# SOLUTIONS FOR ENERGY CRISIS IN PAKISTAN

Islamabad Policy Research Institute (IPRI)

# SOLUTIONS FOR ENERGY CRISIS IN PAKISTAN

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## ACKNOWLEDGEMENTS

This volume is based on papers presented at the two-day national conference on the topical and vital theme of *Solutions for Energy Crisis in Pakistan* held on May 15-16, 2013 at Islamabad Hotel, Islamabad. The Conference was jointly organised by the Islamabad Policy Research Institute (IPRI) and the Hanns Seidel Foundation, (HSF) Islamabad.

The organisers of the Conference are especially thankful to Mr. Kristof W. Duwaerts, Country Representative, HSF, Islamabad, for his co-operation and sharing the financial expense of the Conference.

For the papers presented in this volume, we are grateful to all participants, as well as the chairpersons of the different sessions, who took time out from their busy schedules to preside over the proceedings. We are also thankful to the scholars, students and professionals who accepted our invitation to participate in the Conference.

All members of IPRI staff — Amjad Saleem, Shazad Ahmad, Noreen Hameed, Shazia Khurshid, and Muhammad Iqbal — worked as a team to make this Conference a success. Saira Rehman, Assistant Editor, IPRI did well as stage secretary.

All efforts were made to make the Conference as productive and result oriented as possible. However, if there were areas left wanting in some respect the Conference management owns responsibility for that.■

# ACRONYMS

| | |
|---|---|
| **ADB** | Asian Development Bank |
| **Bcf** | Billion Cubic Feet |
| **BCMA** | Billion Cubic Meters per Annum |
| **BOO** | Build, Own and Operate |
| **Bpd** | Barrels Per Day |
| **CCI** | Council of Common Interests |
| **CHASCENT** | CHASNUPP Centre of Nuclear Training |
| **CNG** | Compressed Natural Gas |
| **DRO** | Debt Retirement Organisation |
| **E&P** | Exploration and Production |
| **ENERCON** | National Energy Conservation Centre |
| **ETS** | Emissions Trading Scheme |
| **EU** | European Union |
| **FDI** | Foreign Direct Investment |
| **GDP** | Gross Domestic Product |
| **GENCO** | Power Generation Company |
| **GNP** | Gross National Product |
| **GoKP** | Government of Khyber Pakhtunkhwa |
| **GoP** | Government of Pakistan |
| **GUSA** | Gulf-South Asia |
| **IAE** | International Energy Agency |
| **IAEA** | International Atomic Energy Agency |
| **IP** | Iran-Pakistan |
| **IPC** | Iran-Pakistan-China |
| **IPI** | Iran Pakistan India |
| **IPPs** | Independent Power Producers |
| **JEXIM** | Japan Export Import |
| **KANUPP** | Karachi Nuclear Power Plant |
| **KINPOE** | Karachi Institute of Power Engineering |
| **KKH** | Karakoran Highway |
| **KPT** | Karachi Port Trust |
| **LCDC** | Lakhra Coal Development Company |
| **LNG** | Liquefied Natural Gas |
| **LPG** | Liquefied Petroleum Gas |
| **MBTU** | Million British Thermal Units |
| **mcf** | Million Cubic Feet |
| **mcm** | Million Cubic Meter |
| **MIT** | Massachusetts Institute of Technology |
| **MMcf/d** | Million Cubic Feet Per Day |

