Development Authority* (various issues) and *Pakistan Energy Yearbook* (various issues).

5. Empirical results

Testing for the presence of cointegration between electricity demand, real prices of electricity, real income, number of customers and average temperature is carried out by estimating Equation (3) using ordinary least squares technique. Boswijk and Franses (1993) emphasised that dynamic specification can affect the size and power of the cointegration tests. Bentzen and Engsted (1993) used only single lag. However, we have started with four lags for all the specifications—aggregate, households, commercial, industrial and agriculture—and used minimum values of SBC and Lagrange multiplier statistics to obtain optimal lag length. Based on the general-to-specific modelling approach advanced by Hendry (1986), we removed insignificant variables in the cointegration tests. For the presence of cointegration between electricity demand, real income, real price of electricity, number of customers and average temperature, we test the hypothesis $\boldsymbol{\pi}_{ed} = \boldsymbol{\pi}_{ed,x} = 0$ against the alternative that at least one of these coefficients is different from zero. The F-statistics that we have obtained for the aggregate and sectoral electricity demand functions at different lag lengths are displayed in **Table 7**.

As evident from Table 7, the calculated F-statistics lie above the upper bound of the critical values, supporting the evidence of cointegrating relationship between the variables at aggregate level, households, industrial and agriculture sectors. However, no evidence of

Table 7 Bound test of cointegration

Equation	Variables included	Test statistic	Optimal lag
1	$(ed^T \mid ry^T, ep^T, cus^T, temp)$	38.48*	4
2	$(ed^H \mid ry^H, ep^H, cus^H, temp)$	31.46*	3
3	$(ed^C \mid ry^C, ep^C, cus^C, temp)$	2.35	3
4	$(ed^I \mid ry^I, ep^I, cus^I, temp)$	4.10*	3[a]
5	$(ed^A \mid ry^A, ep^A, cus^A, temp)$	6.77*	3[a]

Note: Critical values are given in Pesaran *et al.* (2001). T, H, C, I and A stand for total, household, commercial, industrial and agricultural sectors, respectively.

[a] For the industrial and agriculture sectors, average temperature possesses a theoretical inconsistent sign and is statistically insignificant. Therefore, we left out this variable from the industrial and agriculture sectors demand analysis. The exclusion of this variable does not affect the cointegrating relationship for electricity demand for industrial and agricultural sector. F-statistics for industrial sector is 3.70 and for agricultural sector, is 4.82. These statistics are higher than the upper bound of the critical values calculated by Pesaran *et al.* (2001), thus rejecting the hypothesis of no cointegration.

* Indicates significant at the 1 per cent level.

cointegration exists in the case of commercial sector because the calculated F-statistic lies below the lower bound of the critical value.

After obtaining the supportive evidence of cointegration between electricity demand, real income, real price of electricity, number of customers and average temperature, we obtained long run and short-run elasticities by estimating Equation (4) using SBC criterion for the selection of lag order. The estimated long-run electricity demand and the dynamic electricity demand equations are presented in **Tables 8–11**.[12] All parameters are significant and have signs that are consistent with economic theory. The estimated equations pass all the diagnostic tests including the Cumulative Sum of Recursive Residuals and Cumulative Sum of Squares of Recursive Residuals tests of stability.[13]

5.1. Aggregate electricity demand

The results reported in Table 8 show that the aggregate demand for electricity is significantly determined by real income, real price of electricity and average temperature in the long run. The income elasticity of electricity demand has a positive sign and is statistically significant. The size of the income elasticity is 4.7 in the long run. This implies that electricity is a normal good and its demand increases with income.[14] The price elasticity of demand for electricity is significant with a negative sign and is equal to −1.64. This implies that at aggregate level, electricity is a luxury rather than a necessity. This could be justified on the grounds that in Pakistan, more than 70 per cent of the population are residing in rural areas and some villages have not been electrified as yet. Hence, electricity is a necessary good for the urban population and a luxury good for the rural population. The

Table 8 Long run and short-run elasticities of aggregate electricity demand function in Pakistan

