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An Annotated Bibliography of Research Literature on Energy in Pakistan

Matloob Piracha

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Mailing Address: PO Box 2342, Islamabad, Pakistan.
Telephone ++ (92-51) 278134, 278136, 277146, 270674-76
Fax ++(92-51) 278135, URL:www.sdpi.org

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Matloob Piracha

Abstract

This bibliography is an attempt to provide an updated account of the important studies available on energy in Pakistan in the last fifteen years. This will be helpful to researchers who are working to explore either new horizons or refine the existing infrastructure of energy, and it will aid the policy makers in formulating policies. The study is organized in the following four categories.

1. *Energy Conservation and Consumption*
2. *Alternate Sources of Energy*
3. *Pakistan's Energy Policy*
4. *Role of Energy in Agriculture*

Introduction

Energy is vital for survival of human beings in this age of technology and development. Although it is not a luxury to be enjoyed by the rich only, in Pakistan it has been primarily consumed by the rich and the middle class. Attention by researchers and policy makers is urgently needed for the development of appropriate and adequate policies and infrastructure so that every citizen could benefit from this necessity of life. To attain self-sufficiency in energy, extensive research in this area will be crucial.

Energy Conservation and Consumption

1. Abdullah, M., 'Efficient use of Electrical Energy in Industrial Sector,' *The Institute of Electrical Engineers, Pakistan. Seminar on Conservation of Electricity,* Lahore, 17-18 February 1986.
2. Industry is an essential activity which uses energy, especially electricity, as a factor of production. A case for conservation through efficient utilization of energy is presented. A number of devices and operational procedures are examined and the potential for conservation is assessed.
3. Akhtar, M. Y., 'Why Not Live With Loadshedding,' *The Institute of Electrical Engineers, Pakistan. Seminar on Conservation of Electricity,* Lahore, 17-18 February 1986.
4. By avoiding wasteful use of electricity and cooperating with the utility during the low energy available hour, loadshedding could not only be decreased but eliminated. The author suggests different ways of "using energy in a rational way." One way of conserving energy is to avoid leakages by proper maintenance and control of generators, machines, shut-off valves etc. Another way of saving is the optimization of a plant's energy consumption at the planning stage.

5. Burney, Nadeem and Naeem Akhtar, 'Fuel Demand Elasticities in Pakistan: An Analysis of Household's Expenditure on Fuels Using Micro Data,' *The Pakistan Development Review*, Islamabad, 29:2, Summer 1990.
6. The purpose of this study is to examine the pattern of household expenditure on energy. By applying the Extended Linear Expenditure System, price and income elasticities have been estimated. It is found that rural households spend more on fuel as compared to urban households. Price elasticities of different fuels are found to be extremely low which means that the fuel consumption in Pakistan is price inelastic.
7. Chishti, Salim, 'Probability Distribution of Electricity Demand Forecast for the City of Karachi,' *The Pakistan Development Review*, Islamabad, 31:3, Autumn 1992.
8. This paper determines the probability of shortages which would help to set the capacity targets more efficiently. A Four-Equation Model is developed to project the average and peak electricity demand in the year 2,000 in Karachi. The Full Generalized Least Squares technique is used to estimate three out of the four equations. In order to determine the extent of uncertainty in projections, probability distribution of average and peak demand based on 1,000 random samples is generated. The paper deduces that uncertainty should be taken into account in further energy planning.
9. Ciliano, R., M. Eisewerth and K. Abendroth, 'Residential Electricity Study: Analysis of Load Profiles and Determinants of Household Demand,' prepared by RCG/Hagler Bailly, Inc. for Pakistan Household Energy Strategy Study, Government of Pakistan under United Nations Development Programme, PAK/88/036, Islamabad, April 1993.
10. The study is primarily a library of household load profiles. A sample of 1,008 households were selected and values of different variables, such as estimation of household electricity demand, household population and total expenditure, dwelling type etc. were determined. The study is very comprehensive with simulation results and load profile development analysis.
11. ENERCON, 'The Potential of Electricity Conservation in the Industrial and Commercial Sector in Pakistan,' Islamabad, 1987.
12. This report analyzes the potential for electricity conservation in the industrial and commercial sector in Pakistan.
13. National Power Plan, 'Economic and Financial Analysis Parameters and Methodology,' Water and Power Development Authority, Report No. NPP-6, Lahore, May 1993. .
14. The purpose of this study is to provide a set of assumptions and parameters which should be used to carry out system and project evaluation. Design and implementation and economic parameters are determined.
15. Naqvi, S.R.Q., 'Energy Conservation in Airconditioning,' *The Institute of Electrical Engineers, Pakistan. Seminar on Conservation of Electricity,* Lahore, 17-18 February 1986.
16. The study offers some suggestions and recommendations to minimize the consumption of energy by using the correct way of installing air-conditioners or by using the energy efficient air-conditioners.
17. Pakistan Household Energy Strategy Study, 'Household Energy Demand: Consumption Patterns,' Prepared by Energy Sector Management Assistance Programme in association with the Energy Wing, Project sponsored by UNDP, PAK/88/036, Islamabad.
18. The purpose of this study is to provide a comprehensive household energy database for national energy planning and policy making. The study was done with the aim to identify feasible policies which might reduce the social, economic and environmental costs of meeting household energy requirements.
19. Chishti, Salim and Fahkre Mahmood, 'The Energy Demand in the Industrial Sector of Pakistan,' *The Pakistan Development Review*, Islamabad, 30:1, Spring 1991.

