DK9801018

NEI-DK--3062

DK9801018

RECEIVED
JAN 16 1998
OSTI

Biogas Technology in Pakistan

by

Maqbool Ahmed
(01.03.62 - Pakistan)

at

Folkecenter for Renewable Energy
Hurup Thy, Denmark

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED
FOREIGN SALES PROHIBITED

Nordvestjysk Folkecenter for Vedvarende Energi

Folkecenter for Renewable Energy

P. O. Box 208
Kammersgårdsvej 16,
Sdr. Ydby,
7760 Hurup, Thy
Denmark

Telefon: 97 95 66 00
Fax: 97 95 65 65

Int. tel.:+45 97 95 66 00
Int. fax:+45 97 95 65 65

Postgiro: 5 93 41 33

29 - 17

ISBN 87-7778-088-4
FC-Print
February 1997

DISCLAIMER

Portions of this document may be illegible electronic image products. Images are produced from the best available original document.

Biogas Technology in Pakistan

TABLE OF CONTENTS

ACKNOWLEDGEMENT

It is a high time to express my sincere thanks to Preben Maegaard, Executive Director of Folkecenter for Renewable Energy (FC) who, with kind enough, provided me this opportunity to study about the progress of biogas in my own country (Pakistan) which would be absolutely useful for my work in this field in Pakistan.

I also wish to thank all the staff of FC and particularly Jane Kurse for her ever ready co-operation which is directly or indirectly related to my training /stay at FC.

Also sincere gratitude's to Danish Government & Folkecenter for, along with research work, also the financial support which made possible for me to work at Folkecenter in Denmark.

Maqbool Ahmed (Pakistan)

Chapter - 1

Country, The Pakistan

1)- Country, The Pakistan

1.1)- General Information

The Islamic Republic of Pakistan came into existence on August 14, 1947 after the hundred years British regime while Indian sub-continent was divided into India and Pakistan.

Geography

Pakistan is an Asian state situated on Northwest of Indian sub-continent in South Asia having latitudes 23 -- 36 °N and the longitudes 61 -- 75 °E.
Land Area: 778,720 sq. km
Total Area: 803,940 sq. km
Coastline: 1046 km
With Arabian Sea coastline in south and Southwest, physical regions include:
-Indus Plain, the most fertile and densely populated area of the country;
-Baluchistan Plateau; Potohar Plateau and Salt Range; and, high Himalaya, Karakoram and Pamir ranges, containing three of world's highest peaks (K-2, rising to 8 611 metres above sea level, Nanga Parbat, Rakaposhi) in Northeast (lower mountain ranges in north and west). The country has contrasting topography varying from the rugged mountainous regions in the north to the plains and fertile lands in the Indus valley, arid and barren land in the south and west starting from the Chulistan area through the Tharparker desert in the Sind and extending into the Baluchishtan area. Major portion of the country (about 80%) is arid and semi arid but due to extensive irrigation in the Indus basin, it is the land of farmers. Pakistan is basically an agricultural country with the biggest canal network in the world. Main rivers include Indus, Jhelum, Chenab, Ravi and Sutlej.

Neighbouring countries:
West: Iran;
Northwest: Afghanistan;
Northeast: China; and
East and South: India.
Land boundaries: 6,774 km total; Afghanistan 2,430 km, China 523 km, India 2,912 km, Iran 909 km

1.2)- Climate:

Climate is mostly hot, dry desert; temperate in Northwest; arctic in north. It has extremes of high ambient temperature, reaching to 50°C in the plains in Summer and to degrees below the freezing point in the mountainous region in Winter. Rainfall occurs during the monsoon period in the month of July, August & September and some rain spell may appear in December & January. Average rainfall is 1200 mm in northern / mountains to 100 mm in arid/semi arid area. The sky conditions also vary from clear to dusty, hazy and cloudy in different regions in different months of the years. Four well-marked seasons in Pakistan are: cold season: December to March; summer/hot season: April to June; monsoon season: July to September; and post-monsoon season: October to November; average annual temperature 27 degrees Celsius, except in mountain ranges, which are extremely cold in winter but pleasant in summer;

Environment:
Frequent earthquakes, occasionally severe especially in north and west; flooding along the Indus after rainy season; deforestation; soil erosion; desertification; water logging

1.3)- People & Population:

110,370,000 increasing by 3.2 per cent per year; 45.2 per cent under 15 years of age; life expectancy 55 years; and, infant mortality 106 per 1,000 live births. Life expectancy at birth is 57.11 years
Pakistan is ranked 33rd biggest in land area & 10th most populous country in the world. In other words, it covers 0.67% of the world's land, contains 2.15% of the world's people.
Capital: Islamabad (estimated population 350,000).
Other main towns:
Karachi (est. pop. 7,500,000);
Lahore (est. pop. 4,500,000);
Faisalabad; Hyderabad; Multan; Rawalpindi; Peshawar; and Quetta.
Baluchistan province comprises almost half (43%) of the total area of the country and is practically empty (13 persons per km^2). Punjab is comparatively developed and heavily populated (246 persons per km^2). There is an overall average of 154 persons per km^2 in Pakistan

Literacy: 36% (male 47%, female 21%) age 15 and over can read and write (1990 est.)

Languages
Urdu is the national language of Pakistan. English is also spoken widely in the major cities and is also used in the government offices & business centres. Other main/regional languages that are spoken in different parts of Pakistan include:- Punjabi, Sindhi, Balochi, Pushto, Saraiki, Brahvi & Hindko.

Religions:
Most of the population by religion is Muslim (96.7%) with some Christian (1.6 %), Hindu (1.5%) and Others (0.2%).

1.4)- Economy

The economy of country mainly depends on agriculture, industry and foreign exchange. The present annual per capita income is about 400 US $. In 1993, import bill accounted 9481 million US $ which mainly comprises petroleum & petroleum products, chemicals, non-electric machinery, transport equipment, grain, pulses, edible oil, iron & steel products, electronic goods and automobiles etc. and export was 6672 US $ for mainly cotton & leather products, marble, rice, sport goods, garments and hosiery etc.
GNP: exchange rate conversion - $45.4 billion, real growth rate 4.8% (FY91 est.), Inflation rate (consumer prices): 12.3% (FY91), Unemployment rate: 10% (FY91 est.)
Budget: revenues $6.4 billion; expenditures $10 billion, including capital expenditures of $2.6 billion (FY92 est.)
Ports: Gwadar, Karachi, Port Mohammed bin Qasim
Airports: 112 total, 104 use-able; 75 with permanent-surface runways; 1 with runways over 3,659 m; 31 with runways 2,440-3,659 m; 43 with runways 1,220-2,439 m

Labour force: 28,900,000; agriculture 54%, mining and manufacturing 13%, services 33%; extensive export of labour (1990 est.), Organised labour: about 10% of industrial work force

Main crops:
wheat, rice, maize, cotton, sugar cane, pulses etc.

Natural resources:
land, extensive natural gas reserves, limited petroleum, coal, iron ore, copper, salt, limestone. Some natural forests also exist in the north

Currency: (1995)
The unit of currency is rupee.
1 Pakistan Rupee (PR) (US$ 1= 33 Rs.) = 100 paisa.

1.5)- Government

It is a democratic parliamentary republic state ruled by the Prime Minister while the President is the chief administrator of the country. Pakistan, administratively is divided into four provinces namely Punjab, Sind, Baluchistan and Northern West Frontier Province (NWFP) with some Federally Associated Tribal Area (FATA), Islamabad Capital Territory and Pakistani-administrated portion of the disputed Jammu and Kashmir regions which include Azad Kashmir and the Northern Areas. Each province is run by the elected Chief Minister with his cabinet.

Legal system:
The legal system, based on English common law with provisions to accommodate Pakistan's status as an Islamic state; accepts compulsory ICJ jurisdiction, with reservations
Executive branch: president, prime minister, Cabinet
Legislative branch: bicameral Parliament (Majlis-e-Shoora) consists of an upper house or Senate and a lower house or National Assembly
Judicial branch: Supreme Court, Federal Islamic (Shariat) Court