Aggregate electricity demand

$$ed^T = -38.16 + 4.72ry^T - 1.64ep^T - 1.41cus^T + 3.52temp$$
$$(-3.66)^* \quad (2.73)^* \quad (-3.69)^* \quad (-1.49) \quad (2.59)^*$$

Error correction model for aggregate electricity demand

$$\Delta ed_t^T = -8.82 - 0.18\Delta ed_{t-1}^T + 0.39\Delta ed_{t-2}^T + 0.41\Delta ed_{t-3}^T + 1.09\Delta ry_t^T$$
$$(-3.86)^* \; (-2.89)^* \quad (5.70)^* \quad (6.60)^* \quad (5.57)^*$$
$$-0.16\Delta ep_t^T - 0.13\Delta ep_{t-1}^T + 0.31\Delta ep_{t-2}^T + 0.23\Delta ep_{t-3}^T + 0.65\Delta cus_t^T$$
$$(-3.01)^* \quad (-2.65)^* \quad (5.81)^* \quad (3.92)^* \quad (5.12)^*$$
$$+0.63\Delta cus_{t-1}^T - 0.34\Delta cus_{t-2}^T + 1.85\Delta cus_{t-3}^T + 0.29\Delta temp_t - 0.23\Delta temp_{t-1}$$
$$(2.44)^{**} \quad (-1.29) \quad (8.56)^* \quad (2.75)^* \quad (-1.34)$$
$$+0.29\Delta temp_{t-2} + 0.62\Delta temp_{t-3} - 0.23ec_{t-1}^T$$
$$(2.44)^{**} \quad (7.46)^* \quad (-3.86)^*$$

$\bar{R}^2 = 0.96$, SE regression = 0.01, F-stat = 46.74, Durbin–Watson stat = 2.36

Note: Figures in parenthesis are the t values.
*, **, *** Indicate significance at the 1, 5 and 10% levels of significance, respectively.
SE, standard error.

Table 9 Long run and short-run elasticities of households electricity demand function for Pakistan

Households electricity demand

$$ed^H = -18.06 + 0.92ry^H - 0.25ep^H + 0.78cus^H + 0.98temp$$
$$(-21.10)^* \quad (3.71)^* \quad (-6.90)^* \quad (3.81)^* \quad (2.72)^*$$

Error correction model for households electricity demand

$$\Delta ed_t^H = -11.70 - 0.25\Delta ed_{t-1}^H + 0.28\Delta ry_t^H + 0.65\Delta ry_{t-1}^H + 0.67\Delta ry_{t-2}^H - 0.07\Delta ep_t^H$$
$$(-5.58)^* \; (-3.45)^* \quad (1.10) \quad (2.28)^{**} \quad (2.27)^* \quad (-1.32)$$
$$-0.083\Delta ep_{t-1}^H + 0.208\Delta cus_t^H + 0.355\Delta temp_t - 0.645ec_{t-1}^H$$
$$(-1.59)^{***} \quad (1.03) \quad (2.64)^* \quad (-5.85)^*$$

$\bar{R}^2 = 0.96$, SE regression = 0.02, F-stat = 63.70, Durbin–Watson stat = 1.96

See notes below Table 8.
SE, standard error.

coefficient associated with the number of customers is negative and insignificant, while the coefficient of mean temperature is positive and statistically significant. This implies that in the long run, an increase in average temperature increases the aggregate demand for electricity.

The results further suggest that real income, real price of electricity and mean temperature is the major determinants of aggregate electricity demand in the short run. The short-run elasticities are smaller than that of long-run elasticities. Growth in the electricity consumption in the previous 3 years has significant negative and positive effects on current consumption. The sum of the impact is 0.62 and statistically significant.[15] Real income

Table 10 Long run and short-run elasticities of industrial electricity demand function for Pakistan

Industrial electricity demand

$$ed^I = -14.06 + 0.50ry^I - 0.87ep^I + 1.80cus^I$$

(−3.47)* (1.34) (−1.58)*** (2.42)*

Error correction model for industrial electricity demand

$$\Delta ed_t^I = -3.16 + 1.08\Delta ry_t^I + 0.09\Delta ry_{t-1}^I + 0.65\Delta ry_{t-2}^I - 0.20\Delta ep_t^I + 0.40\Delta cus_t^I$$

(−2.84)*(4.41)* (0.36) (3.78)* (−1.47) (2.97)*

$$- 0.22ec_{t-1}^I$$

(−2.14)**

$\bar{R}^2 = 0.59$, SE regression = 0.04, F-stat = 8.75, Durbin–Watson stat = 2.31

See notes below Table 8.
SE, standard error.

