Electricity consumption and economic growth: evidence from Pakistan

Javid, Attiya Yasmin and Muhammad, Javid and Awan, Zahid Ashraf

Pakistan Institute of Development Economics, Islamabad, Pakistan, Planning Commission, Government of Pakistan, Pakistan

19 April 2012

Economics and Business Letters
1(3), 16-27, 2012

Electricity consumption and economic growth: evidence from Pakistan

Attiya Yasmin Javid[1*] • Muhammad Javid[2] • Zahid Ashraf Awan[3]

[1] *Economics Department, Pakistan Institute of Development Economics, Islamabad, Pakistan*
[2] *Pakistan Institute Of Development Economics, Islamabad, Pakistan*
[3] *Planning Commission, Government of Pakistan, Pakistan*

Received: 19 April 2012
Revised: 1 October 2012
Accepted: pending

Abstract

The prime objective of this study is to examine the long run relationship between real GDP per capita and electricity consumption for Pakistan over the period 1971 to 2008. The results reveal that there is unidirectional causality from electricity consumption to real GDP per capita. The findings of the study also show that there is long run relationship between real GDP per capita and electricity consumption. The unidirectional causality running from electricity consumption to economic growth indicate that electricity is a limiting factor to economic growth and hence, shocks to electricity supply will have a negative impact on economic growth. The implication emerges from this study is that for electricity deficient country like Pakistan where electricity sector operates at bare capacity margin, there is need of planning and investment in infrastructure development to fulfill increased electricity demand.

Keywords: electricity consumption, economic growth, causal relationship, cointegration

JEL Classification Codes: Q43, C52

1. Introduction

In the globalizing world, rapidly increasing demand for electricity and dependency of countries on electricity indicate that electricity will be one of the biggest problems in the world in the next century. Macroeconomic growth theories in the economic literature focus on labor and capital;

[*] Corresponding author. E-mail: attiyajavid@pide.org.pk.
Citation: A.Y. Javid, M. Javid and Z.A. Awan (2012) Electricity consumption and economic growth: evidence from Pakistan, Economics and Business Letters, 1(3), 16-27.

Oviedo University Press
ISSN: 2254-4380

they do not attach necessary important to the role of energy which is important for economic growth and production (Stern and Cleveland, 2004). It is seen that electricity is the highest quality energy component and its share in energy consumption increases rapidly. Electricity consumption is considered as an indicator of socio-economic development along with its role in the production function. Recent rise in energy prices, shrinking existing resources, and the search for alternative sources of energy and energy conservation technologies have brought into focus the issue of causality between energy use and economic growth. Various studies have been applied to find the nature of casual relationship between energy consumption and economic growth. Energy is an important element for production and economic growth. This study analyzes the electricity consumption and its relationship with economic growth is Pakistan.

Pakistan currently has been going through one of its worse electricity crisis, with a shortfall of more than 5000 MW (Economic Survey of Pakistan, 2011). The resulting power cuts in the form of load shedding, not only affects the normal life of the people of the country but it also badly damages the commerce, industry, and agriculture sectors. Which have ultimately effect on economics growth of the country. This down term of economics growth has severe consequences for unemployment and socio economics condition of the country. The electricity crisis is not a recent phenomenon in Pakistan, but this power crisis particularly is result of power policy adopted in 1994. In 1994 Power Policy of the government which has opened electricity generation to the private sector. With the induction of the private sector in power generation, the fuel mix in electricity generation has changed in favor of imported furnace oil. Until 2002, this policy worked reasonably well because the oil price in international market remained low. After 2002, the international price of fuel started rising and so did the cost of electricity generation. The cost of electricity generation, however, increased drastically in 2007-08 with an unprecedented surge in international fuel prices. In response of higher cost of electricity generation, government has been rising the price of electricity continuously for last four year.

With this background, it is important for the policy makers to understand the relationship between electricity consumption and economic growth in order to design effective power policy. The general conclusion from previous studies regarding Pakistan electricity consumption and economic growth nexus is that there is no consensus on the direction of causality between electricity consumption and economic growth.