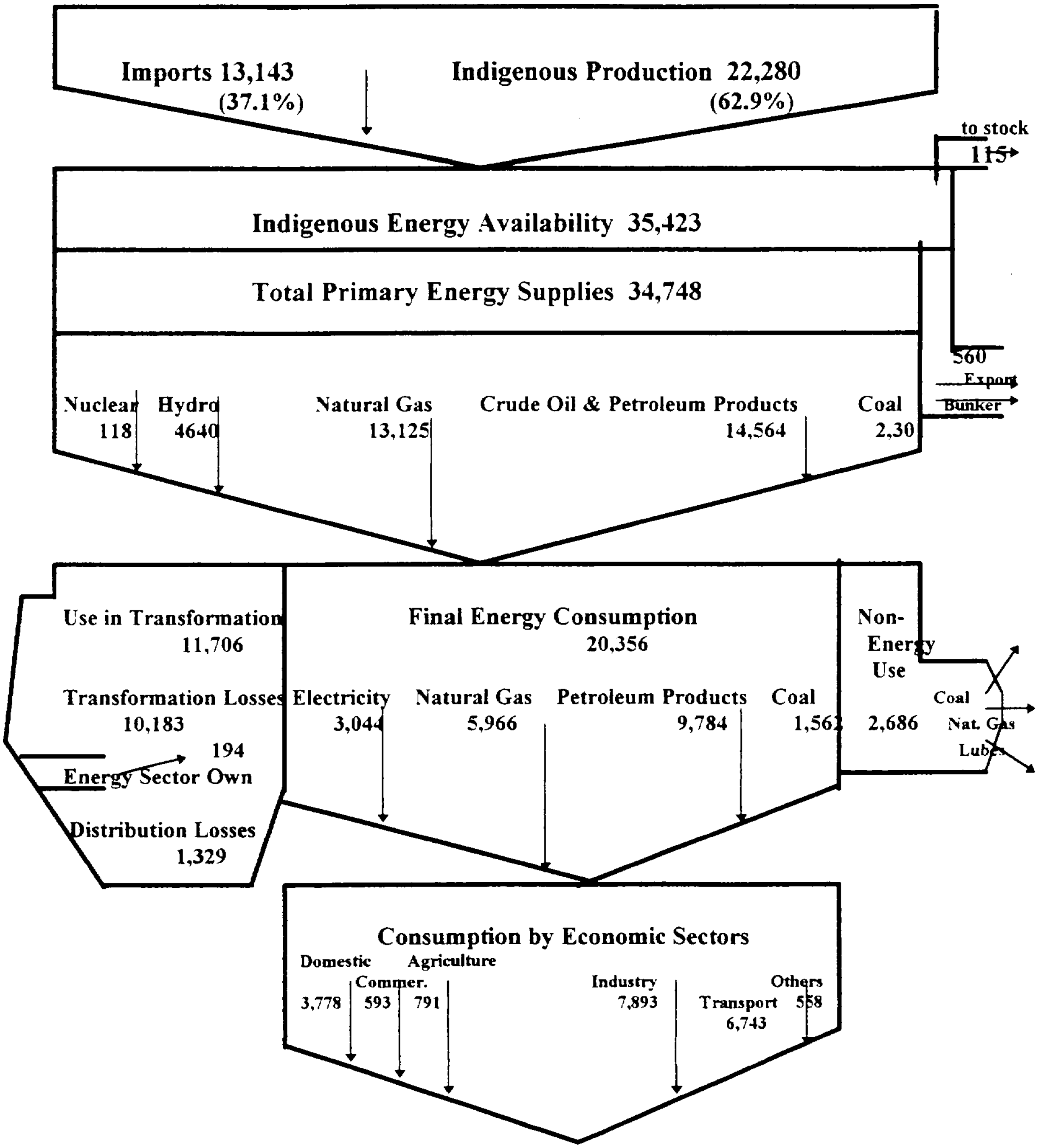
Chapter - 2

Energy Sector & State

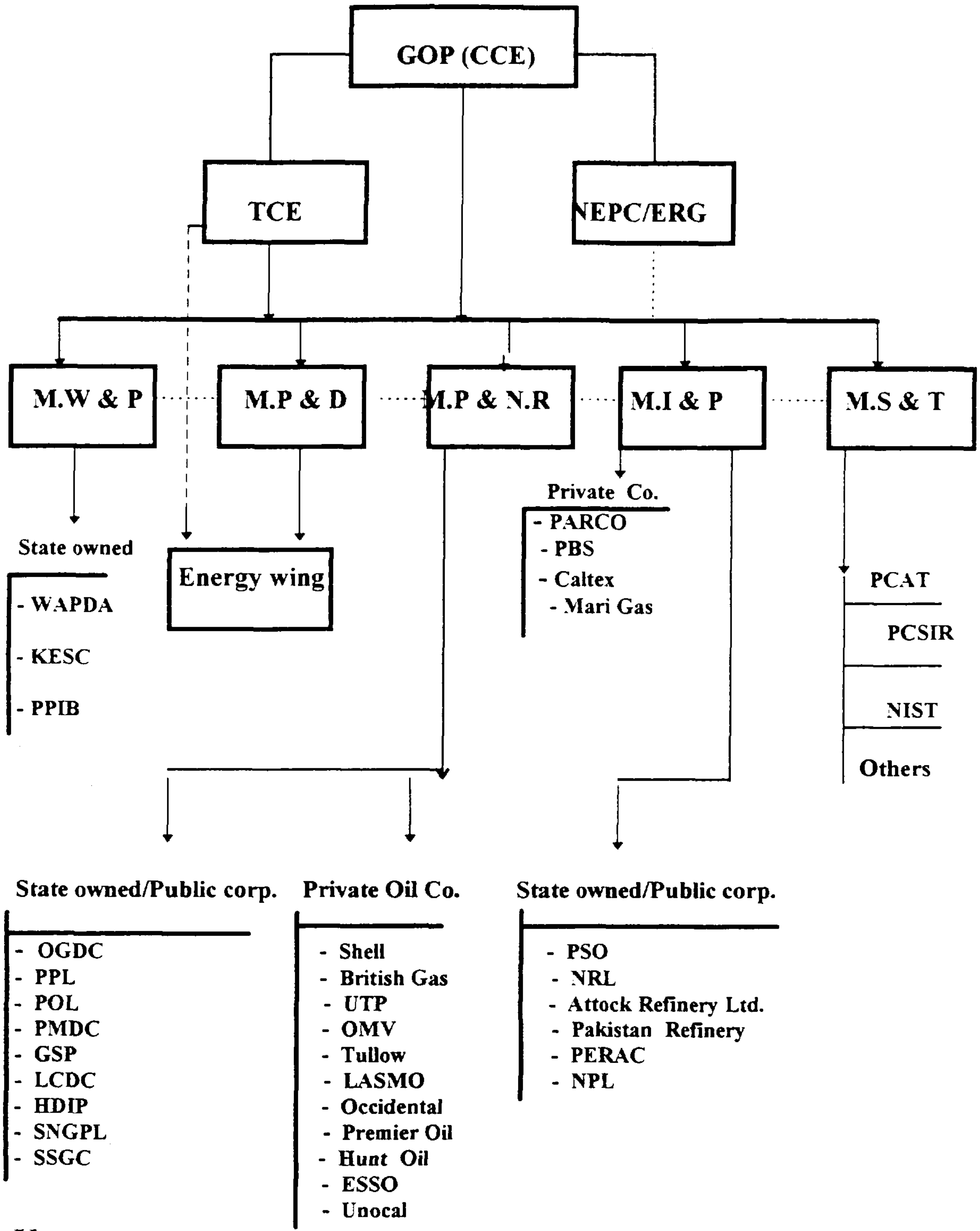
2)- Energy Sector & State

2.1)- Energy Flow Chart 1993-94

Thousand Tonnes of Oil Equivalent



2.2)-Chart of Institutional Setting & Major Energy Contributors of Pakistan



Key;

GOP	Government of Pakistan	M.W & P	Ministry of Water & Power
CCE	Cabinet Committee of Energy	M.P & N.R	Min. Petroleum/ Natural Resource
NEP C	National Energy Planning Com.	M.P & D	Min. of Planning & Development
ERG	Energy Review Group	M.I & P	Min. of Industries & Production
TCE	Technical Committee on Energy	M. S & T	Min. of Science & Technology

2.3)- State & Energy Enterprises

In Pakistan, the responsibility for the energy sector is shared mainly by four ministries : the Ministry of Petroleum and Natural Resources (M.P & N.R), Ministry of Planning and Development (M. P & D), Ministry of Water & Power (M.W & P), and Ministry of Industries and Production (M.I & P) along with the Ministry of Science and Technology (M.S& T) which is doing some work for Renewable Energy and related research & development activities under some of its organisations. Co-ordination between the ministries on energy matters is provided by the Energy Wing of M.P & D, which acts as a secretariat for the National Energy Policy Committee (NEPC) and Energy Review Group (ERG). The former is responsible for overall energy policy while later reviews progress on project's implementation.

A high level Cabinet Committee on Energy (CCE), chaired by the Prime Minister is responsible for the review and approval of all plans, policies and projects in the energy sector for both private and public sectors. Implementation of the approved projects is the under control of the respective ministries and entities. The CCE is assisted by a Technical Committee on Energy (TCE), chair by the Deputy Chair Planning Commission, Ministry of Planning and Development. TCE reviews and clears proposals and projects for consideration by the CCE. Reviews of proposals for the TCE are in-deed prepared by the Energy Wing of commission, a division of ministry of Planning and Development. Furthermore, all power schemes are forwarded to the Energy Wing of the Water & Power, who receives the same from WAPDA, KESC and the Private Power and Infrastructure Board (PPIB). PPIB is government (under the Ministry of Water & Power) agency that negotiates with private power companies on ONE WINDOW operation basis. After screening the proposal PPIB presents it to the (CCE) Government of Pakistan for approval.

The management of day to day operations and implementation of approved projects by the CCE, then becomes the responsibility of the number of public and private sector entities. The public sector entities are: The Water & Power Development Authority (WAPDA) is responsible for developing Pakistan's water resources. Besides, construction, operation and maintenance of power generation, transmission and distribution facilities through the country, except for the Karachi region where Karachi Electric Supply Corporation is responsible for the same. The Oil & Development Corporation (OGDC), Pakistan Petroleum Limited (PPL), and Pakistan Oil-field Limited (POL) are three organisations for the exploration and development of oil & gas in the country. The Pakistan Mineral & Development Corporation (PMDC) do the same for mineral resources. The State Petroleum Refining and Petrochemical Corporation (Holding company) that owes the National Refinery Limited (NRL), Pak-Arab Refinery Company (Pak-Arab is joint venture between Pakistan and Abu Dhabi), and Pakistan Refinery Ltd. (PRL). These are the crude oil processing refineries within the country. Government of Pakistan (GOP) also owes the shares in the NPL, which has developed the hydrocracker facility.

Also involved in energy sector are a number of semi-autonomous entities in which GOP has a controlling interest either directly or through public institutions. These are:- a)- KESC, b)- Sui Northern Gas Pipeline Limited (SNGPL) and Sui Southern Gas Corporation (SSGC) which are responsible for the transmission and distribution of natural gas in country, c)- Pakistan State Oil Ltd. (PSO) is responsible for marketing and distribution of petroleum products within country. All operational entities (public and semi-autonomous) are under the jurisdiction of M.P &N.R. On the other hand, PPIB, WAPDA and KESC, are under M.W&P. NRL, PRL, PSO, PARCO, NPL & ARL are under M.I&P.

Furthermore, there are some private oil companies in both upstream and downstream of petroleum sub sector. In downstream (distribution sector), Shell Pakistan Limited and Caltex Oil, are two major private companies. In the upstream (exploration & production) sector, Union Texas Petroleum (UTP), LASMO Oil, Occidental of Pakistan, OMV (Pakistan), Tullow Oil are included. In addition British Gas, Unocal, Hunt, ESSO Exploration, Premier Exploration Pakistan Limited are among the international companies operating in Pakistan.

2.3-A)- Power sub-sector

The responsibility of the power supply for Pakistan is shared by two main agencies : WAPDA and KESC. Other smaller agencies active in power supply, include Pakistan Atomic Energy Commission that operates Kanupp (Karachi Nuclear Power Plant). Moreover, recently, the North West Frontier Province (NWFP) has created the Sarhad Hydel Development Organisation (SHYDO) to participate in hydroelectric development in the mountainous northern areas of the province.

WAPDA and KESC are presently owned by the GOP, which are also responsible for setting tariffs, regulating the sector and determining their invest programmes. WAPDA and KESC are under the Ministry of Water and Power. Government of Pakistan approves Wapda's investment plan, annual budgets, tariff changes and allocation of foreign exchange, salary structure and personal policies. Also, Ministry of Water & Power and Government of Pakistan appoints the Chairman and members, and all other senior officers down to the level of General Manager of major functions

(Asian Development Bank, Phase 1 report, 1992)

Chapter - 3

General Energy & Environmental Situation of the Country

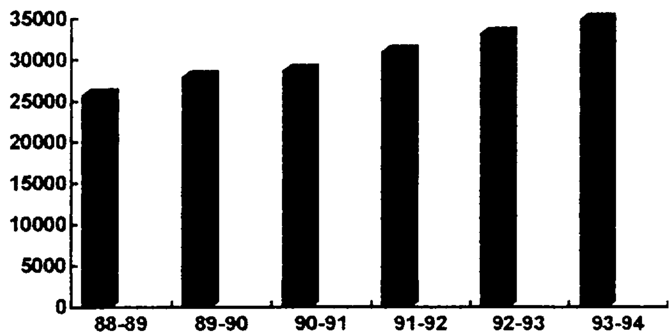
3)- General Energy & Environmental Situation of the Country

3.1)- Energy Scenario in Pakistan

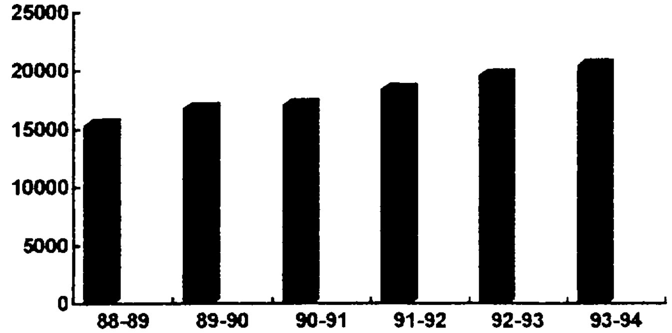
Pakistan, like any other developing country, has severe energy problems. It has been remained an energy deficient country since its existence in 1947. The demand of rapid industrialisation, increasing population, modernisation, urbanisation, rural development and the concomitant expansion of transport system etc. requires greatly increasing supply of energy. The country is yet far away to reach the stage where it can be claimed that the supply is enough to cope with the increasing demand. During 1993-94, the per capita energy consumption was 0.21 TOE (excluding biomass) which is lower even among some developing countries. The production/consumption ratio was recorded 0.65 during 1990. Although, the consumption of energy has been grown at an average rate of more than 6% per annum over the last 5 years in the country. But the present hydrocarbon reserves and hydel power capacity is insufficient to maintain it at longer time.

In spite of low level of energy consumption, Pakistan is unable to meet its energy requirements from indigenous resources and has to rely upon import to cover 37.5% of its liquid fuel requirements. The scenario of the primary energy supply and final energy consumption for the previous six years will enable to elaborate the present energy situation with its background in Pakistan.