20. This paper analyzes the role of manufacturing sector in Pakistan. Using Zellner's iterative procedure, the translog cost function and the input demand equations corresponding to energy, capital and labour are estimated. The results justify energy as a separate factor of production. The negative partial substitution elasticities between energy and capital show that higher energy prices adversely affect investment in capital goods. On the other hand, positive substitution elasticities between energy and employment implies that higher energy prices will raise employment level.
21. Chishti, Salim and Fakhre Mahmood, 'Energy Substitution in Pakistan's Manufacturing,' *Pakistan Economic and Social Review,* Islamabad, Winter 1988.
22. The objective of this study is to determine the role of energy prices in the decision making process of input demand. Price and substitution elasticities are computed using translog cost function. Four firms from the large scale manufacturing are selected, which are: cement, rayon, tobacco and sugar. The elasticity of substitution of capital and energy is positive in three out of four firms while between labour and energy the elasticity is positive for only two firms.
23. Chishti, Salim and Fakhre Mahmood, 'The Demand for Energy in the Large-Scale Manufacturing Sector of Pakistan,' *Applied Economic Research Centre,* University of Karachi, Karachi. Discussion paper # 127.
24. In this study inter-fuel and energy and non-energy substitution in the large-scale manufacturing sector is examined, using Zellner's iterative procedure. It is deduced from the level of substitution that, on the whole, there has not been much interfuel substitution in the manufacturing sector of Pakistan. Overall, the results show that energy and labour are substitutes while energy and capital are complements.
25. Pasha, Hafiz, Aisha Ghaus and Salman Malik. 'The Economic Cost of Power Outages in the Industrial Sector of Pakistan,' *Applied Economic Research Centre,* University of Karachi, Karachi, Discussion paper # 117, October 1989.
26. This study determines the cost of power outages in the industrial sector of Pakistan. Anticipated and unanticipated outage costs are determined on per KWh basis by type of industry. Data for 843 industries were collected nationwide. The study found that 1.8 percent of GDP is lost because of power outages which warrants an expanded programme of investment in energy generation and refining of the pricing policy.
27. Rehman, Fazal, 'Use of Good Quality Materials to Conserve Electricity,' *The Institute of Electrical Engineers, Pakistan. Seminar on Conservation of Electricity,* Lahore, 17-18 February 1986.
28. This paper assesses the effects of poor quality components on the electrical system and shows that a substantial amount of electricity could be saved if correct quality cables, chokes, fans, etc. are used.
29. Shah, Syed Aman Ullah, 'R & D Potential of the Educational Institutions in the Field of Energy Conservation,' *Science Technology and Development*, Islamabad, March-April 1984.
30. The author of this article is primarily concerned with the role universities and colleges could play in the development in the energy sector. He gives a description of the energy problems that Pakistan currently faces and suggests that local educational institutions are major reservoir of talent and creativity and therefore they are the most appropriate places for the formulation of energy policy in the country. He emphasizes that universities should undertake R&D studies in the areas of industry, tribology, renewable sources, solar technology etc.