The main objective of this study is to analyze the role of electricity in the economic development process of the country. The study examines the causal relationship between electricity consumption and real GDP and the long run relationship between electricity consumption and real GDP. The dynamic relationship and forecasting between electricity consumption and real GDP is also investigated.

The study differs from earlier studies in two dimensions. First, earlier studies examine the issue of causality for Pakistan but ignore the impact of changes in other sources of economic growth. The study intends to analyze the role of electricity in economics growth while controlling for changes in primary factors of production and other sources of growth. Second, earlier studies examine the impact of total energy use on economic growth; this study will only focus on electricity. To our best of knowledge no study is available which analyze the causal relationship between electricity demand and economic growth. To test the causal relationship between electricity demand and real GDP growth, Granger causality test and the Dolado–Lutkepohl test using the Vector Autoregressive (VAR) in levels and the other is standard Granger causality test.

The study is organized as follows. After this introduction, the literature review is presented in section 2. Section 3 discusses the data and methodology, the empirical results are presented in section 4 and last section offers conclusion.

2. Literature review

The issue of demand of energy is well researched area both in the developing and developed economies. This section briefly reviews the previous empirical literature in this area. Energy is an essential input for continuation of production process and energy is the highest quality element and its share in energy consumption increases rapidly. According to study of International Energy Agency (IEA) energy is incorporated by some of the developing countries in the production function from the period 1981-2000included in the production functions of some of the developing countries for 1981–2000 period and it is included that the energy played a very major role in economic growth compared to other variables which take place in production function in the countries which are at intermediate stages of economic development economic growth compared to other variables which take place in production function in the countries which are at intermediate stages of economic development (IEA,2004). The increase in energy is expected to lead to higher growth and its deficiency may cause to slowdown the growth process as well as the economic growth may affect the demand for energy significantly (Siddiqui,2004).

The evidence for Pakistan also reveals that energy consumption affects economic growth significantly and there is bi directional causality between economic growth and consumption of petroleum products and no causal relationship between natural gas consumption and economic growth (Butt and Aqeel, 2001).The evidence at the sectoral level shows that the use of energy affects the growth of manufacturing sector of Pakistan, However the substitution possibilities are limited among energy and non-energy inputs and between electricity and gas for the period 1972-93 (Mahmud, 2000).

Many studies have examined the causal relationship between energy consumption and economic growth. In disaggregated level, electricity consumption not only related to economic wealth but also an indicator of socioeconomic development, has been of another interest. Electricity consumption especially, which is not only related to economic wealth but also an indicator of socioeconomic development, has been of another interest. For instance, Ferguson et al. (2000) finds that there is strong correlation between electricity use and economic development study covering in over 100 countries. They have concluded that there is a strong correlation between electricity use and wealth creation. Since correlation analysis does not involve causality, recent studies, for example (Ghosh, 2002; Shiu and Lam, 2004; Moritomo and Hope, 2004; Jumbe, 2004; Wolde-Rufael, 2004; Narayan and Smith, 2005; Yoo, 2005; Altinay and Karagol, 2005) have focused on the casual relationship between electricity consumption and economics growth for several developing countries. This kind of information is useful for making assumption about the energy policy implication. We find very mixed results from previous studies, there is no consensus neither on the existence nor on the direction of causality. Table 1 reports the results from some recent studies.