| | |
|---|---|
| **MMCMD** | Million Metric Cubic Metres Per Day |
| **MMTOE/MMOE** | Million Matric Tons of Oil Equivalent |
| **MoU** | Memorandum of Understanding |
| **MW** | Mega Watt |
| **NCNDT** | National Centre for Non-Destructive Techniques |
| **NDFC** | National Development Finance Corporation |
| **NEPRA** | National Electric Power Regulatory Authority |
| **NPPs** | Nuclear Power Plants |
| **NREL** | National Renewable Energy Laboratory |
| **NSG** | Nuclear Suppliers Group |
| **NUST** | National University of Sciences and Technology's |
| **OECD** | Organization for Economic Cooperation and Development |
| **PAEC** | Pakistan Atomic Energy Commission |
| **PEPCO** | Pakistan Electric Power Company |
| **PIEAS** | Pakistan Institute of Engineering and Science |
| **PMD** | Pakistan Metrological Department |
| **PNRA** | Pakistan Nuclear Regulatory Agency |
| **POL** | Petroleum, Oil, & Lubricants |
| **PPIB** | Private Power & Infrastructure Board |
| **PPP** | Public Private Partnership |
| **PQA** | Port Bin Qasim |
| **PSEDF** | Private Sector Energy Fund |
| **PWI** | Pakistan Welding Institute |
| **SECMC** | Sindh Engro Coal Mining Company |
| **SHS** | Solar Home Systems |
| **SNRS** | School for Nuclear and Radiation Safety |
| **SNS** | School for Nuclear Security |
| **TAPI** | Turkmenistan-Afghanistan-Pakistan-India |
| **TPES** | Total Primary Energy Supplies |
| **UNOCAL** | Union Oil of California |
| **US** | United States of America |
| **USAID** | US Agency for International Development |
| **WAPDA** | Water and Power Development Authority |
| **WHS** | Wind Home Systems |
| **WISDOM** | Woodfuel Integrated Supply/Demand Overview Mapping |
| **XENEL** | Xenel Industries Limited |

# Contents

# INTRODUCTION

**Ambassador (R) Sohail Amin**
**Air Commodore (R) Khalid Iqbal and Aftab Hussain**

This volume is based on the papers read and presentations made at the two-day National Conference on *Solutions for Energy Crisis in Pakistan* jointly organised by the Islamabad Policy Research Institute (IPRI) and the Hanns Seidel Foundation (HSF), Germany at Islamabad Hotel, Islamabad on 15-16 May 2013. Prominent scholars, academicians and policy-makers from Pakistan participated and shared their views on different aspects of the energy crisis which Pakistan is facing and what could be the possible solutions to address the issue.

Pakistan is facing an acute and lingering energy crisis which is not only affecting the daily life of the people but is also hindering overall development and progress of the country. Although the installed generation capacity is greater than peak summer demands, exorbitant production costs make electricity unaffordable for the domestic consumer and uneconomical for commercial users. Electricity prices have skyrocketed due to an increasing reliance on thermal sources. Regrettably, most of the vendors presenting alternative routes end up focusing more on production issues than the actual cost.

As stop-gap measures, various agreements with neighbouring countries have already been put in place to meet the country's energy demand through direct purchase of electricity. Moreover, Iran-Pakistan (IP) and Turkmenistan-Afghanistan-Pakistan-India (TAPI) gas pipeline projects are already underway. Studies reveal that Pakistan has a huge potential for generating renewable energy from sources such as solar, wind and water. Biomass, coal and nuclear power generation are other untapped cheaper options. The central challenge facing the country at the moment is to find cheaper and sustainable means of generating electricity and to reconfigure the energy mix for continued supply of uninterrupted power, at an affordable price — a task easier said than done.

Considering the importance of this issue, Islamabad Policy Research Institute (IPRI) organized a two-day national conference in collaboration with Hanns Seidel Foundation, Islamabad, focused on the topic *Solutions for Energy Crisis in Pakistan,* on May 15-16, 2013, at the Islamabad Hotel. Its aim was to formulate a "National Energy Vision: 2030", covering aspects like policy making, alternative energy sources, attraction of investment, development strategies and estimating the amount of electricity required in 2030 in order to sustain an economic growth rate of 6-8 per cent. The proceedings of the conference including the speeches, papers read and presentations made are being compiled in a book for the use of policy makers and other interested readers.