Table 11 Long run and short-run elasticities of industrial electricity demand function for Pakistan

Agriculture electricity demand

$$ed^A = -15.75 + 1.16ry^A - 0.38ep^A + 0.90cus^A - 0.89D_{98}$$

(−2.21)** (2.54)* (−2.56)** (2.21)** (−2.21)**

Error correction model of electricity demand for agricultural sector

$$\Delta ed_t^A = -5.94 - 0.28\Delta ed_{t-1}^A + 0.44\Delta ry_t^A - 0.14\Delta ep_t^A + 0.34\Delta cus_t^A$$

(−2.37)**(−1.72)*** (1.63) (−1.64)*** (1.91)**

$$- 0.09\Delta D_{98} - 0.38ec_{t-1}^A$$

(−1.38) (−2.59)**

$\bar{R}^2 = 0.53$, SE regression = 0.08, F-stat = 7.34, Durbin–Watson stat = 2.24

See notes below Table 8.
SE, standard error.

growth influences aggregate demand for electricity significantly with positive signs in the short run. The coefficient of real income is equal to 1.09. This value implies that a 1 per cent increase in the growth of real income causes the electricity demand to increase by 1.1 per cent in the short run.

The direct impact of increase in electricity price is negative and significant. However, the short-run effect is mixed (negative in the first year and positive in the second and third years), but the overall effect of real price changes on electricity demand is positive and equal to 0.25 and statistically significant. This implies that electricity is a complementary good rather than a substitute in the short run. Furthermore, in short run, as the number of customers increases, the demand for electricity increases by 2.8 in overall terms. This relatively large effect could be due to increased use of appliances and electricity-intensive goods and services. Finally, changes in average temperature will lead to increase the demand for electricity by 0.97.

The error correction term is –0.23 and statistically significant. This implies that if consumption deviates from the long-run equilibrium by 1 per cent, then 23 per cent of these deviations are eliminated in 1 year to achieve the long-run equilibrium level.

5.2. Households electricity demand

The long run and short-run elasticities of households electricity demand are reported in Table 9. It is clear from Table 9 that real income is positively related to electricity consumption for households in the long run. The long-run income elasticity is 0.92. This implies that electricity is a normal good for households because it increases with the level of income. The price elasticity is negative and statistically significant but less than unity (i.e. –0.25). This implies that for the households, electricity is a necessary good in the long run. Moreover, the low price elasticity implies that a substantial upward tariff adjustment has to be initiated to curtail electricity consumption. Similarly, the number of customers in the households sector and the average temperature exert positive and significant effects on households electricity demand in the long run.

In the short run, growth of current and lagged real income exerts positive and significant impacts on households electricity demand. Real price change lagged by 1 year effects the households electricity demand negatively. However, the coefficient of lagged real price change is –0.08 and significant only at the 10 per cent level, showing a weak relationship between households electricity consumption and prices in the short run. This means that households electricity demand is price inelastic in the short run and upwards tariff adjustment is needed to curtail the consumption. The average temperature exerts positive and significant impact on the electricity demand for household sector. The effect of electricity users is, although positive, insignificant. The error correction term is equal to –0.65, suggesting a relatively faster speed of adjustment towards the long-run equilibrium level.

5.3. Industrial sector electricity demand

Table 10 presents the results of electricity demand for industrial sector. It can be seen from the results that income elasticity of electricity demand for industrial sector is positive but statistically insignificant. The real price elasticity of electricity is less than unity. This implies that for the industrial sector, electricity is a necessary good in the long run. The number of electricity users in the industrial sector exerts positive and significant effect on electricity demand.