Table 1. Evidence from some selected studies

Authors	Variables	Methodology	Country & period	Findings
Jamil and Ahmad (2010)	GDP, electricity price, electricity consumption	Johansen Cointegration, VECM Granger causality	Pakistan 1960-2008	GDP cause EC. Growth in output in commercial, manufacturing and agriculture sectors tend to increase EC
Khan and Qayyum (2009)	GDP, electricity price, electricity consumption, number of customers, temperature	ARDL	Pakistan 1970-2006	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 disaggregate level.
Aqeel and Butt (2001)	Per capita GDP, per capita energy, gas, electricity, & petroleum consumption	Cointegration test Hsiao's version of Grange causality	Pakistan 1956-1996	GDP cause energy consumption GDP cause petroleum consumption EC cause GDP No causality in gas consumption and GDP
Mehrara (2007)	GDP per capita, Energy consumption per capita	Panel Cointegration, Panel Granger causality	Oil exporting countries 1971-2002	Unidirectional causality from economic growth to energy consumption
Narayan and Smyth (2008)	GDP, energy consumption, gross fixed capital (all in per capita)	Panel Cointegration with and without structural break, Panel causality	G 7 Countries 1972-2002	Capital formation, energy consumption and GDP are cointegrated Capital formation and energy consumption cause real GDP positively in the long run.
Ozturk and Acaravci (2010)	GDP, Carbon dioxide emission, energy(all in per capita) consumption, Employment ratio	ARDL	Turkey 1968-2005	Neither carbon emission nor energy consumption cause GDP. Employment ratio cause GDP
Ghosh (2002)	Per capita GDP, Pper capita electricity Consumption	Engel-Granger approach Standard Granger Causality	India 1950-1997	No cointegration Unidirectional causality from EC to GDP
Shiu and Lam (2004)	Real GDP Electricity Consumption	Johansen Cointegration	China 1971-2000	EC cause GDP
Morimoto and Hope (2004)	Real GDP , Electricity production	Granger Causality	Sri Lanka 1960-1998	Electricity production cause GDP

To our best of knowledge no study is available which analyze the causal relationship between electricity demand and economic growth. Two different methodologies are employed to test the causal relationship between electricity demand and real GDP growth. One is Granger non-causality: the Dolado–Lutkepohl test using the Vector Autoregressive (VAR) in levels and the other is standard Granger causality test.

3. Methodology and data

There are two main approaches to analyzing the causal relationship between income and energy consumption in empirical studies i.e. multivariate approach and bivariate approach. Stern (1993) uses variable vector autoregressive (VAR) model for the USA in the post-war period other studies like Stern (2000), Oh and Lee (2004), and Narayan and Smyth (2005), used multivariate model. These studies usually investigate the relationship between GDP and energy within a production function model. In multivariate model studies includes GDP, energy, labour capital, and technological change.

On the other hand several studies use a bivariate model in detecting the causality between GDP and electricity. For example, Ghosh (2002), Soytas and Sari (2003), and Yoo (2005) among others have focused just on the directionality of causality. To simplify the analysis we have adopted a bivariate approach in detecting the direction of causality between the total electricity consumption and the real GDP in Pakistan.

Causality testing in Granger sense is conventionally conducted by estimating autoregressive or vector autoregressive (VAR) models. Based upon the Granger Representation Theorem, Granger (1988) shows that if a pair of I(1) series are co-integrated there must be a unidirectional causation in either way. Thus, a usual methodology of testing for causality between two time series involves pre-testing for a unit root and co-integration. Conditional upon the results of the unit root test, that are usually the Dickey-Fuller type tests in practice, then a co-integration test, either the Engle–Granger or the Johansen test, is applied to the pair of series. If co-integration exists, the causality test may be conducted in two ways. First, the integrated data may be used in levels in a bi-variate autoregressive model, due to the super consistency properties of estimation in case of co-integration. Secondly, a bi-variate model containing error correction mechanism terms due to the Granger Representation Theorem may be used in causality testing. If the data are integrated but not co-integrated, then causality tests can be conducted by using the first differenced data to achieve stationarity (see Oxley and Greasley, 1998 for a review of causality tests).

Data on electricity consumption in unit's kilowatt hours (KWh) and real GDP per capita are taken from world development indicator over the period 1960 to 2008.