Alternate Sources of Energy

1. Ahmad, Nisar and Surriaya Mir, 'Perspectives of Coal Share in the Energy Economics of Pakistan,' *Science Technology and Development,* Islamabad, January-March 1991.
2. This paper reviews and analyzes the government's energy policy with reference to indigenous coal. The approaches, efforts and the partial success for utilizing indigenous coal in thermal generation and in industrial and domestic utilization by the government are discussed. The possible role of coal in replacing imported energy in Pakistan is also envisaged.
3. Associated Mining Consultants Ltd., Alberta, 'Coal as Fuel Source,' prepared for National Power Plan, Lahore, June 1992.
4. This report analyzes the use of coal as a potential fuel for power generation. The study carries out a detailed assessment of the indigenous coal resources, production capability, production cost and product quality.
5. Butt, Masud M.H., 'Energy Systems and Thermal Power Generation in Pakistan,' *Science Technology and Development,* Islamabad, January-February 1988.
6. The paper simply lists the type and amount of energy available in Pakistan. In light of the obtained data, the author asserts that nuclear energy is the only option for survival.
7. Butt, Masud M.H., 'Exploitation of Renewable Energy Resources in Pakistan,' *Science Technology and Development,* Islamabad, July-August 1986.
8. The author lists all the hydel-power potential and gives the year of installation and capital cost of each operating power station. He then provides a tentative list of sites for Micro-hydel, Mini-hydel and Small-hydel power stations.
9. Conservation for Development Centre and International Union for Conservation of Nature and Natural Resources, 'Pakistan: Natural Resources Expertise Profile,' Switzerland, February 1988.
10. This report is a survey of the availability of professional expertise in the field of conservation-oriented development in Pakistan. The information contained in this report covers government and non-governmental organizations, universities, consultancy firms, international agencies and individual experts.
11. Hasnain, Syed Mahmood, 'The Importance of Utilization of Renewable Energy Resources in Pakistan,' *Science Technology and Development*, Islamabad, July-Aug 1989.
12. The author discusses the significance of renewable energy sources to the development of rural areas. He gives evidence that nuclear, hydel and thermal energy are not viable and could be dangerous (at least in the case of nuclear). On the other hand, biogas, solar energy, energy from refuse and wind energy are non-depletable and are easy to convert to conventional energy forms with the existing technology know-how and minimal fuel cost.
13. Hosier, Richard H., 'Wood Energy in Pakistan: Evidence for Sustainability,' Pakistan Household Energy Strategy Study, Islamabad, May 1993.
14. This paper addresses the sustainability of Pakistan's wood-energy system from the perspective of national household energy policy. The overall conclusion is that although more wood-fuel is consumed than is produced, there is no immediate crisis of availability.
15. Javed, Rafi and Mukhtar Sahir, 'Role of Renewable Energy Resources in the Future of Pakistan,' *Science Technology and Development,* Islamabad, May-June 1990.
16. This short paper has used market penetration and adoption analyses to evaluate the future role of renewable energy resources in Pakistan. Both optimistic and pessimistic viewpoints are brought into focus.
17. Khan, Arshad M. and A.I. Jalal, 'Status and Potential of Nuclear Energy in Pakistan,' Applied Systems Analysis Group, Pakistan Atomic Energy Commission, Islamabad, National Workshop on Energy Information Handling, 12-16 May 1991.

18. This paper discusses the limitations of indigenous energy resources in coping with the future requirements of electricity and compares the economic cost of nuclear power with that of electricity generation based on imported oil and coal. It also describes the efforts being made to make nuclear power in a self-reliant manner.
19. Khan, R.A.R., 'Wind Mill as Augmenting Alternate Source of Energy,' *Pakistan Agriculture,* Islamabad, March 1985.
20. In the areas where wind velocity is at least 10 to 15 mph, windmills are economically efficient. Windmills could be used successfully for: (1) lifting water for rearing livestock; (2) irrigating farms; (3) grinding/milling; (4) crushing sugarcane; (5) threshing of crops specially wheat and paddy; (6) cutting of timber; (7) generating electricity on small scale mainly for electrifying villages and lifting water for human consumptive purpose. Because of a continuous "Four Knots" wind velocity there is a great potential for the use of windmill technology in the southern parts of Pakistan. In October 1965 Pakistan had a great success when a windmill was installed in Tandojam on trial basis.
21. Khan, T.M., *Energy 2000*, Royal Book Company, Karachi, 1991.
22. A collection of articles on energy, this book highlights the importance of different renewable energy sources and their need in the future as an alternative to conventional energy sources.
23. Malik, K and S.H. Mujtaba Naqvi (eds.), *Biotechnology for Energy,* Nuclear Institute for Agriculture and Biology and National Institute for Biotechnology and Genetic Engineering, Faisalabad, 1991.
24. This is a collection of papers presented at the symposium which was meant to compile research work in the areas of conversion of biomass to bio-fuels, petroleum biotechnology and biohydrometallurgy, and in light of all this, formulate plans and projects to solve Pakistan's energy problems.
25. Pakistan Household Energy Strategy Study, 'Woodfuel Use in Pakistan: Sustainability of Supply and Socio-Economic and Environmental Implications,' Islamabad, February 1993.
26. According to this report, wood-fuel represents 53% of the total energy consumed in 1991. The study was done to help develop a viable energy strategy based on resource sustainability. The HESS survey indicates that the biomass stock is over 210 million tons and includes all kinds of tress, shrubs and twigs. The yearly production is 23 million tons whereas the demand is 32 million tons. Farmers plant trees to fulfil their need for woodfuel, and therefore, in order to sustain the present level of tree planting, wood-based energy should be encouraged.
27. Sheikh, M.I. and M. Amjad, 'Creation of New Resources for Fuel-wood and Wood Energy,' *Progressive Farming,* Islamabad, Sep-Oct 1985.
28. Wood is shown to be a major source of energy for several rural areas in Pakistan. The authors give example of different countries like Indonesia and Nepal where fuel-wood plantation has increased in the wake of the two oil crises. The authors predicted that by the end of 1985 Pakistan will raise plantation for fuel-wood by over 35000 hectre.