In the short run, overall impact of real income is positive and statistically significant on the electricity demand for industrial sector. However, the short-run price elasticity for industrial sector is –0.20 and statistically insignificant. The number of customers exerts positive impact on electricity demand in the industrial sector. The error correction term is –0.22, suggesting that the speed of adjustment towards the long-run equilibrium is slower.

5.4. Agricultural demand

Table 11 reports the estimates of long run and short-run elasticities of electricity demand for agricultural sector. The income elasticity of electricity consumption in agricultural sector is positive and greater than unity (i.e. 1.16). This implies that as the productivity activities in the agriculture sector increases, the electricity consumption also increases. The real price elasticity is –0.38, implying that real price exerts negative effect on the electricity demand in agriculture sector. Some outliers are seen in the data between 1998 and 2001. To correct the outliers, we have used a dummy variable (D98). The dummy variable is significant and has negative impact on electricity demand in the long run.

In the short run, real income exerts positive but insignificant impact on electricity demand of agricultural sector. This result suggests that real productivity of agriculture sector plays no role to effect the electricity consumption in the short run. The short-run price elasticity is –0.14 and statistically significant. This means that the demand for electricity with respect to prices is inelastic in the short run. This implies that an upward tariff adjustment may initiate to curtail consumption. The number of customers exerts positive impact on the demand for electricity in the agriculture sector. The coefficient of error correction term is –0.38. This indicates that 38 per cent of the previous period's deviations are eliminated per year to restore long-run equilibrium.

The general conclusions emerge from this study are: first, stable long run as well as short-run electricity demand functions exists for Pakistan at aggregate and disaggregate levels over the period of study. Second, the long-run income elasticity of aggregate demand for electricity is statistically significant and lies above unity (i.e. 4.72). Similarly, income elasticity of electricity for households and agriculture sectors are 0.92 and 1.16, respectively. The results suggest that electricity consumption of household and agriculture sector is highly responsive to the changes in income. Third, households sector electricity demand is price inelastic (i.e. the long-run price coefficient is –0.25) in the long run. Fourth, the numbers of customers exert positive and significant impact on electricity demand at aggregate and disaggregate levels. Fifth, the short-run electricity demand functions are income elastic and real price changes play a significant role in the determination of short-run demand while change in the number of customer also have great impact on short-run demand in almost all the cases. Finally, long-run elasticities are larger than that of short-run elasticities, which means that income and pricing policies have great impact over time. As time passes, consumers will have more flexibility to curtail their demand through conservation in response of higher tariffs.

Our findings appear to have significant policy implications, particularly with respect to the revenue generation and regulations in the energy system in Pakistan. For example, if the government wants to increase its tax revenues, relatively more tax could be charged on the households sector than on other sectors, because our results show that the price elasticity for households sector is lower than other sectors. However, it is very difficult for the government to impose higher taxes on the household sector because this would adversely affect the welfare of the poor. The price for industrial sector cannot be increased because this would erode industrial competitiveness of exports and would enhance the use of fuel substitutes like kerosene and firewood. This in turn would contribute to severe deforestation with undesirable ecological effects (Haider, 2003). Furthermore, raising energy prices would be inflationary and adversely affects economic growth and employment. Hence, the government subsidises electricity to alleviate poverty and curb inflation. However, there is a need to adopt a more transparent and predictable energy pricing policy after thoroughly analysing the costs and benefits of subsidising electricity consumption.

6. Conclusions and policy implications

Electricity is an important source of energy in Pakistan. The growth in various sectors of the economy leads to higher demand for the energy, especially the electricity, which is viewed not only as a clean and cheaper source of energy, but also have massive implications for building and strengthening the infrastructure requirements to meet the growing needs of electricity in future. To assess future electricity demand, accurate knowledge of income and price elesticities is essential. For this purpose, we have estimated the electricity demand function for Pakistan at aggregate level and for subgroups of electricity users, such as households, industry and agriculture. The results suggest that in almost all categories, the income and the number of customers exert positive impact on electricity demand in the long run as well as in the short run. The price of electricity exerts negative impact on electricity demand in the long run at aggregate as well as for subgroups of electricity users. The error correction terms possess negative signs and are highly significant. The magnitude of the error correction terms is reasonable in terms of size, suggesting a moderate and reasonable speed of adjustment towards the long-run equilibrium.