In order to test the direction of causality between electricity consumption and real GDP, first we use the Granger causality test then to find the long run relationship between electricity consumption and real GDP, Engel and Granger co integration test has been used in the study. Finally Structural Vector Autoregressive (SVAR) has been used for forecasting. In granger causality test we can check the direction of causality between two variables. The granger causality test assume that the information relevant to the prediction of the respective variables in our case Electricity consumption and real GDP, contained solely in time series data on these variables. The Test involves estimating the following Pair of regression.

$$lgdp_t = \alpha_1 + \alpha_2 lec_t + \varepsilon_{1t}$$
$$lec_t = \beta_1 + \beta_2 lgdp_t + \varepsilon_{2t} \quad (1)$$

Where $lgdp_t$ and lec_t are log of real GDP per capita and log of electricity co*nsumption ε_{1t} and ε_{2t} are uncorrelated disturbances. For the existence of long run relationship both variables should be non-stationary at level and stationary at first difference.

$$\varepsilon_{1t} = lgdp_t - \alpha_1 - \alpha_2 lec_t$$
$$\varepsilon_{2t} = lec_t - \beta_1 - \beta_2 lgdp_t \quad (2)$$

If ε_{1t} and ε_{2t} are stationary at level, then we can conclude that both variables are co-integrated.

Cointegration approach

To test the long run relationship between two variables in Engel Granger co integration approach, all the variables must be non-stationary at level and become stationary after taking first difference and their linear combination is stationary at level.

Unit Root Test

The use of time series data necessitates the investigation of unit roots in variables as a first step. The augmented Dickey-Fuller (ADF) is used to test the time series properties of the data.

Vector error correction mechanism (VECM)

When two variables are co integrated that is there is a long run relationship between the two. However there may be disequilibrium in the short run. Therefore error term can be considered as equilibrium error and this error term can use to tie the short run behavior of the dependent variable to its long run behavior. The well known Granger representation theorem states that if two variables are co integrated and integrated of order one i.e. I(1), then the relationship between the two can be expressed as ECM. VECM is therefore, specified to detect the direction of causality in co-integrated vectors.2 if variables are I(1) and co-integrated, then Granger Representation. In an error correction model, the error in previous period ε_{1t-1} and ε_{2t-1} summarizes the corrections towards the long-run equilibrium. The VECM in two variables case can be written as follows:

$$\Delta lgdp_t = \alpha_1 + \sum_{i=1}^{m} \alpha_{11} \Delta lgdp_{t-i} + \sum_{i=0}^{n} \alpha_{12} lec_{t-i} + \delta 1 \varepsilon_{1t-1}$$
$$\Delta lec_t = \alpha_1 + \sum_{i=0}^{m} \alpha_{11} \Delta lgdp_{t-i} + \sum_{i=1}^{n} \alpha_{12} lec_{t-i} + \delta 2 \varepsilon_{2t-1} \quad (3)$$

The optimal lag length to be used in the error correction model has been determined using SBC criterion. The speed of adjustment coefficients δ_1 and δ_2 are very important implications for the dynamics of the system. If δ_1 and δ_2 are negative and statistically significant then VECM exist and it support the long run relationship.

4. Empirical results

The use of time series data necessitates the investigation of unit roots in variables as a first step. The augmented Dickey-Fuller (ADF) is used to test the time series properties of the data. Results reported in Table 2show that both variables are nonstationary at level but become stationary after taking first difference. Hence both the series are integrated of order one.

Table 2. Results of unit root tests

Variable	ADF		Order of Integration
	Level	First difference	
Elc	-2.003	-5.033***	(1)
Lgdp	-1.388	-5.237***	(1)

Note: The regressions in level include both intercept and trend whereas in first difference include intercept only. *** indicates rejection of null hypothesis of non-stationary of the variable at 1%level of significance.

where *Elc* is log of electricity consumption and *lgdp* is the log of real GDP. As both variables are integrated of order one justifies the use of Engel Granger approach to co-integration. In this approach, if both variables are non-stationary at level and become stationary after taking the first difference and their linear combination is integrated of order zero, i.e. I (0).
This study examines the causal relationship between electricity consumption and real GDP per capita. Lag order is selected on the basis of AIC and SBC criteria. Both criteria show that lag order is one.