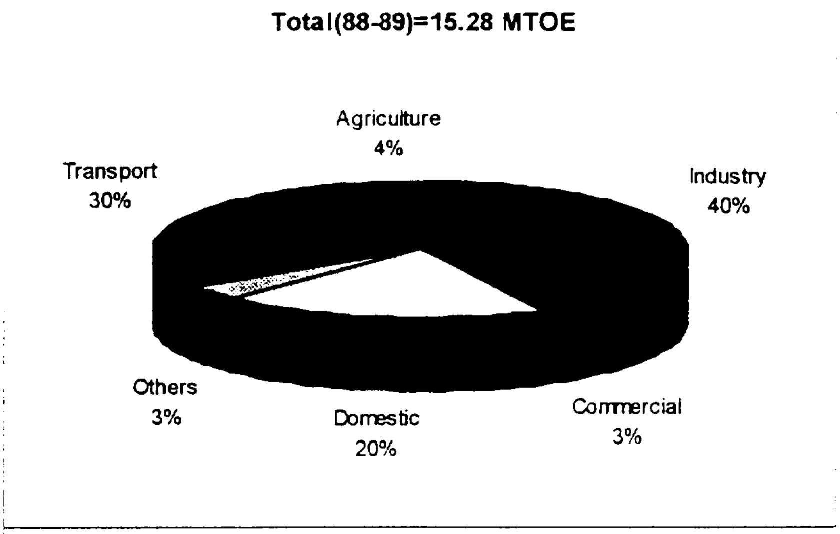
Total Primary Energy Supply (in TOE)

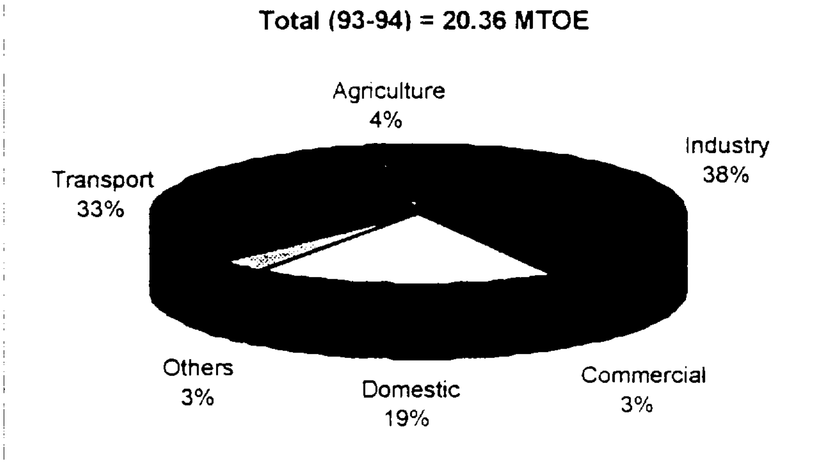


Total Final Energy Consumption (in TOE)



The *energy consumption by sector* comparing the year 1988-89 and 1993-94 is described as :-





(Source : Pakistan Energy Year-book 1993-94)

The energy trend with reference to the primary energy supply by source and final energy consumption (excluding the biomass consumption) by sector for the previous three years is given in the tables below

Primary Energy Supply by Source (Unit: Thousand TOE)

Source	1991-92	1992-93	1993-94	ACGR *
Oil	12,089 (39 %)	13,187 (40 %)	14,492 (42%)	7.54%
Gas	11,734 (38 %)	12,394 (38 %)	13,125 (38 %)	6.38%
LPG	92 (0.30%)	106 (0.32%)	73 (0.21%)	-5.71%
Coal	2327 (7.5 %)	2115 (6.4%)	2301 (6.2%)	5.0%
Hydro Electricity	4,451 14.45%	5,039 15.28%	4,639 13.35%	2.75%
Nuclear Electricity	99 0.32%	139 0.42%	119 0.34%	75.33%
Total A. growth rate	30,793 8.21%	32,981 7.11%	34,748 5.36%	6.27%

* Annual Compound Growth Rate

Energy Consumption by Sector

(Unit :Thousand TOE)

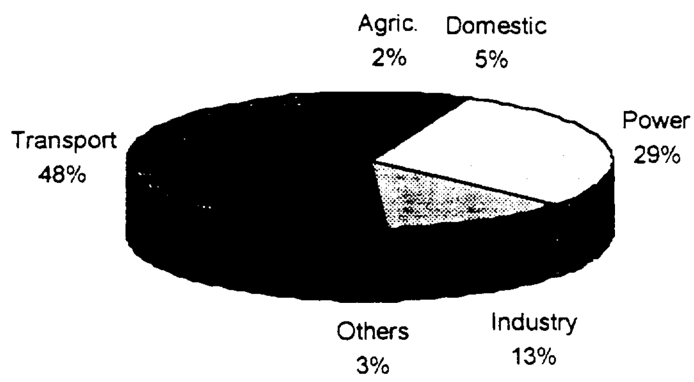
Sector	1991-92	1992-93	1993-94	ACGR
Domestic An. growth rate	3,330 (18.5 %) -5.00%	3,598 (18.5%) 8 %	3,778 (18.5%) 5 %	4.46%
Commercial An. growth rate	515 (3 %) 3.7 %	562 (3 %) 9 %	593 (3 %) 5.6%	5.94%
Industrial An. growth rate	7,238 (40 %) 9.5%	7,559 (39 %) 4.4 %	7,893 (39 %) 4.4 %	5.50%
Agriculture An. growth rate	770 (4 %) 4.8 %	758 (4 %) -1.5%	791 (4 %) 4.3 %	3.6%
Transport An. growth rate	5,914 (32 %) 16 %	6,420 (33%) 8.5 %	6,743 (33 %) 5 %	8.07%
Other Govt. An. growth rate	510 (3 %) -2.12%	560 (3 %) 9.7 %	558 (3 %) -0.24%	1.34%
Total	18,277 (100%)	19,456 (100%)	20,356 (100%)	5.90%

3.2)- Main Energy Components

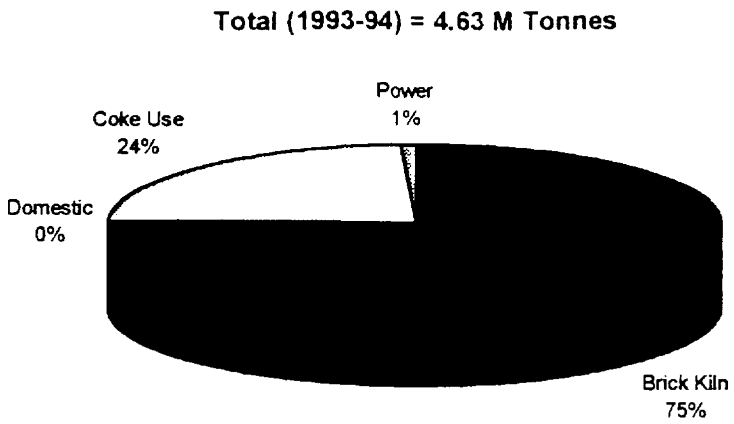
The energy supply mix during 1993-94 comprised mainly oil (41.7%), gas (37.8%) and hydel (13.4 %), comparing with the last year, the share of oil and gas registered an increase of 9.9% and 5.9% respectively. The quantity of oil imports increased by 14% from 10.6 to 12.1 million tonnes, but the import bill decreased from US $1.56 to 1.47 billion during 1993-94. The consumption of the main energy components by sector is as under:-

Petroleum Oil & Petroleum Products

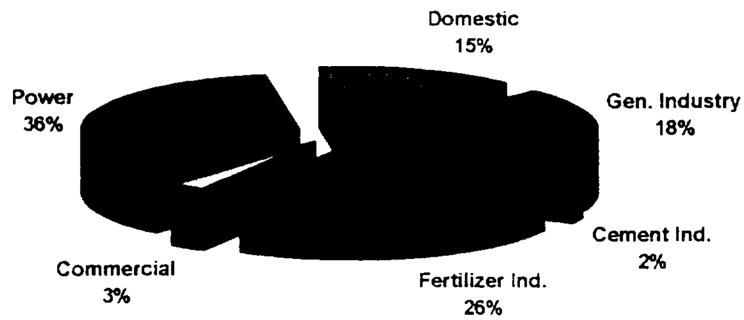
Total (1993-94) = 13.23 M.Tonnes



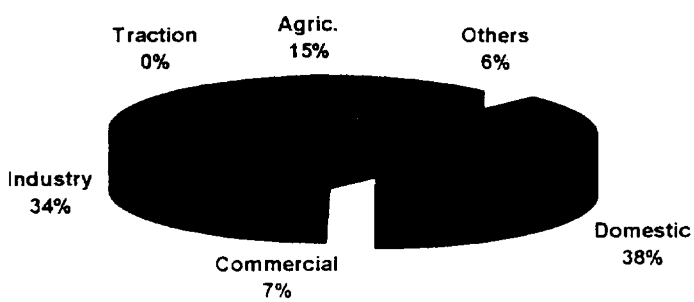
Coal



Natural Gas (1710 million cubic ft /day (1.7 mil. M^3) in 1993-94)



Electricity (Total =37381 GWh in 1993-94)



3.3)- Energy Prices

Prices of petroleum product (33 Rs. = 1 US $)

S.No	*Product*	*Period*	*Production cost*	*Sale price*
1	HOBC *	05-07-1994	6.56 Rs/Lt.	15.97 Rs/Lt
2	Kerosene	" "	5.87 "	7.0 "
3	Gasoline	" "	5.17 "	13.13
4	HSD**	" "	4.19 "	7.12 "
5	Light diesel	" "	4.15 "	4.84 "
6	Furnace oil	" "	2461 Rs/ton	2843 Rs/ton
7	Asphalt	23-04-1994	2057 "	5247 "

* High Octane Blending Component ** High Speed Diesel

The revised prices of the petroleum products per litre as on July, 96 are as under:
Motor gasoline -regular (Rs. 14.54), Super /Premier Plus (Rs. 15.956), Kerosene (Rs. 7.91) High speed diesel (Rs. 8.11), Light diesel oil (Rs. 6.35), Furnace oil (4234.71 Rs /M.Ton) (Daily News DAWN, Karachi Pakistan)

-*Natural gas* prices in December, 1994 for the different consumers (in Rupees) for one thousand cubic feet are as

Industrial	Commercial	Domestic
6.77	76.27	37.45 to 63.37

The cost of *thermal electricity* generated by KESC (Karachi Electricity Supply Corporation) is 68 Ps/KWh and WAPDA (Water & Power Development Authority) produces a little bit expensive 100 Ps/KWh but the *Hydel* electricity is much cheaper about 12 Ps/KWh only. The sale prices are different depending upon the sector & quantity of consumption.

Coal is produced by the different firms and its production cost varies from 1380 to 2450 Rs./tonne but it is sold on subsidised prices between 800 to 1500 Rs. / tonne on December, 1994.

3.4)- Environment & Pakistan

Pakistan is a developing country. Rapid increase in population (growth rate =3.2%), urbanisation and industrialisation has occurred in Pakistan during the past 30 years. Since then environmental concern has been growing progressively. Pakistan, in order to develop its economy, is adapting almost the same material, method & technology which are in common use either environmentally friendly or not. The economic policies have traditionally been formulated with other imperatives in mind, not on the basis of their impacts on the environment. In addition, the environmental laws are less than satisfactory and not implemented fully or effectively.

The industries in Pakistan are diverse, polluting and usually without or inadequate treatment of effluents. Almost all the major drains and stream carrying industrial wastes have been heavily polluted. Pakistan, being an agricultural country, relies on irrigation for more than 90% of its food & fibre production. Toxic hospital wastes have been generated at the rate of 0.11 kg / bed / day.

Comparing with the water pollution, air pollution is comparatively less severe but exceeding the permissible limits. The pollutants from the industrial stacks and the traffic exhausts at peak hours are quite severe in big cities. About 50% vehicles are badly operated. For example, the WHO limit for lead concentration is between 0.5 and one micro-organisms per cubic metre of air. As against this, lead levels are as high as three micro-organisms per cubic metre even in the residential areas of Karachi. In the city's busy commercial centres, the density is eight to nine times higher than WHO's safe limits. Constant exposure to fumes of motor vehicles that use leaded petrol poses serious health hazards. According to World Bank report, Karachi as being among the world's nine cities where people are at risk of being afflicted with disorders related to increased lead poisoning. Lead pollution consequently is increasing to alarming levels. Motor vehicle emissions in Lahore account for a large part of the noxious emissions of hydro-carbons, aldehydes and carbon monoxide.

The transportation sector, without doubt, must take a large part of the blame for aggravating the air pollution problem. In the case of Karachi alone, the number of vehicles has been growing at the annual rate of 12.5 per cent as against a population increase of five per cent. The total number of vehicles would be close to 1.1 million by the year 2000 as more and more new cars and other motorised vehicles join the cavalcade. The international survey report in question has regretted that regulations concerning petrol use or emissions were not in place even ten years after the issuance of the Pakistan Environmental Ordinance. Proper monitoring of this serious health hazard was also not introduced.

The disturbing aspect is that while the problem exists, little has been done by the government to find out it magnitude and cope with its presence. Environmental and scientific experts put the blame for this health hazard squarely on the continued availability and use of sub-standard petrol primarily used by rickshaws, and old badly- maintained vehicles (Dawn Newspaper, 2nd July, 1996). Further, the combined effects of natural climate factor result settle able dustfall of 695 ton/square mile /month.

In 1993-94, 4718 MW electricity was generated by thermal source with oil, gas and low graded coal. In 1991, about 78187 thousand tons of CO_2 were emitted. Except CO_2, the other emissions are SO_2 and NO_X. It is assumed that 14-20 kg of SO_2 per ton of fuel is emitted by coal fired plants, of which 25% is not caught by electrofilter and about 9-12 kg of NOx per ton of fuel is released into the atmosphere. UNEP (Environmental Data 1993-94) estimated the annual emissions of 381 thousand tons as SO_2 (3.4 kg per annual per capita), 231 thousand tons as NO_2 (2.1 kg per annual per capita) and 10 thousand tons as CFCs (0.14 kg per annual per capita) in 1990-91. Strip mining coal has increased soil erosion and health effects for mine workers.