The findings of the present study carry important policy implications for Pakistan. The estimates of electricity demand equations can be used for the policy purposes, since these are stable and do not suffer from any structural break. Given that our results suggest that increase in the number of electricity users and changes in pricing policy can increase revenue both in the long run and in the short run, the argument for policy relevance gains more strength. To design electricity pricing policy, up-to-date estimates of price and income elasticities of electricity demand that this study provides will prove useful. The policy makers and private investors could benefit from this study because it provides useful information regarding the market for electricity consumption.

Notes

1. The national energy policy is based on national energy security and regional energy cooperation, and the success of national energy policy is based on three main pillars: (i) ensuring availability of sufficient energy on sustainable basis and at affordable prices; (ii) ensuing stable and secure conditions for uninterrupted supply of energy; and (iii) ensuring environmental protection while maximising energy output and utilisation (see ISSI, 2007a).
2. Rural women are less informed about the social, financial and material impacts of efficient use of energy. Furthermore, women are more susceptible to indoor air pollution due to burning of bio mass, crop residues, untreated coal and other conventional means of energy generation for household purposes. Besides leaving homes for seeking bio mass and other conventional energy stuff, rural women invite harassment and other security threats. Energy consumption behaviour also affects the health, education and upbringing of children and the productivity of male workers. Therefore, provision of clean renewable technologies significantly affects the socio-economic position of women, men and children. Access to electricity will facilitate the rural population to seek education and awareness of health, nutrition and other social and environmental issues. Access to clean energy resources will not only help to improve the overall standards of living in the rural areas, but also reduce poverty through savings and other income generation activities.
3. The use of energy sources saves time, helps people in improving the quality of life and environment, improves the delivery of better quality social services, increases the duration of working hours and productivity of the rural small scale industries and generates employment (Siddiqui, 2004). Thus, the use of energy as an input directly exerts positive impact on output and indirect positive impact on poverty and quality of life through employment generation.
4. To attain maximum efficiency of existing energy utilisation, particularly in the power sector reduction in transmission and distribution losses and energy theft, the government has initiated various measures to reduce these losses. These measures include the introduction of Army Monitoring Teams to check the electricity bills, electricity theft and transmission losses (Siddiqui, 2004).
5. The average end user charge for the year 2005 is estimated around 3.93 rupees per kWh. It involve cross subsidies from industrial and commercial consumers to agriculture and small domestic consumers (using less than 50 kWh per month).
6. ISSI represents 'The Institute of Strategic Studies', Islamabad.
7. The anonymous referee suggests this point.
8. Nuclear power plants are sometimes seen as a cheap source of power generation, but taking account of full-cycle costs throws doubt on this.
9. Lowercase letters denote that the variables are expressed in logarithms.
10. This argument may be true for developed countries. But in the case of developing countries like Pakistan, changes in temperature affect electricity consumption adversely. For example, the share of hydroelectricity is more than 60 per cent and there is mismatch between the electricity consumption and electricity availability. This mismatch has been eliminated through load shedding. Another reason may be the increase in the price of electricity.

During the 1990s, majority of the farmers switched over their Tube Wells from electricity to diesel, and many industrial units partially uses generators and increases the use of gas and coal.

11. However, Pesaran and Shin (1999, p. 3) noted that ARDL based on SBC performed slightly better than ARDL based on the Akaike Information Criterion.
12. *t*-ratios are given in the parentheses.
13. The results are available from the authors.
14. Al-Faris (2002) has noted that there are three channels that link electricity consumption to income level. First, electricity is an indispensable input into the production function where increase in output necessitates a corresponding increase in output. Second, a rise in per capita income will increase the electricity use of appliances and increase demand for energy-intensive goods and services. Third, income growth is strongly correlated to capital formation and energy-driven machinery and durable equipments.
15. We report here the average values of the coefficients by summing the coefficients associated with the current and lagged variable for each variable.

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