Pakistan's Energy Policy

1. Azhar, T., *The Quest for Power. Pakistan's Policy Options for the Nineties,* Lahore: Ferozsons Ltd, 1991.
2. The book points out the shortcomings of the present power policy and how it could thwart progress in the future. The author has given some suggestions and guidelines to refine the existing policy for sound economic growth. The book starts with an historical perspective of electricity in Pakistan and develops into today's predicament caused by decisions taken in the

past. He emphasizes the need for a load management policy which he thinks is most effective and quick solution for this country. He also cites reasons for load-shedding in Pakistan and suggests least cost solutions to eradicate this menace.

3. Azhar, T., 'Policy Options for Efficient Utilization of Electrical Energy,' *The Institute of Electrical Engineers, Pakistan. Seminar on Conservation of Electricity,* Lahore, 17-18 February 1986.
4. This paper differentiates electrical energy from other forms of energy and gives a different perspective on conservation than the conventional one. It proves that a unit cost of electricity is a stochastic variable.
5. Butt, Masood M.H., 'Strategy of Electrical Energy Planning in Pakistan [Beyond 2000 A.D.],' *Indus*, Islamabad, April-June 1987.
6. In this article Butt points out the shortcomings of the present electrical energy planning and presents some suggestions to improve the existing planning. According to him, to meet the growing demand of energy, renewable and non-renewable resources should be exploited on a larger scale. Co-generation should be encouraged and incentives should be given to the private sector for power generation. Fossil fuels and hydro-electric power should be exploited. Presently the Government of Pakistan is exploiting coal as a potential source of power generation.
7. Freeman, Ken, 'Energy Management for Higher Profit,' *Pakistan Management Review*, Karachi, 27(2-3), 1986.
8. The author provides some suggestions to improve the management of energy. He asserts that savings of 20 percent or more could be achieved by better management of energy. The steps which are necessary towards refining the management are: measuring and monitoring; setting targets and norms; and making management and workforce much more aware of the impact of their decisions and actions on energy costs. He further adds that workers should be included in the management team since they have the control over energy distribution and other such functions.
9. Karimullah, M.M. Qurashi, M. Shafquat Hussain Siddiqui, M.K. Bhatty and A.H. Chotani, *Energy and Its Development (with Special Reference to Pakistan)*, Pakistan Academy of Sciences, Islamabad, 1982.
10. This report identifies problems in the energy sector and suggests to prepare comprehensive and authoritative feasibility reports for tackling various problems. The authors, after giving a brief survey of world energy situation with special reference to the developing countries, gives energy utilization and conservation strategies for Pakistan. They list the conventional resources in Pakistan and suggest measures for further development and exploitation. They recommend to increase the efficiency with which the fuels are used in various sectors, utilize the opportunity for energy conservation by reducing consumption which is better than increasing supply, shift of energy system away from its dependence on imported oil by maximum development and by using conventional domestic resources.
11. Lutfi, N. and T.N. Veziroglu, 'An Outlook of Pakistan's Energy Situation and Prospective Planning,' Islamabad.
12. Pakistan will need a large amount of energy in the future to cope with its growing developmental needs. Analyses of the consumption pattern and availability potential make it evident that Pakistan will face an acute shortage of energy in the coming years. According to the authors, to alleviate the situation of energy scarcity, Pakistan should seek ways to conserve energy, bring in coal gasification technology and explore renewable resource technology.
13. Riaz, T., *Pakistan: The Energy Sector. A study in sector planning*, Lahore: Ferozsons Ltd., 1984.
14. This study analyzes the role of resource allocation in the energy sector of Pakistan by employing sectoral, national and linear programming models. The author criticizes the existing ministerial

setup to be too inefficient due to the existence of parallel organizations involved in energy planning and a lack of clear responsibility for any ministry. He proposes another alternative setup under a separate Ministry of Energy that he claims will be more efficient.