Pakistan has only 5% forested area. Besides the state ministries, the Government of Pakistan in collaboration with some foreign agencies (World Bank , GTZ etc.) has started many afforestation programmes and energy conservation projects. But burning of firewood is common in our large population which is depleting the forest swiftly. Sanitation & drinking water facilities are very limited. Nearly half of the population (38%) has not access to safe drinking water while 12.9 % are living without access to basic health services (1992).

Energy sector (production, transportation and consumption) has low efficiency and is assumed to contribute about 60% environmental pollution. So environmental issue is primarily an energy issue. Because of the low literacy rate, people are not well aware about the importance of environment. A recent assessment of UNDP has summarised the progress of Pakistan so far as being a case of "unbalanced development" i.e. an impressive growth record accompanied by poor achievements in human development (ranked 132nd in 1994).

The main environmental problems identified in the NCS (National Conservation Strategy 1993-98) are the rapid increase in demographic and economic pressure on finite natural resources, a growing scarcity of water, progressive impoverishment of land, high rate of deforestation, wasteful energy consumption, inadequate systems for the disposal of industrial and municipal wastes, and a high level of water and air pollution. The NCS has also recommended to develop and deploy the renewable sources and to increase the energy efficiency.

As many as 80 million more people in the world will suffer from malaria each year if global warming continues. The result is that 60 percent of the world's population would be at risk from malaria. The heat-related deaths in cities -- like thoserecorded in recent years in the United States -- would be among one of the most certain results of global warming. Further, more ultraviolet radiation from the sun will result in higher rates of skin cancer and possibly cataracts. But poorer countries already suffering from severe health problems would be hardest hit by persistent warming

(United Nation Geneva Report, issued by Dawn Karachi, 23rd July, 96)

Keeping in view the existing situation, Government of Pakistan (GOP) has already (1994), started an "Environmental Technical Program for Industries, Air and Water Pollution,, in the Country. However, there are some other government departments (Environmental Protection Agency / Pakistan Environment & Urban Affairs) and Non-Governmental Organisations (NGOs) working for awareness, motivation and development of the environment in the country. Now GOP has started to implement some standards for all the industrial units since July, 96 to combat pollution through the newly established National Environment Quality Standards (NEQS) / Environment Protection Department (Dawn Newspaper, 2nd July, 1996). Some projects have also been started which help to promote environmental development directly or indirectly in the country. In 1993-98 (8th fifth year plan), GOP is commencing 236 different schemes of worth Rs. 19,234,78 million in environmental sector.

Chapter - 4

Energy & Rural Pakistan

4)- Energy & Rural Pakistan

4.1)- Rural Pakistan & Rural Energy

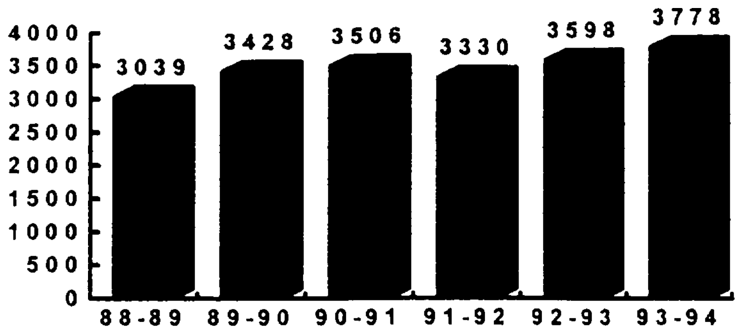
Pakistan has a vast rural sector which is comprised of more than 55000 villages scattered all over the country. More than 67% (1994) of the total population lives in rural area. Over 65% rural population is engaged in agriculture and related activities.

The importance of rural sector in the national economy is evident from the fact that it produces food for the entire nation, contributes about 53 % of GNP, earns about 41% of foreign exchange and employs 47% of civilian labour force (1992). It may be legitimately termed as back bone of the country's economy. Rural development, therefore, lies at the very heart of any meaningful development strategy. This is the only mechanism to carry the change to the majority of people. But, on the other hand, the life in rural area in Pakistan is hard. Literacy rate is very low about 20% only.

Most of the natural resources lie in these areas. But because of the lack of technology and in some cases because of application of inappropriate techniques/technologies, the life is neither comfortable nor does it make efficient use of local natural resources. Most of rural population has not access to the modern facilities of life and even some of them are without basic human needs. Rural infrastructure is not planned. The more enterprising, talented and rich people, due to lack of facilities, migrate to the cities in search of their dreams which were seldom realised and such migrants only add to the urban squalor (average annual urban growth = 4.6% in 1990).

About 20% of the villages have not access to electricity. Electric load shedding is a common observation especially in Winter or peak hours. The duration in rural areas is always more than in cities due to their less political influence. The natural gas supply is mainly confined to urban areas while the rural communities have not access to this source except for the few villages in the vicinity of big towns where LPG is also available in cylinders. Access to the safe drinking water is 45% in rural area while urban area has more than 82 % of this facility (on average in total = 62% in 1993) while sanitation services in rural areas (12%) is also one fifth of the cities (54%). Similarly, 85% rural area have access to basic health services as compare to about 100% in urban area.

The rural poor depend on wood, dung or kerosene oil and cotton sticks etc. as fuel to meet their daily domestic energy requirements. Among these non commercials, the firewood is dominant (54%). Large amount of wood is cut and burnt every year. It is estimated that fire wood is consumed 7 times more rapidly than it is reforested resulting in rapid deforestation (annual deforestation rate was 0.4% in 1992) and related problems. This is particularly serious because Pakistan constitutes only 5% forested area. Fire-wood is also commonly used in village industry (brick making, khoya production etc.). The energy consumption in rural sector (*in Thousand TOE*) for the some previous years is shown in the following graph:-



(Source = Pakistan Energy Year-book 1993-94)

The above mentioned figures do not include biomass use in this sector which is estimated about 12 M tonnes of firewood and 15 M tonnes of fresh dung annually. A household energy survey made in 1991 shows the energy trend in rural sector.

Unit :- Thousand TOE

FUEL	URBAN	RURAL	TOTAL
Firewood	1708	8926	10637
Dung	511	1303	3613
Crop residues	286	2529	3816
Charcoal	17	102	119
BIOFUELS	*2523*	*14660*	*17185*
Natural gas	1358	58	1416
Electricity	475	376	852
Kerosene	90	353	422
LPG	57	36	92
MODERN	*1980*	*765*	*2802*
TOTAL	4502	15425	19988

(Source : Household Energy Survey 1991)

The above data indicates that about 95% of total biofuels are used in rural areas. About 9% of the total fuel in rural area is used in the form of dung cakes. The shortage of energy and other facilities in rural sector has far reaching consequences on the economy of the country.

According to very recent survey of human development profile in South Asia compiled by the Human Development Centre - WHO (1996), Pakistan's urban population may exceed that of the rural areas by the turn of the century. Pakistan has not only the highest growth rate of population of around three percent in South Asia implying that the population doubles every 24 years but is also experiencing one of the fastest rates of urbanisation in the developing world. Notwithstanding the highest per capita GNP increase in the region in the last two decades, 35 million people live in absolute poverty. Its 42 million are still illiterate while 60 million do not have access to any health facilities. Twenty-eight million are without safe drinking water and 89 million have no basic sanitation facilities.

(The Daily "DAWN July 20, 96).

4.2)- Socio-Economic Situation of Rural Households

In Pakistan, many farmers have their own land. About 50% houses in rural area are made of mud, bricks or stones. Rural families have their own cattle either they are farmer or doing other jobs. The cattle are leathered in open air and are taken to river to drink daily once or twice. There is long tradition of plastering the floor in the houses and terrace with dung after one or two months depending on the nature of soil.

The consideration of prevailing socio-economic conditions and cultural parameters of rural community plays important role before the implementation of any project. Annual per capita income in rural area is anticipated not more than 250 US $ only. Data on the following variables are required for biogas dissemination projects in the region under consideration :-
1)- Eating and cooking habits
2)-The staple diet and method for food preparation
3)-The site of food preparation
4)-Kitchen Structures
5)-The number of persons for whom meals are prepared
6)-The role of fire place in the family / community life
7)-The degree of fuel wood commercialisation
8)-Constructing power of the target group
9)-Social & economic status of the women
10)-Receptivity to innovation
11)-Fuel Situation
12)-Social Resistance

4.3)- Eating/Cooking Habits & Society

The household demand for energy is greatly influenced by eating and cooking habits e.g. gas demand for cooking is lower in regions where preserved vegetables are eaten with bread or millet soaked in milk than in area where rice or beans are a part of daily nourishment.

The cooking habits are different in the different parts of country. Usually the rural population eats cooked food three times a day. The breakfast is also mostly hard food as the lunch. The common food is bread (chapati) with different vegetables or sometimes meat etc. cooked with hot chillies. In some area, the rice instead of bread, is common. However, the dinner is usually not much hard as lunch. Generally, food is cooked three times a day. Therefore, the fuel consumption is higher in the villages than in urban areas which, for biogas is estimated 0.35 m^3 per person per day while in urban it is 0.3 m^3 per person per day for cooking purpose.

There is normally a kitchen room (built with bricks or stone) in normal families but the poor houses have cook-stoves made of brick or mud under the shadow or open air. The agricultural resides or dung is used as fuel which is easily and usually free of cost is available. The average family size is 6-7 member per family.

Chapter - 5

Renewable Energy Resources in Pakistan

5)- Renewable Energy Resources in Pakistan

5.1)- Why Renewable Energy Option ?

Pakistan is facing severe energy crises since its existence (1947). The per capita energy consumption (0.21 TOE) is lowest even among the some developing countries. The load shedding is common observation usually in winter and peak hours when it is badly needed and its duration is always more in the rural areas than cities because of their less political influence and this situation is expected even to be worse in near future due to projected delay in project implementation, bureaucratic inertia & corruption in society etc. The Task Force on Energy (Govt. of Pakistan) in January 1994 reported that "Since the early eighties, power shortage ranges among 15% to 35% (between 1000 MW to 2200 MW) of system peak demand. This shortage is costing the nation between rupees five to twelve billion annually in the direct and indirect economic losses. The electricity demand growth rate anticipated at 8.8%, if the traditional planning approach is followed, then a minimum of 7000 MW of generation capacity would need to be added to the system to enable the existing shortage to be gradually overcome by the year 1998." The report further sighted that " addition of 7000 MW of generation capacity, and associated generation & transmission facilities would require a total investment outlay of Rupees 329 billions over five years. However, the present projections of private sector investment are around Rupees 54 billion. This means that Rupees 275 billions would have to be provided in to the public sector only. This implies that over 43% of the total expected public sector investment outlay would have to be allocated to the power sector only, which is totally unrealistic. In the past 15 years, resources allocation of power sector development program has varied between 7% to maximum 35% of the total development outlay " (Task Force report on Energy 1994).It means that we would have to face serious deficiency of energy in near future. For example, our main energy component is petroleum oil which is 41.7% of the total energy supply mix being imported (1.47 billion $ in 1993-94)

The GOP has decided to meet the increasingly energy demand through the private sector. A 300 megawatt unit of 1,292 megawatt Hubco Power Plant, first private sector electric power generation projects, is expected to operate in July, 1996. Government has also contracted 12 more private sector power projects with generation capacity of 2,300 megawatt. But these are insufficient and we really need the alternative sources of energy in order to cope with the serious deficiency of energy supply & high energy demands in the forthcoming years and there is only the best solution to develop the available renewable source. Technical and social conditions are completely feasible for renewable option of energy and the renewable sources, no doubt, can play a fundamental, significant and important role especially for the development of rural area to fulfil their basic energy demands. Rural population which is 67% of the total, mostly depends on firewood, dung, agriculture residues and kerosene oil for their daily domestic requirements while urban population, except some main cities, also use the fire wood. Besides, fast deforestation and environmental degradation also openly encourage the renewable energy option

The trends that are shaping the Nation's energy future suggest that we face substantial challenges in meeting our economic, environmental, and national security goals. These trends indicate that the Nation also needs to find the ways to improve energy productivity, prevent pollution, and enhance national security. The major risks that threaten the attainment of our national goals include high energy demand (especially due to rapid increase in population), unstable world oil supplies, growing recognition of environmental threats and a slow-down in investments to develop and deploy new energy technologies.