Table 3. Granger causality test

Null Hypothesis:	Obs	F-Statistic	Probability	Decision
LGDP does not Granger Cause LELEC	37	0.98363	0.46338	Do not Reject
LELEC does not Granger Cause LGDP		3.21787	0.02361	Reject

The results reported in Table 3 show that there is unidirectional casualty and it runs from electricity consumption to real GDP per capita. It implies that high electricity consumption cause high real GDP per capita, because electricity is an important input in the production function.

Table 4. Modeling electricity consumption

Variable	Coefficient	Standard Error	t-Statistic	Probability
lec_t	0.341493	0.024429	13.97886	0.0000
C	2.614347	0.253736	10.30343	0.0000
AR(1)	0.787421	0.132422	5.946303	0.0000
Adj R^2 = 0.99				
DW=1.74				

The residual term ε_{1t} obtained from the above regression model is stationary at level and result is reported in following equation.

$$\varepsilon_{1t} = -0.91076\varepsilon_{t-1} \qquad \tau = -5.1869 \qquad R^2=0.43 \quad DW= 1.96$$

ε_{1t} is stationary at level show that there is long run relationship between electricity consumption and real GDP per capita income over the period studied.

Table 5. Result of ECM (ΔLGDP)

Variable	Coefficient	Standard Error	t-Statistic	Probability
$\Delta LGDP_{t-1}$	1.116868	0.491553	2.27212	0.0304
$\Delta LGDP_{t-2}$	0.396544	0.142022	2.792119	0.0090
ΔLELEC	0.142798	0.059736	2.390475	0.0233
$\Delta LELEC_{t-1}$	0.317627	0.17394	1.82608	0.0778
Ecm_{t-1}	-1.097266	0.519746	-2.11116	0.0432
Adj. R^2 = 0.18				

Results reported in Table 5 show that coefficient of residual term is negative and significant which confirm short run adjustment and support the results of long run relationship between electricity consumption and real GDP per capita.

Table 6. Modeling GDP per capita (Elc)

Variable	Coefficient	Standard Error	t-Statistic	Probability
C	6.071522	2.951393	2.057172	0.0474
LGDP	0.929931	0.370575	2.509428	0.0170
AR(1)	0.97113	0.013771	70.51747	0.0000
Adj. R^2 = 0.997015				
D-W = 2.064884				

The residual term ε_{2t} obtained from the above regression model is stationary at level and result is reported in following equation.

$$\varepsilon_{2t} = -1.06032\varepsilon_{2t-1} \qquad \tau = -6.3925 \qquad R^2=0.54 \quad DW= 1.95$$

Table 7. Results of vector error correction model (dependent variable: D_LELEC)

Variable	Coefficient	Standard Error	t-Statistic	Probability
$\Delta LELEC_{t-1}$	0.813362	0.305473	2.662634	0.0120
$\Delta LGDP$	0.549513	0.408626	1.344782	0.1882
$AR2_{t-1}$	-0.897661	0.346601	-2.58989	0.0143
C	0.000823	0.02288	0.035984	0.9715
Adj. R2 = 0.190109				
D-W = 1.667717				