15. Sahir, Mukhtar H., 'Use of IEP approach in National Energy Planning — The Only Choice,' *Science Technology and Development*, Islamabad, Sep-Oct 1990.
16. This paper points out the shortcomings of the present energy policy and reveals the modern trends in the planning of energy policies. The author asserts that presently sub-sectoral planning is prevailing which has many disadvantages, such as inter-sectoral sub-optimism, lack of balanced resource development, diffusion of conservation efforts etc. The author introduces the IEP approach and reviews its current status both at the national and international levels with a brief description of the essentials of energy system modelling and their use.

Role of Energy in Agriculture

1. Ali, Sultan, Ahmad Saeed Khan and Bashir Ahmad, 'Energy —Key Issue in Agriculture,' P*akistan Agriculture,* Special Report, Islamabad, August 1987.
2. The purpose of this paper is to find out the energy use on the main crops by farm categories, to determine the extent of use of available animate energy, to find out the effect of change in energy application on yield of different crops and to suggest policy measures and recommendations. The study was carried out in Faisalabad dividing farmers into three categories: Small (0-7.0 acres); Medium (7.1-12.5 acres); and Large (above 12.5 acres). The overall energy consumption pattern indicates that Large farmers used about 40 percent of commercial energy mainly for tractors. Animate energy used by small farmers was 73.5 percent while it was only 38 percent by Large farmers. Technological development like small tractors and technologies appropriate for small and medium farmers are needed. The authors also recommend that credit should be provided on easy terms and conditions to small and medium farmers.
3. Ansari, M.A.A., 'Energy for Rural Areas,' *Pakistan Agriculture,* Islamabad, May-June 1982.
4. The author is primarily concerned with the best energy source for rural areas in regard to agriculture. Although fuel-wood is a good source of energy in the rural areas, increase in population will cause serious supply problems. Therefore, he thinks, that the most feasible conventional energy substitute for rural areas are solar energy, energy from windmill, and biomass as compared to fuel-wood and kerosene oil.
5. Arif, Muhammad, 'New Energy Systems Based upon Rice Husk,' *Science Technology and Development,* July-August 1988.
6. Pakistan, in the wake of persisting energy crises, is in dire need of some alternate energy source. Rice husk which is available in abundance, is economically a very attractive source of energy. It has a heating value of about 3,000 to 3,600 K cals/Kg which is almost 40% of the fuel value of bituminous coal. Possible means of converting rice husk to energy are: (1) Steam driven electric power generation; (2) Pyrolytic cracking of rice; (3) rice husk gasifier system.
7. Food and Agriculture Organization, 'FAO Efforts for the Development of Sources of Energy,' *Pakistan Agriculture,* Islamabad, April 1984.
8. This article lists a few issues to be raised in regional conferences. These include: fuel-wood; biogas; producer gas; biofertilizers; draught animals; wind and water; and solar energy. The author wants the government to review their policies and formulate strategies to integrate these kinds of energy as a constituent of an appropriate energy mix.

Conclusion

Literature published on energy in the last fifteen years has been presented in this annotated bibliography. It is evident that the majority of the work has been done in the field of conservation, consumption and alternate sources of energy. In the context of Pakistan these issues are very important and need the most attention. However, alternate sources of energy should be further explored and utilized so that energy could be provided to rural poor where conventional energy is not available. The other two areas in which research has been done in the last decade are the policy issue and agricultural energy. Although some remarkable work has been done in the area of policy, much more is needed because of its significance in an underdeveloped country like Pakistan where resources are limited, as discussed by Tanveer Azhar in his book "The Quest for Power: Pakistan's Policy Options for the Nineties".

In the course of this research it was found that there has not been any paper or book published on the topic of load forecasting in Pakistan . Research on load forecasting would be helpful in predicting demand more accurately. Also, more seminars, in which people from the planning department participate, should be held so that ideas could be brainstormed and solution searched for a bright and efficient energy future.

SDPI is an independent non-profit research Institute
on Sustainable development

Mailing Address: PO Box 2342, Islamabad Pakistan

Street Address: 3rd Floor, Taimoor Chamber, 10-D West,
Fazal-ul-Haq Road, Blue Area, Islamabad.

Telephone: +(92-51) 2277146
2278134 2278136 2270674-6

Fax: +(92-51) 2278135

URL: www.sdpi.org e-mail: main@sdpi.org