Continuing political and social upheaval in the Middle East and Central Asia could lead to significant and prolonged disruptions for the countries in these regions to supply oil. Resulting high oil prices, combined with inadequate monetary and fiscal policy may create problems to our development. Clear evidence of significant global climate changes or other energy-related environmental problems demands to take measures to reduce greenhouse gas emissions or other environmental risks from energy production and use which favours the use of renewable option. Many scientists believe that stronger evidence could emerge in the next decade or two indicating that human-induced climate changes would result in large adverse impacts. Although it is difficult to forecast but it is clear that the developing countries like Pakistan would face worst problems due to their less resource to tackle with the resulting changes.

The Pakistan, luckily, is geographically situated on the place where it is endowed with renewable energy sources. The available sources of renewable energy in the country are Solar, Wind, Mini/Micro Hydel and Biogas Technology. There are some indication of the availability of geothermal energy in Chagi area in the Baluchistan, Gilgit Agency in Frontier region and some potential for tidal / wave energy along the coastal line. Actually, no serious effort has been made on the available potential of renewable sources especially for geothermal because their exploitation is expensive & also with tidal, which is still at pilot plant level. The brief description of the other sources is as under :-

5.2)- Hydel Power

Hydro is major energy source potential in Pakistan. The theoretical hydroelectric potential of the country is estimated to be about 25000 to 30000 MW of which some 10000 to 12000 MW may be exploited economically. The present installed capacity is 4726 MW (1993-94).

When we talk strictly about the renewable energy, it is necessary to describe Mini / Micro Hydel energy in Pakistan. There are more than two hundred mini / micro hydel plants with the different capacity ranging 5 to 50 kW, installed by the different departments (PCAT, SHYDO, WAPDA & Power Wing of Irrigation Department) in the Northern part and AJK. The indicated potential is more than 200 MW in the mountain areas. Although, the actual potential has never been measured. The installation of such plants is very useful because the population is scattered in these hilly area and the supply from the distant grid is much expensive and not feasible economically.

The cost per plant is estimated about 7000 US $ for 5 kW depending upon plant site. The cost of turbine is rather low due to local manufacturing using indigenous raw material while max. use for construction is also made of stone and wood which is locally available, almost free. Cost of electricity generation is 65 to 78 Ps/unit which is cheaper than thermal source in Pakistan (1994).

Beside the hilly area, there are more than 4000 water falls with low head high discharge in canal network where MHPP can be installed.

5.3)- Solar Energy

Pakistan is situated on the sunny belt with the latitudes 24N°--37N° and longitudes 61°E -- 75°E having annual sunshine of about 3000 Hr. The maximum temperature in plain area in summer (June--Sept.) reaches near 50°C. The maximum intensity of solar radiation at noon, on a clear day in summer, may reach a value of 1000 watts /sq. meter with a major portion of direct radiation. The total solar radiation input on the horizontal surface may vary from 2 kWh/m^2/day to 8 kWh/m^2/day. Thus, on whole land area, the total solar radiation energy input amounts to about $1.46 * 10^{15}$ kWh equivalent or $115 * 10^9$ TOE. Although solar energy in Pakistan has considerable potential but it is still expensive for large scale electricity production. Therefore, in spite of these large numbers, the practical applications of solar energy are limited only for small scale. There are only 20 solar power station (1993-94) with total installed capacity of 437.99 kWp ranging between 0.45 to 57 kWp each. P.V.Cell are also manufactured at very limited scale due to high manufacturing cost. Only one department on government level (Pakistan Institute of Silicon Technology) is working for the development of photovoltaic cell. However, some organisations like PCAT (Pakistan Council of Appropriate Technology) and NGOs (Non-Governmental Organisations) are disseminating appropriate solar technologies like solar cookers, solar dehydrators/dryers, solar water heater/stills etc. The field of solar energy in Pakistan is considerably under-exploited.

5.4)- Wind Energy

There have been some random efforts to install wind mills for water pumping in the Sind and Baluchistan area near the coastal line by WAPDA, PCAT and DGNRER (now closed) in the past years. The available wind speed data in the temperature zone / wind swap coastal region was recorded 2 m/s to maximum 6.4 m/s by the Meteorological Department of Pakistan (1981). The best potential is available along the Baluchistan coastline and Karachi area. The data from Karachi shows an average wind speed of 4 m/s at about 10 m above the sea level and the 2nd best potential at the different station in Baluchistan (e.g. Lasbella, Nokkundi and Nnushki) is between an average of 3.5 and 4 m/s annually. The useful wind energy Potential is $2 * 10^{10}$ kWh/year. In general terms, the wind potential of Pakistan can be characterised by the word low to moderate but can be considerably used for water pumping and possibly for small scale irrigation rather than wind electric. There are 13 wind mills installed in the different parts of country mostly near coastal line for water pumping only. The individual installed capacity ranges from 2 kW to 10 kW. The wind pumping (water table depth = 10 meter) is cheaper than small scale diesel pumping but more costly than electric pumping (only in those cases where grid connection can be made available).

5.5)- Biogas

The Biogas Technology has been acknowledged for its global applications. It is somehow more related to the developing country in general and ours in particular, since the resources and other requisites for biogas generation are abundant. The rural economy in Pakistan is mainly based on agro-livestock activities, generation of biogas from animal and agricultural wastes becomes an attractive option for the rural areas where burning of firewood, dung, agricultural & crop residues for domestic energy applications is common practice. Further, this technology may offer a scope for more widespread applications in the most parts of the country.

Biogas is a clean fuel in the form of gas and may rightly be termed as an alternative to natural gas. It is produced by the anaerobic fermentation of organic material like animal manure, poultry waste, agriculture residue, municipal waste etc. in a "biogas plant". The produced gas consists of methane (CH_4) about 55% to 70%, carbon dioxide (CO_2) of 20 to 45% with major impurities (but in small quantity) like hydrogen sulphide (H_2S) less than 1% and traces of carbon monoxide (CO), nitrogen (N_2), Hydrogen (H_2), Oxygen (O_2) & water vapours. Impurities are removed using various techniques, such as water scrubbing, membrane cleaning, activated carbon, $Ca(OH)_2$, Fe_2O_3, etc. Methane is the gas which is wanted.

In general, the properties of biogas are as under:-

Property	Value	Unit
Calorific Value	21.5	MJ/m^3
Density	0.94	relative to air
Critical Point	-82.5	°C @ 46.7 bar
Self-ignition temperature	600	°C
Flame velocity	0.25	m/s
Air/fuel ratio (130 octane)	5.7	l/l

Comparison of Biogas with other fuels

Fuel	Unit (u)	Calorific Value (kWh)	Application	Efficiency (%)	Biogas (m^3/u) Equivalent	u/m^3 biogas
Cow dung	kg	2.5	cooking	12	0.09	11.11
Wood	kg	5.0	cooking	12	0.18	5.56
Charcoal	kg	8.0	cooking	25	0.61	1.64
Hard coal	kg	9.0	cooking	25	0.69	1.45
Butane	kg	13.8	cooking	60	2.49	0.40
Propane	kg	13.9	cooking	60	2.54	0.39
Diesel	kg	12.0	cooking	50	1.83	0.55
Diesel	kg	12.0	engine	30	2.80	0.36
Electricity	kWh	1.0	motor	80	0.56	1.79
Electricity	kWh	1.0	light	9	0.56	2.00
Biogas	m^3	6.0	cooking	55	1	1
Biogas	m^3	6.0	engine	24	1	1

Chapter - 6

Economics & Biogas Technology

6)- Economics & Biogas Technology

The economy of methane production by anaerobic conversion of organic material is affected by a number of factors determined not only by the selected process scheme but also by the availability of suitable financial conditions. The factors will include the size of the operation, the location and site requirements, the feeding stock used, the digestion concept, product utilisation and credit allowances, environmental constraints and surcharges in effect, market rates, tax incentives, the cost and availability of material, and the projected competition from alternative energy sources. It may be important that all of these factors be considered in the determination of the projected rates of return of any project. Each project is needed to be analysed individually and scrutinised for its economic value. The potential economic benefits of anaerobic digestion are, however, evident from the attractive pay back period, rate of return, and gas costs.
Apart from biogas, the beneficiary also has monetary advantages either mineral fertiliser and with this expenditure on fertiliser can be saved, or additional crops can be harvested resulting in an increase in income. The monetary value of biodung depends on the additional nitrogen content compared to the fertiliser used. The other benefits can be seen in terms of ecological effects, effects on health sector, effects on employment & foreign exchange saving as well as increase in living standard.

When looking toward biomass conversion for the primary purpose of the methane production, the projected gas cost is a more meaningful indicator of economic feasibility.

6.1)- Potential of the biogas from the livestock in Pakistan (1991)

Pakistan is basically an agricultural country with lot of agriculture residue every year. Present available data indicates that a favourable gas costs can be achieved. The average dry matter production from cotton, maize, sugar-cane etc. is estimated about 320 tons/hectares. There are more than 50 M. tonnes of crop residues available annually in the country. But the anaerobic digestion of agricultural residues is somewhat difficult and need high technology. Besides, the statistical estimate of the cattle and buffalo population in Pakistan is 30.3 millions for the years 1990-91. The sheep and goats population estimate for this period is 47.3 millions. The wet excreta waste availability for biogas plants is estimated to be 0.25 million tons per day. Actually, the yield is more than twice of this figure, because most of the faeces cannot be completely collected. This quantity is sufficient to feed more than 3 million family size plants. The biogas technology may turn available wastes (dung) into money (energy and fertiliser). However, for the conversion of that material for potential beneficiary, a large amount of money is needed for the construction of biogas plants. Currently, however, commercial data do not exist for the large scale plant. On the basis of available data, it is estimated as :-

6.2-A) - Fuel Value

No. of animals (cows & buffalo) in Pakistan	= 30 million (approx.)
Total No. of animals in rural area (excluding suburb)	= 25 mio.
Total dung available per day (10 kg/animal, 50% collectivity)	= 125 mio. kg
Total dung available per annum	= 45625 mio. kg

Capacity of gas generation per annum (45624 * 0.04 M^3/kg)	= 1825 mio. cubic meter
Kerosene equivalent per annum (1825 * 0.62)[1]	= 1131 mio. litres
Economic value of gas per annum. (Rs. 7.25 /lt.)	= 8200 mio. Rupees

It infers a saving of 8200 million rupees per year to be spent otherwise, in terms of foreign exchange, on kerosene import.

6.2-B) - Fertiliser Value

One kilogram of dung, when composited gives 0.56 kg of composit with 1.5% of nitrogen .

Total dung available per year	= 45625 mio. kg
Total nitrogen available (on the basis of 20% total solid)	= 76.65 mio. kg

And one kilogram of dung after passing through biogas digester yields 0.72 kg dry sludge with minimum 2% nitrogen (i.e. increase 0.5% N_2)

Therefore, Total nitrogen available after fermentation	= 131.4 mio. kg
Excess nitrogen available	= 54.75 mio. kg
Additional economic value (@ Rs 15/kg) 1 $ = 33 Rs.	= 821 mio. Rs.

Therefore, the total gain from biogasification per year = 9021 million Rupees

6.2-C) - Biogas from Poultry Dropping

No. of poultry birds in Pakistan (1990)	= 95 million
Average dropping per bird per day	= 90 grams
Poultry dropping per day	= 8.55 mio. kg
Poultry dropping per year	= 3120 mio. kg
Total available potential / year (50% collectivity)	= 1560 mio. kg
Gas generation / annum (0.065 m^3/ kg)	= 101 mio. m^3
Kerosene equivalent (1 m^3 gas = 0.62 lt.)	= 62.8 mio. lt.
Economic Value (7.25 Rs. / lt.)	= 455 mio. Rs.

6-3)- Financial Analysis of Family Size (3m^3) Floating Drum Biogas Plant (for family of 6 members)

Fixed Cost (3 m^3 gas capacity)	= 11700 Rs.
Annual running cost (paints.)	= 200 Rs
Total Annual cost (interest rate = 11%)	= 1300 Rs
Gas production / day	= 3 m^3
Gas production / annum	= 1095 m^3
Kerosene oil equivalent of gas (0.62 * 1095)	= 678.9 lt.
Economic Value (678.9 * 7.25 Rs. / lt.)	= 4922 Rs.
Additional fertiliser value	= 500 Rs.
Total benefit per year	= 5422 Rs.
Annual Saving	= 3922 Rs
Pay Back Period (First cost / annual saving)	= 3 years

[1] All conversion factors have been taken from PCAT literature.