Table 8. Variance decomposition and impulse response function

a) Variance Decomposition of LELEC

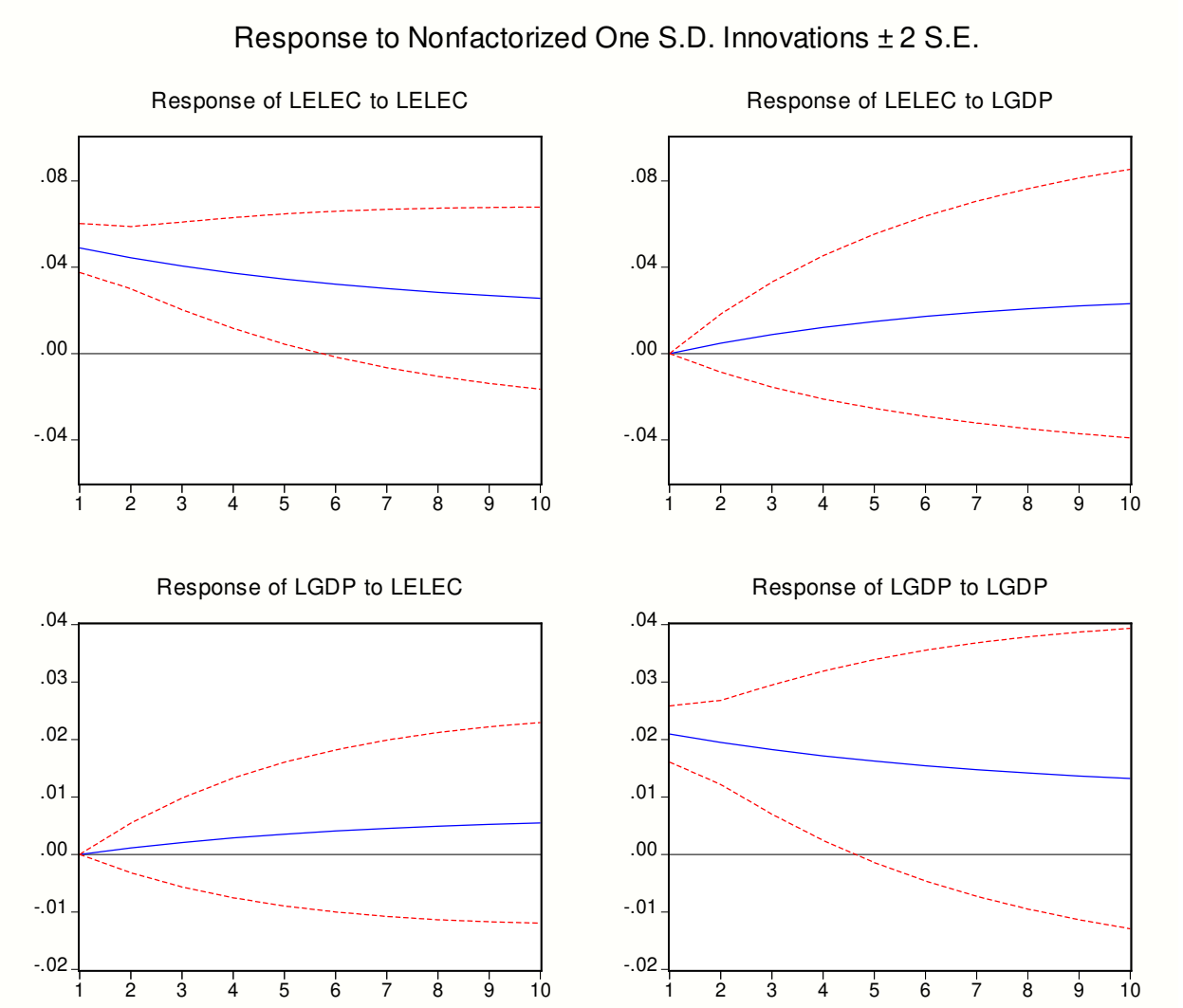
Period	S.E.	LEC	LGDP
1	0.048918	100	0
2	0.067523	99.58151	0.418494
3	0.081057	98.72868	1.271317
4	0.092056	97.56327	2.436727
5	0.101512	96.18941	3.810587
6	0.109923	94.69146	5.308542
7	0.117575	93.13472	6.865284
8	0.124646	91.56774	8.432264
9	0.131250	90.02519	9.974813
10	0.137467	88.53073	11.46927

b) Variance Decomposition of LGDP

Period	S.E.	LEC	LGDP
1	0.020953	16.26479	83.73521
2	0.028945	18.17149	81.82851
3	0.034715	20.01739	79.98261
4	0.039339	21.7865	78.2135
5	0.043243	23.46855	76.53145
6	0.046648	25.0579	74.9421
7	0.049687	26.55239	73.44761
8	0.052441	27.95252	72.04748
9	0.054971	29.26061	70.73939
10	0.057315	30.48028	69.51972

Variance decomposition tables show that at maximum horizon of ten year, log of real GDP per capita explain only 11 percent variation in electricity consumption. Electricity consumption explains 16 percent to 30 percent variation in log of real GDP per capita.