6.4)- Biogas for Saving Fuel-wood & Deforestation in Pakistan

The calorific heat value of biogas is 6 kWh/m³ cooking efficiency of 55% as shown in 6.4 The biogas production per annum is $1926 * 10^6$ m³ as calculated in 7.2-A & 7.2-C which is equivalent to $11556 * 10^6$ kWh/annum ($1926 * 10^6$ m³ * 6 kWh) or $4.16 * 10^{10}$ MJ/annum.(1 kWh = 3.6 M.J)

Sixty percent of the total biogas produced is assumed to be efficiently utilised and the rest considered to be lost due to different reasons. Therefore, efficiently used biogas amount is equivalent to $6933.6 * 10^6$ kWh ($11556 * 10^6$ kWh/annum * 0.60). or $24960.96 * 10^6$ MJ / annum. The efficiency of biogas for cooking is 55%. Therefore, available heat would be ($24960.96 * 10^6 * 0.55$) equal to $13728.5 * 10^6$ MJ per annum or $1.373 * 10^{10}$ MJ annually.

7.4-A)- Fuel wood

Calorific heat value of fuel wood	5.0 kWh/kg
Fuelwood consumption per capita per day	2.0 kg
Cooking efficiency of fuelwood	12%
Fuel wood consumption of rural population per day, ($73.5 * 10^6$ rural population * 2 kg * 5 kWh/kg)	$7.35 * 10^8$ kWh = $2.646 * 10^9$ MJ
Annual fuelwood demand & consumption of rural population ($2.646 * 10^9 * 365.25$)	$9.66 * 10^{11}$ MJ
Annual useful energy ($2.646 * 10^9 * 365.25 * 0.12$)	$11.597 * 10^{10}$ MJ
Biogas contribution in percentage for household energy consumption, the efficiently available heat for cooking from biogas ($1.373 * 10^{10}$ MJ) divided by the annual heat supply from fuel wood ($11.597 * 10^{10}$ MJ) which is ($1.373 * 10^{10}$ MJ / $11.597 * 10^{10}$ MJ) of the fuel wood can be substituted for rural household consumption from biogas	= 11.84% i.e. 12 % (approx.)

6.4-B)- Afforestation

Average amount of fuel wood per capita per day needed	2 kg
Total rural population	$73.5 * 10^6$
Total rural consumption per day ($73.5 * 10^6 * 2$ kg)of fuel wood at 25% m.c.w.b.	$147 * 10^6$ kg
Total rural consumption of wood per day, ($147 * 10^6$ kg /500kg * 1m³) 500 kg fuel wood is assumed at 25% m.c.w.b.,	294000 m³
Amount of fuel wood consumption per annum ($147 * 10^6$ kg * 365.25)	$5.369 * 10^{10}$ kg
Fuel wood consumption per annum ($5.369 * 10^{10}$kg/500 kg * 1m³)	$107.38 * 10^6$ m³
12% of $5.369 * 10^{10}$ kg fuelwood	$6442.8 * 10^6$ kg or $6.443 * 10^6$ tons
Necessary area of afforestation to provide 12% as above table, 12 % of the fuel wood consumption could be substituted by biogas (with 5 tonne per ha yield) =$6.443 * 10^6$ tons/5 tonne per ha	$1.289 * 10^6$ ha
Therefore, afforestation cost can be calculated by multiplying with unit cost	

6.5) - Biogas Comparison with Kerosene, Natural Gas & Wood for domestic consumption

6.5-A) - Data / Conversion Units :

Biogas heat content = 20 to 28 MJ / m^3 depending upon percentage of methane.
Natural gas heat content = 35 to 37 MJ/m^3
Natural gas price for domestic purpose = 38 to 64 Rs. per thousand ft^3 (let ave. 50 Rs) depending on the quantity of gas unit consumed (35.3147 ft^3 = 1 m^3)
Kerosene 1 litre = 0.2 m^3 biogas
Kerosene sale price = 7.25 Rs. per litre
1 kg of wood = 0.25 m^3 of biogas.
In actual practice, the wood (agri. residue) are collected free of cost. However, it, in big & also in small town, costs from min. 1 to 0.5 Rs. per kg. (let price= 0.5 Rs /kg)

The annual price for natural gas, kerosene oil or wood equivalent to heat contents of 1095 m^3 biogas for a family would cost yearly Rs. 1324, 3969 or 2190 respectively as on December, 94.

6.5-B) - Comparison

Taking as an example of family size biogas plant having 3m^3 gas capacity (annual production = 1095 m^3) and equivalent energy from natural gas, kerosene and wood, The results obtained (by using the economic evaluator software) are compared as under. The levelized cost of biogas is less than the other sources.

General Parameters:
Rate of interest = 11 % , Rate of inflation = 10 % , Time Horizon = 15 years

(33 Rs. = 1 US $)

System	***Investment (Rs.)***	***Cost (Rs.)***	***Production***
Biogas	total plant = 11700 (life =15 years)	paint/labour = 200 fertiliser (by-product)=-500	Energy =27000 MJ (constant over 15 yr.)
Kerosene	stove = 300 (life =15 years)	maintenance = 25 kerosene bill = 3969	Energy =27000 MJ (constant over 15 yr.)
Natural gas	stove etc. = 550 (life =15 years)	maintenance = 50 gas bill =1324	Energy =27000 MJ (constant over 15 yr.)
wood	mud stove = 25 (life = 1 year)	maintenance = 10 wood bill = 2190	Energy =27000 MJ (constant over 15 yr.)

System	*NPV Investment*	*NPV Cost*	*NPV Total*	*Production (1) in* MJ	*Disc. Sum Production*	*Lev. Cost (Rs. MJ)*
Biogas	11700	-2394	9305	27000	215510	0.0432
Kerosene	300	31879	32179	27000	215510	0.149
Natural gas	550	10967	11517	27000	215510	0.0534
wood	199.5	17560	17759	27000	215510	0.0824

6.6)- Scope & Advantages of Biogas Technology in Pakistan

The energy scenario of Pakistan exhibits at an earnest need to exploit and develop new, non-commercial and renewable sources of energy. There is need of well designed, small scale, integrated energy systems to sustain the development and to achieve the adequate energy supplies especially in the rural areas, the back bone of our economy, for the environmental & socio-economic development and to substitute the commercial fuels.

Biogas is an appropriate village technology and has been developed to cater the fuel requirements of the rural families. It is a very suitable option in the country like Pakistan where energy pattern, economic development, the unusually high ratio between growth rate of energy consumption and the growth rate of economy, and continuing urbanisation have caused tense supply demand situation. The situation of rural energy has been described already in detail under the section "Rural Area & Rural Energy". The advantages of biogas are being listed below :-

* Saving fossil fuels
* Saving fuelwood and other biomass
* Saving straw and crop residues for animal fodder
* Reducing expenditure on fuel
* Less dependence on commercial fuels
* Narrowing the gap between cities and villages.

There are some other advantages of this technology over the other sources of renewable energy. For example, it

* is produced from waste.
* gives an effluent of high potential fertiliser value (depends on feeding material).
* improves hygienic conditions in the villages because of no odour or insects near the plant waste, which in fact, is test of proper working of plant.
* has low capital cost and affordable for average rural (but expensive for very poor faction of rural villagers).
* has no significant operational or maintenance cost.
* uses local & easily available material and can have wide spread implementation in the most part of country.
* can be operated, understood, controlled and maintained by villagers after a small training without high level of education/training.
* may be manufactured locally out of small metal shop.
* raises the living standard by providing clean energy/smokeless fuel & environmental friendly.
* reduces the drudgery of house wives.

Chapter - 7

Biogas Programmes in Pakistan

7)- Biogas Programmes in Pakistan

7.1)- History & Evaluation of Biogas Projects in Pakistan

The program of the biogasification was started in 1976 and so far more than 6000 plants of different capacities mostly ranging from 3 to 8 cubic meter with a few plants (only 2) of community size, have been commissioned in the different parts of the country in the past decades. The most of the plants have been installed in the rural area in order to meet their daily cooking requirements only. However, the biogas plants at present, make use of the negligible percentage of the available potential resources.

Initially, the Chinese design (fixed dome-roof) was adopted and 21 Chinese type plants were installed. Though relatively cheaper than floating drum, the workability of these plants were not found satisfactory. It was soon found to raise certain local problems e.g. 1)- fixed dome rendered the pressure variable, effecting the burning efficiency & acceptance; 2)- difficulty of quality execution in rural areas and 3)- use of costly form work, its transportation & erection and resultant delay due to curing needs etc. Then this design was abandoned.

Therefore, the Indian design (a floating drum type) was adopted in around 1980. This is simpler in design, easier for construction and quicker in installation in far flung remote areas. However, the following modifications were made in the Indian design i.e.

i)- Central partition wall was removed (up to 7 m^3 / day capacity) unit
ii)-Central guide & pulleys were replaced by side supports (rods & rings)
iii)Thickness of wall was reduced from 9 to 4.5 inches in small (up to 5 m^3 gas capacity)
iv)-M.S. Sheet of 1/16 is used in place of 1/12 gauge with additional, uniformly distributed, weight (bricks, blocks, gunny bags filled with earth etc.) added on the top.

It is estimated that these steps decrease the expenditure 30% of the total cost of plant.

So far, no comprehensive survey has been undertaken to evaluate the performance of the installed plants. Therefore, no reliable data is available about the working of the installed plants. However, based on some verbal reports, it is believed that 20 - 30% of the total plants have been in working condition except the complete failure of plants (about 4000) installed throughout the country by the Director General of New & Renewable Energy Resources (DGNRER) in pursuance of ADP project costing Rs. 33.54 million during the period 1981 - 1985. The plants were of 5 to 7 cubic meter capacity of Indian design. The other about 2000 plants are mainly installed by PCAT.

As evaluated by the Energy Wing, Planning & Development Division, the project (ADP) which was planned to meet the total energy requirements of selected villages by installation of biogas, has failed to achieve the objectives. Out of totalled units, only 17% were found to be working but with low pressure. Even the working units were not able to meet the total energy requirements, and owner were being compelled to shift to some other sources of energy. The more alarming feature was that out of total installed units, about 50% never became operative, which shows a high rate of failure. The department-DGNRER has been now closed.

7.2)- Reasons for Failure

In spite of the impressive list of advantages of biogas in Pakistan discussed earlier, there is general belief that the biogas programme has been failed in Pakistan. Energy Wing's survey underlines the following reasons for the

7.2-A)- Failure of DGNRER,s Biogas Plants :

No proper feasibility study was carried out for the selection of sites
Weather conditions were not given due recognition in site selection
Socio-economic conditions of beneficiaries were not assessed to determine their suitability on the cost sharing basis
Enough interest in the beneficiaries was not generated to make them committed to the concept
Technical factors (e.g. design parameters) were not implemented accordingly
Easy availability of firewood and in some area easy access to LPG & electricity
Lack of co-ordination between provincial & federal agencies in implementation, operation and maintenance of units installed under the project
Absence of built in follow-up system, supervision and guidance by DGNRER.

7.2-B)- Failure of PCAT,s Plants

Although no systematic data exists about the factors that contributed to the failure of PCAT,s plants. The following points are considered as the major causes of the failure.
The dissemination methodology was not properly adopted and implemented. The selection of target groups/beneficiaries was made on personal recommendations of staff or by some other agencies. Therefore, many recipients may have not been sufficiently motivated to put requisite efforts to operate the plants.
The ambient temperature of some areas in Pakistan forms second major cause for failure of the biogas plants. Plants which were not designed for the colder climates, were installed in the areas like Murree, AJK, etc. where the temperature even in summer is not high enough for proper functioning of the plants.
There were many problems associated with the technologies itself. First, the digester requires daily loading and unloading, the manure & effluent has to be dealt with, which was considered to be messy job by many villagers. Secondly, the floating drum needs regular painting to avoid corrosion. This requires careful maintenance and villagers were not properly trained and motivated to do this job themselves.
There is the possibility of formation of a hard layer of crust on the top of the effluent inside the digester. This layer, if not dealt properly, can hamper the production and collection of gas. This aspect has also not been taken into account.
The floating drum involves some what high cost component for poor villagers because of metal drum and fixture. The return to the investment is seen too low in relation to the other uses of resources. The return to the individual were often thought to be inadequate because they are intangible & non-fiscal; they are in forms of savings in the use of other resources rather in direct sales resulting decrease in interest.
It has been observed that the plants which were handled and looked after by the servants, faced frequent breakdown problems due to lack of interest, thus disturbing the whole process.
Promotional activities to generate demand were not adequate.
Disposal / treatment of effluent which is initially water like solution, but can be converted in to high quality fertiliser, was not promoted; therefore problems ensured.

Limited diffusion of technical knowledge and experience to run the plants, lack of institutional infrastructure, credit and extension facilities & above all, lack of qualified & trained technical personnel have contributed to the failure of PCAT,s biogas programme.
No special associated equipment like burners and gas lamps have been designed and provided to the beneficiaries. The burners designed to operate on natural gas were used with the biogas resulting in loss of heat and efficiency.
The programme was not evaluated after its implementation and no follow-up guidance or technical assistance has been provided.

It may be resulted overall that the failure seems to be connected with the subsidy and technical drawbacks. The plants were installed without meeting the basic requirements (suitable plant site, required raw material availability, & gas demand etc.). which are necessary for the successful operation of the plants. The other were found unsuccessful due to lake of advice, maintenance & repair etc. The commonly observed installation & operational problems during the evaluation study are enlisted as :-

* Mainly gas leakage from gas holders in the working plants (improper welding)
* Blockage and scum formation (due to improper mixing of influent)
* Maintenance of pH (due to improper filling)
* Low temperature (installed in cold/hilly area)
* Low pressure drop (due to more distance between plant and kitchen etc.)
* Corrosion & rusting of gas drum (due to improper painting and in some cases, presence of H_2S in poultry dropping) usually after 2 years of period.
* Incombustible gas (due to improper feeding material)
* Accumulation of water in pipeline (improper installation of water tap)
* Addition of more than the required quantity of dung/water.
* Unavailability of appliances (gas burner / lamps etc.)

7.3)- Strategic Factors Consideration as the Case in Pakistan

7.3.1)- Institutional Approach

The diffusion of biogas technology through existing institutions at national level is very important to be considered. There is no organised approach for the dissemination of biogas technology in Pakistan. Before constructing a large number of biogas plants, the institutes which are interested in this technology, should be organised and have work on :-

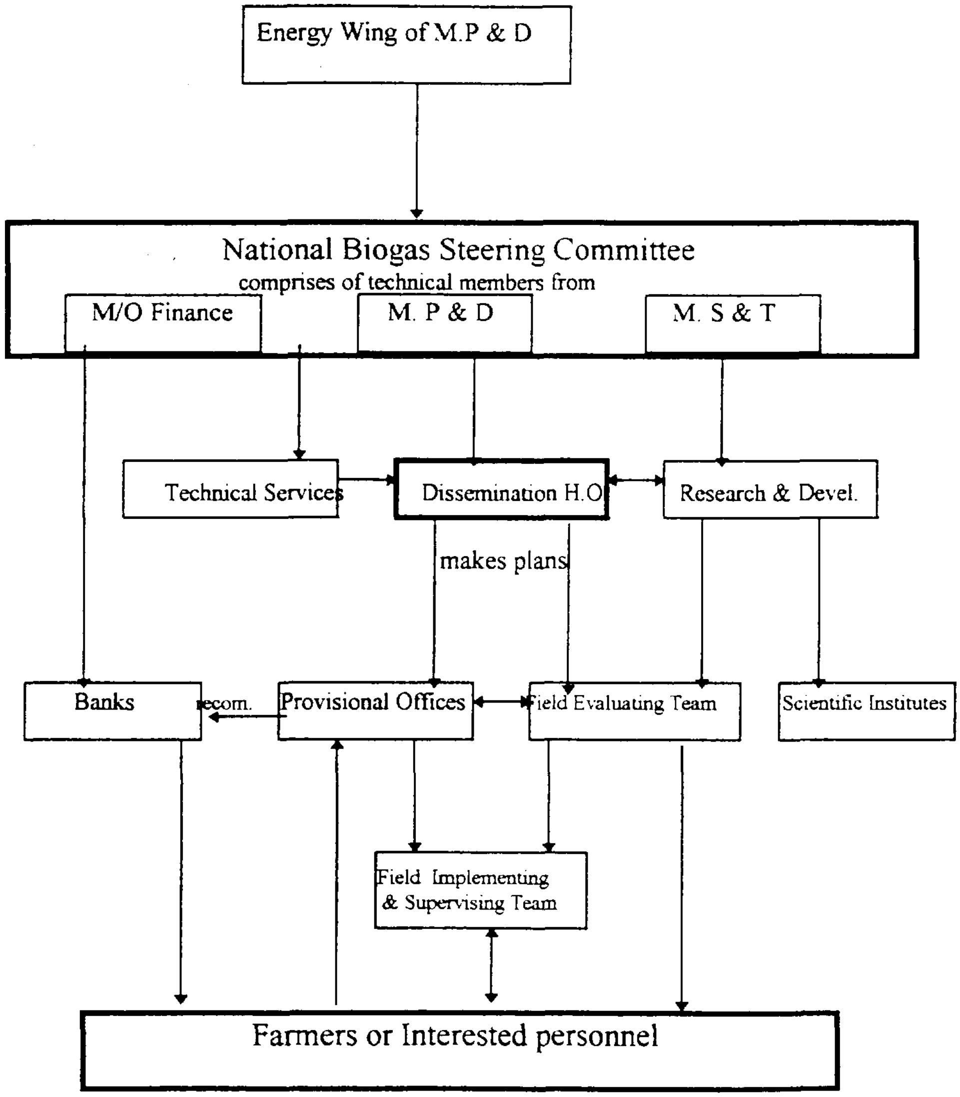
° Demonstration of biogas plants
° Training programmes for biogas construction
° Operation and appliance adoption to integration into live stock and forage management systems and in longer term publicity.
° Public awareness programmes through TV and Radio broad casting and different language songs (in local languages) in different regions
° Introduction of biogas technology into primary and secondary schools and courses at college level and related programmes can provide a sound basis for self sustained dissemination of biogas technology
° Promotional efforts using brochures, pamphlets, posters, T-shirts and lectures, seminars and workshops will have to be undertaken to assist in promoting awareness of benefits of biogas utilisation nationally
° The experience made by the different organisations like PCAT which gain a little bit success, should be reviewed and utilised

°Biogas technology activities should be supported within a consistent multi-sectoral strategy for rural population

° Extension know-how must be more closely integrated, more linked. The know-how and the experiences spread over the country need to be utilised in a comprehensive manner.

7.3.2)- National Level Proposed Institutional Approach in Pakistan.

The government consultation is a central and significant element in establishing, disseminating and developing the biogas programme. Government needs to provide the material and financial basis for the biogas projects by issuing the directives and by providing the budget and has to place mandate with other relevant institutions as well as diffusion through the existing institutions. On the state level, the complexity of biogas is normally understood. It is often referred to as "Simple Technology,,. and the essential personnel, organisational and functional aspects are overlooked. The organised approach for the dissemination of biogas technology in Pakistan may be constructed as under proposed organisational set-up.



7.3.3)- Social Resistance

Biogas gas technology is not likely to face serious resistance from rural population purely on the social conditions except some very remote area where the education rate is very low (below 5%) in Baluchistan and NWFP. Outside the anaerobic treatment of human excrement (which is widely not acceptable), no resistance has been identified in the most part of country. But it is needed to motivate the rural community.

7.3.4)- Women

Biogas plants are normally used by women since fuel wood is collected by their force. This provides a focus for channelling development assistance to this often ignored target group and becoming an important catalyst in empowerment of women, an essential prerequisite for development and for the eradication of poverty, ignorance and disease. In Pakistan, women are kept out of many social and decision making processes. But women are the main interested parties particularly when gas is used as cooking energy.

The involvement of women in the biogas application for rural household may not result in great profit but they can play a significant role in filling the plant and using the gas. It needs detail investigation how women benefit from it. Before biogas projects are implemented, the participation of women through women institution has great influence to improve the benefits for the women. The women should get training on how to use the biogas and in some preliminary maintenance and service work as well.

7.3.5)- Regional Emphasis

Large dissemination will have to be based on a regional analysis of the potential for the technology and of the socio-cultural conditions. As Pakistan has contrasting topography, the region under consideration should be assessed in more detail to establish which ones have the physical and social potential for significant replication of biogas technology. The number and geographic spread of farmers, livestock, topography, transportation facilities, water availability, climatic conditions, availability of financial resources have to be assessed in detail to determine which geographic extension model should be followed in terms of the country diversity.

7.3.6)- Zero- grazing, forge production

To increase the amount of manure, urine and water collected in the digester biogas plants construction should include a modification. In practice, there is no cemented floor for animals places in the country. The influence of the feed and feed production pattern should be seen. Vegetation growth in the some regions is the factor which decides whether it is more economic to take the forage to the livestock and thus enjoy the benefits of indoor stock keeping. This includes recommendations for a better balance between fuel wood trees and the planting of fodder trees.

7.3.7)- Health Considerations

Biogas stoves are more convenient to use and can substantially reduce the risk of contracting respiratory diseases due to unhealthy levels of smoke in the kitchen and to improve the living standard. Normally, there is no availability of biogas stoves.

7.3.8)- Water Level / Ground Conditions

The underground water level and ground conditions are also necessary to be considered before the installation of biogas plant. The water table is different in different regions. Very rocky underground or a high ground water table is unfavourable. In both cases, more work is involved in building the plant which also increases the cost.

7.3.9)- Technical Aspects

The most important factors governing the decision for the technical concept for the biogas plant are :

reliability under rural conditions like simple to operate and as little mechanical motion in the plant as possible
little maintenance requirements as possible
adaptability to locally available maintenance
maximum possible standardisation of the construction for typical applications
development of biogas appliance to be manufactured

7.3.10)- Practical Factors

Theoretically, the process parameters (are described under Section 7.3.11) are the guarantee for the successful biogasification operation. However, the evaluation studies of the previous plants/projects has found some practical shortcomings which are directly or indirectly related to process parameters. It is high time that efforts to propagate biogas in Pakistan must be reviewed. This would, however, require a commitment to evolve a national biogas policy at high level, and dedication to the work at executing level. Any half hearted effort without sufficient technological inputs may again result in yet another failure story.

For successful implementation and operation of a new biogas programme, following points should be considered carefully.

* The present biogas technology must be thoroughly studied at the institutional level before the actual take-off of some field programme. The study, and R&D part must be significant component of total project.
* The technical staff must be trained in design, manufacture and operation of biogas plants, to enable them to make modification in design, depending upon the local conditions. The training must also include maintenance and trouble shooting.
* A systematic dissemination strategy should be formulated, including the production of manual, and implemented.
* Propagation campaign must be launched through mass media including popular radio programmes.
* Do-it-yourself manuals, brochures and posters may be prepared and distributed.
* Careful selection of recipients / beneficiaries must be considered as an integral part of programme. This should be considered in cases where the recipients are even willing to bear the entire expenses of the biogas plant.
* Efforts must insure proper quality control.
* Biogas appliances like burners, gas lamps must be specially designed & tested.
* Outright subsidies must be avoided. Minimum possible cash inputs from government side, preferably in the form of hidden subsidy or loan may be provided.
* Standardisation and ease of availability of spare parts should be ensured.
* A programme for the installation of at least 500 biogas plants may be undertaken and credits & facilities should be initially provided to the recipients of the biogas plants
* Some community size plants (about 30 in number) coupled with the biogas driven engines to generate electricity and/or motive power may also be installed, preferably at remote dairy farms.

7.3.11)- Important Parameters

The brief detail of important factors which influence the anaerobic digestion process in the biogas technology are as under :-

-pH (alkalinity , Acidity)

This is the measure of the activity of hydrogen ions in the slurry. The pH control is very important in maintaining optimal bacterial growth and or conversion process in anaerobic digestion. The optimum range of pH for biogasification is between 6.6 to 7.2.

-Temperature.

Methanogenesis occurs practically in two optimal way in two ranges of temperature at its best on 35°C for Mesophlic i.e. 30 to 37°C. It does take place at lower temperature but the gas production rate is diminished while for Thermophelic at about 55°C that is between 50 to 60 C.

-Mixing .

There are several objectives of agitating/mixing in the digestion process as follows:

° to have an dispersion of suspended materials such as granules or flocs to promote max. biomass / waste contact;

° to mix fresh substrate with the bacterial population:

° to prevent scum formation and sedimentation;

° to maintain constant temperature within the digester;

° to provide a uniform bacterial density; and

° to prevent the formation of dead spaces that would reduce the digester's effective volume.