Figure 1. Title (delete title from the figure)



Impulse response function predict that due one standard deviation shock in log of real GDP per capita, electricity consumption will rise continuously over the 10 year of horizon. Similarly one standard deviation shock in electricity consumption will cause continuous rise in log of real GDP per capita.

5. Conclusion

In this study, long run relationship between electricity consumption and real GDP per capita has been investigated over the period 1971 to 2008. The evidence of cointegration between these two variables in all the cases indicates the existence of long-run equilibrium relationship. It implies that although electricity consumption and output may exhibit short term deviations, it eventually returns to long-run equilibrium. The direction of causality between the variables and within sample exogeneity for each variable is detected by employing VECM. The results indicate a unidirectional causal relationship from electricity consumption to economic growth which

implies that that electricity is a limiting factor to economic growth and hence, shocks to electricity supply will have a negative impact on economic growth.

Pakistan is electricity deficient country and electricity sector operates at bare capacity margin. To fulfill increased electricity demand, planning and investment in infrastructure development is essential. The unplanned outages may negatively affect economic growth. The government should adopt a policy so that the sustainable electricity supply may be ensured. Since, potential capacity of hydroelectricity is abundant in the country that can be tapped by constructing dams.

The pros of hydroelectricity are its low variable cost and lesser hazardous to environment than thermal and nuclear power stations. Its cons are its cyclical nature and seasonal fluctuations in water availability. Hence, the electricity sector needs sufficient generation capacity in excess to demand to avoid shortages due to seasonal factor. The authorities need to take steps to extend the provision of elasticity.

Acknowledgements. The authors wish to thank to Dr Shamim Sahibzada and an anonymous referee for their valuable comments. Any remaining errors and omissions are the authors' sole responsibility.

References

Aqeel, A. and Butt, M.S. (2001) The relationship between energy consumption and economic growth, Asia Pacific Development Journal, 8, 101-110.

Ferguson, R., Wilkinson, W and Hill, R. (2000) Electricity use and economic development, Energy Policy, 28, 923-934.

Ghosh, S. (2002) Electricity consumption and economic growth in India, Energy Policy, 30, 125-129.

Jamil, F. and Ahmad, E. (2010) The relationship between electricity consumption, electricity prices and GDP in Pakistan, Energy Policy, 38, 6016-6025.

Jumbe, C.B.L. (2004) Cointegration and causality between electricity consumption and GDP: emprical evidence from Malawi, Energy Economics, 26, 61-68.

Khan, M.A. and Qayyum, A. (2009) The demand for electricity in Pakistan, OPEC Energy Review, March, 70-96.

Mehrara, M. (2007) Energy consumption and economic growth: the case of oil exporting countries, Energy Policy, 35, 2939-2945.

Morimoto, R. and Hope, C. (2004) The impact of electricity supply on economic growth in Sri Lanka, Energy Economic, 26, 77-85.

Narayan, P.K. and Smyth, R. (2005) Electricity consumption, employment and real income in Australia: evidence from multivariate Granger casualty test, Energy Policy, 33, 1109-1116.

Narayan,P.K. and Smyth, R. (2008) Energy consumption and real GDP in G7 countries: new evidence from panel cointegration with structural breaks, Energy Economics, 30, 2331-2341.

Ozturk, I. and Acaravci, A. (2010) CO_2 emissions, energy consumption and economic growth in Tutkey, Renewable and Sustainable Energy Reviews, 14, 3220-3225.

Siddiqui, R. (2004) Energy and economic growth in Pakistan, The Pakistan Development Review, 43, 175-200.

Shiu,A. and Lam, P. (2004) Electricity consumption and economic growth in China, Energy Policy, 32, 47-54.

Wolde-Rafael, Y. (2004) Disaggregated industrial energy consumption and GDP: the case of Shanghai 1952-1999, Energy Economics, 26, 69-75.

Yoo, S. (2005) Electricity consumption and economics and economic growth: evidence from Korea, Energy Policy, 33, 1627-1632.