The effect of agitation and mixing is highly dependent on the type of substrate used. The better distribution of feeding material is always important but excessive or too frequent mixing can adversely affect the process and slow stirring is considered better than rapid agitation (Sahm, H. 1982)

-Absence of air.

Methanogensis is strictly an anaerobic micro-biological process and these bacteria die in the presence of air / O_2.

- C / N ratio.

Fermenting nitrogen contributes to the neutral pH stability of the liquor. It is also required for cell growth, a phenomenon necessarily linked to methane production. Based on experiments, the metabolic activity of methanogenic bacteria can be optimised at certain C/N ratios, and the optimum point depends on the nature of substrate used. C/N ratio is optimum between the range of 20:1 or 30:1 for maximum methanogenic performance.

- Feed loading rate, Solid concentration & Absence of toxic material :-

Volumetric loading rate refers to the daily amount of organic substances fed to the digester in relation to the rector's total volume. The loading could be expressed in terms of organic loading (kg of BOD or kg of COD /m^3 - day or kg of volatile solids (VS/ m^3-day). The normal loading rate is 1 to 1.5 kg of volatile solids per m^3 of digester capacity per day is satisfactorily although the recommended value for the standard sewage plant digester varies from 0.48 to 1.6 kg VS / m^3-day. For swine and poultry manure waste, the optimum loading ranges within 1.0 to 4.0 kg of COD /m^3-day. Overloading effects high concentration of fatty acids resulting the toxic condition for methanogenesis bacteria.

Besides the excessive quantity of feeding material, some organic (like chloroform) & inorganic substances also create the toxicity e.g. formation of NH_3.

-Micro-nutrient availability :
Metal ions are required as micro nutrients in methanogenesis. Large amount of iron cations (Fe^{++}) up to 2μM are necessary for optimum performance of acetoclastic methanogenic archae-bacteria. Copper ions (Cu^{++}) at the concentration of 1 ppm (part per million) in the methane-digesting mixed liquor enhance the methane rate. Nickel ions and Cobalt ions are required at concentration of 100 μM and 50 μM respectively.

-Hydraulic Retention Time (HRT)
The time period in which the organic matter remains in digester, dictates the volume of digester & gas, and economics as well. Optimum HRT depends on the temperature and nature of the field stock.

7.4)- ($3M^3$) Floating Drum Plant as an Example

In Pakistan, the average size of the family is about 6-7 members per family. A plant of $3M^3$ gas capacity is sufficient to meet their daily cooking requirements. The observations and conclusions indicate that biogas technology can be implemented successfully in the country. Actually, the design parameters, along with other reasons, were not implemented accordingly which contributed in the failure of biogasification. However, the following modifications are being proposed in the Indian design to reduce the installation cost :-

Taking $3M^3$ Plant as an example, the two main parameters, digester & gas storage volume, are calculated as under:-

HRT in Pakistan
The rate of gas production per week in Mianwali (central Pakistan) is reported as under:-

Its week	7 %
2nd week	17 %
3rd week	28 %
4th week	33 %
5th week	11 %
6th week	3 %
7th week	1

7.4-A)- Calculation of Volume of Digester and Gas Holder
Assumption
6 cattle with some calves and sheep / goats etc. (part time stable)
Daily amount of dung collected = 75 kg (DM = 20%)
Gas available :- 75 kg * 0.04 m^3/kg = 3 m^3
Amount of feeding substrate = 112 litres (by adding water as step 9.4.5)
Temperature :- 30 °C
HRT = 50 days (in most area of Pakistan)
As the volume of digester is calculate by HRT and daily quantity of feeding material. Therefore, Volume of Digester = 112 * 50 = 5.6 litres = 5.6 m^3

Volume of Gas Holder: The size of gas holder depends on the gas production & gas consumed daily.
Normally the half of the daily gas production or/otherwise about 1/3 of the digester volume. So in this case, the digester volume is recommended from 1.5 to 1.8m³. If possible from economical point of view, it is preferable to choose it as big as possible.

7.4-B)- Estimated investment cost of 3 M³ floating type biogas plant

The plant cost depends upon the site, labour cost and availability of material where plant is being installed and other factors. Based on the experience, the estimated plant cost in Northern area or central Punjab of the Pakistan is described as under :-

Material	Unit (Size)	Quantity	Total Price(Rs.)*	Remarks
Cement	50 kg each	7 bags	1200	
Sand		30 m^3	200	
Concrete (bajri)		20m^3	150	
Bricks	9*4.5*4 inch each	1800 Nos.	1650	
Concrete pipe	D= 0.5 ft., L= 6ft.	02 Nos.	200	
M.S. Iron sheet	8ft *4 ft each	04 Nos.	3800	
Drum welding	No.	01	500	10 hr skilled
Gas pipe		70ft. (let)	350	
Digester digging	No.	01	750	40 hr unskilled
Labour constru.	Hr. / days		750	40 hr unskilled
Masonry	hr. / days		1500	40 hr skilled
Paint	Packet (1 litre each)	02	150	
Other / fixture	-		500	

Total Cost: 11700 Rupees

e.g. gas drum/welding cost about = 37.0%, Skilled/unskilled labour =25.5% & Other material = 37.5% of the total initial investment for installation of 3m³ biogas plant.

Chapter - 8

Conclusions

8)- Conclusions

Although, biomethanation is a mature technology but its implementation is paradoxically only partly success. Biogas plants on family farms can be economical but seldom are so in Pakistan. Either the investment cost has been high or satisfactory performance of the process could not be maintained or in some case for the short period of time only.

A technology is considered appropriate if it gains acceptance. In Pakistan, biogas has gained little acceptance so far. Some complete failures due to wrong implementation of schemes have resulted in a loss of people's confidence, even in the basic concept of this technology.

It is, however, concluded that biogas plants, if correctly operated and maintained, may prove to be appropriate to the technical abilities and economic capacity of Pakistani farmers. It, as rural energy, can get a chance to be disseminated in rural areas. Biogas technology is appropriate to the ecological and economic demands of our future. Biogas programmes have been fairly successful in both our neighbouring countries i.e. in India and China where the millions biogas plants are working. In India, about 1.2 million biogas plants have been installed and 50 to 70% of them are reportedly in proper working condition. China, with 7 million plants in 1987, appears to be another successful story. Also other counties, like Nepal and Sri Lanka, are well ahead of Pakistan in the field of biogas utilisation in the same region (South Asia).

In fact, there is ample scope for the development of this technology in the country. It can be resulted that it would be negligence on part of system itself that biogas is being defamed rather than promoted in Pakistan.

The dual utility of biogas, as fuel and fertiliser, makes it one of the most important technologies to be promoted to meet the massive rural energy needs as well as fertiliser for our agricultural country. Even though interest in biogas in Pakistan dates back to more than two decades, the technology has not witnessed any breakthrough. Therefore, any future programme for the promotion must invariably include study of the plants and technology with regard to their output, problems and life under given circumstances, plus the lessons learned from the former schemes.

The devastating natural resources, the decrease of productivity of land and disturbance of ecology due to cutting of forest for fuelwood rises attention to search the rural energy options. Biogas is more reliable in this context and could be implemented as the most part of the country is suitable for the installation of biogas plants. The environmental conditions are favourable for the implementation and promotion of biogas technology. But, economically, the investment cost of biogas plants for the poor faction of farmers is not affordable. The government has to facilitate credit systems to invest the biogas or has to put subsidies for dissemination for biogas at national level for rural household energy.

Pakistan has endowed with considerable wealth of renewable source but this field is under-exploited & need to be develop. It is utilising only a negligible portion of available potential. Fossil fuels are extremely dominant. With the potential from existing cattle population only, 3 to 4 million family size biogas plants may be installed in Pakistan which can substitute a considerable part of rural fuel wood demand for their daily household energy requirements.

A large amount of dung is burnt every year by households which if is put in the biogas plant, may provide a considerable amount of energy along with organic fertiliser could be saved from being burned at the same time. On the basis of available data from the livestock excluding agriculture residue (50% collectivity-1991), in terms of fuel substitution, this would be equivalent to 1200 million litres of kerosene at worth economic value of 9021 million rupees saving in the form of gas and 821 million rupees as additional fertiliser value annually. On the other hand, if it was possible to replace the entire fuel-wood use in Pakistan with cow dung, the loss of nutrients would be insignificant which is estimated that the farmers would have to add over Rs. 4 thousand million worth of fertiliser to make-up for the fertility-loss. The burning of dung is not only the deprives the agricultural land from a natural fertiliser, leading to less productivity but also degrading our natural environment and adversely affects human health. However, if the dung is converted into biogas, it, along with the substitute of fuelwood, will enhances the fertiliser value in the form of slurry (about 20% economic value).

It is estimated that an average family (6 persons) with 3m^3 biogas plant can save 4000 rupees / year. The estimated pay back period is not more than three years only.

The allocation of trained manpower in biogas in the regions and the facilities of rural technology centres are needed which can give better chances to implement biogas technology.

Pakistan has only 5% forested area. The deforestation rate is much more than reforestation. If the biogas projects are implemented successfully, it can save firewood equivalent to 6.4 million tonnes annually.

The biogas technology has to be disseminated at national level and comprehensive implementation programmes are needed and should be drafted between differential governmental institutes and NGOs. There are only few and small organisations working on the research, development and installation of biogas plants. PCSIR (Pakistan Council for Science and Industrial Research), Directorate of Agricultural University and Engineering University Lahore have been mainly confined to research and development while PACT, DGNRER (now closed) and a few NGOs are rendering the plants installation services in rural area. There must be effective co-ordinating system with a National Biogas Steering Committee including the experienced personnel from different related technical organisations.

List of Acronyms

ACGR	Annual Compound Growth Rate
AJK	Azad Kashmir
CCE	Cabinet Committee on Energy
DGNRER	Directorate General of New & Renewable Energy Resources
FC	Folkecenter for Renewable Energy
GOP	Government of Pakistan
GTZ	German Technical Organisation
HOBC	High Octane Blending Component
HSD	High Speed Diesel
KESC	Karachi Electric Supply Corporation
LPG	Liquefied Petroleum Gas
MHPP	Micro Hydel Power Plants
MW	Mega watt
NCS	National Conservation Strategy
NWFP	North West Frontier Province
NGOs	Non-Governmental Organisations
OGDC	Oil & Gas Development Corporation
PCAT	Pakistan Council of Appropriate Technology
PCSIR	Pakistan Council of Scientific and Industrial Research
PSO	Pakistan State Oil
PPIB	Private Power & Infrastructure Board
Rs.	Rupees
TCE	Technical Committee on Energy
SHYDO	Serhad Hydelpower Development Organisation
SNGPL	Sui Northern Gas Pipeline Limited
SSGC	Sui Southern Gas Corporation
TDG	Technology and Development Group
TOE	Tonnes of Oil Equivalent
UNDP	United Nation Development Programme
UNEP	United Nation Environmental Programme
WAPDA	Water and Power Development Authority
WHO	World Health Organisation

References

1- Pakistan Energy Year-book (1993-94)
Ministry of Petroleum and Natural Resources Pakistan.

2- Biogas Technology, Prospects of Revival in Pakistan
A report submitted to M/O Science & Technology by Pakistan Council of Appropriate Technology (PCAT) Islamabad (March 1991)

3- Environmental Profile in Pakistan
M / O Environment and Urban Affairs Pakistan.

4- The Pakistan National Conservation Strategy (Plan of Action 1993-98)
Environment & Urban Division, Government of Pakistan (GOP)

5- EIA Guide-line, The Energy Sector Pakistan (Nov. 1991)
Environmental & Urban Affair Div. ,GOP & The World Conservation Union

6- "Rural Pakistan at a Glance"
M/O Local Govt & Rural Development

7- UNDP (Human Resources) and UNEP (Environmental Data) 1993-94

8- Biogas Technology, a brochure from Pakistan Council of Appropriate Technology Islamabad.

9- Criteria for the Dissemination of Biogas Plants for Agricultural Farm and Household Systems (May 1993), BORDA / GTZ, Germany.

10-The Possibilities for Biogas Production in Developing Countries
Dr. J.S.Clancy, TDG- University of Twente, The Netherlands (Jan. 1994)

11- Biogas Plants; Design and Details of Simple Biogas Plants
By Ludwig Sasse, GTZ / GATE Publication.

12- 3 Cubic Meter Biogas Plant
A VITA Publication, USA (A Manual- 1995)

13- The Daily "Dawn ,, Karachi, Pakistan.