The book has two parts. The first part includes the inaugural address by the chief guest, Dr. Masoom Yasinzai, Vice Chancellor, Quaid-i-Azam University, Islamabad, welcome address by Dr. Noor ul Haq, the then Acting President IPRI, and opening remarks by Mr Kristof W. Duwaerts of the HSF. The second part of the book consists of sixteen papers/presentation/ abstracts, presented at the conference. The papers describe the overall energy mix of Pakistan, its economics, the options, impediments for renewable energy and the **National Energy Vision 2030**.

**Mr. Mirza Hamid Hasan**, former Secretary, Ministry of Water and Power presented a paper titled "An Overview of Pakistan's Energy Sector: Policy Perspective" which said that access to reliable, affordable and uninterrupted supply of energy was the key to economic growth and welfare of any society. Discussing the current energy situation he pointed out a number of factors which were responsible for the severe shortage -- line losses caused by inefficient transmission and distribution systems, high level of theft, low recovery of revenues by distribution companies (DISCOs) from public as well as private users, and inadequate and delayed payment of subsidy by the government. This was making it difficult for the power generation companies (GENCOs) and IPPs to utilize their existing generation capacity. This has also given rise to a huge circular debt which was currently around Rs.400 billion.

**Prof. Dr. Khanji Harijan**, Professor Mehran University, Jamshoro, presented a paper on "Renewable Energy: Potential and Prospects," which described the various sources of renewable energy such as sunlight, wind, water, tides, and biomass. The contribution of these renewable energy sources (RES) world-wide was 16.7 per cent in energy consumption. The use of RES was growing in the world. Dr Khanji hoped that if the present resources were developed and utilized they could meet 17 to 30 per cent of the net energy needs of Pakistan by 2030.

**Dr. Vaqar Ahmed**, Deputy Executive Director, SDPI, talked about "Economics of Energy Mix." He stressed the need to implement an integrated energy plan and criticized the present fragmented handling of the problem by nearly two dozen departments. He called for provincial governments and the private sector to join in the national effort. He said a quick fix solution for the problem of circular debt could be for the government to take the existing burden on its books, after which the energy sector entities could be made available for private sector participation.

**Dr. Gulfaraz Ahmad**, former Secretary, Ministry of Petroleum and Natural Resources, spoke on "Least Cost Power Generation." He pointed out some of the strengths and challenges in the energy sector. One major challenge was low per capita energy consumption. Besides, he said, the cost of power generation was too high; there was a huge shortfall in power and gas supply due to theft and losses. The heavy reliance on gas had complicated the job for the policy makers. The gas supply projects that could provide quick relief like IP, TAPI, LNG and LPG had been delayed since the early 1990s. He recommended that we should buy maximum capacity (90%-95%) from efficient power plants to reduce per unit tariff; and it is these units which must be supplied the necessary inputs in proportion to their efficiency. This would bring down production costs.

**Dr. Ehsan Ali**, Head of Department, Centre for Energy System, NUST, in his paper on "Prospects of Biofuel" said that since fossil fuel supplies faced depletion in the future Pakistan could ensure its energy needs by utilizing its biofuel resources of molasses, bagasse and feedstock. In Pakistan, approximately 6.3 million hectares of agricultural land was saline underlain with brackish ground water where fields of algae could be easily cultivated. This would both provide an energy resource as well as leach the salt from the land making it cultivable in a few years for normal farming.

**Syed Shaukat Hasan**, Director, Pakistan Atomic Energy Commission, talked about "Nuclear Power Generation: Challenges and Prospects." He said that nuclear power was a safe, clean and reliable source of power that could provide base-load electricity and minimize oil imports. It was supplying 4.9 per cent of total generation in 2011-12. He said two more N-power plants were under construction at Chashma. Under the energy security plan nuclear power generation was expected to reach 30,000 MW by 2050. An 8800 MW unit was in the plans for construction by 2030.

**Dr. Shaheen Akhtar**, Associate Professor, NDU, gave a presentation on "Hydel Power: Confronting Dwindling Resources." She said that Pakistan had a hydro potential for 60,000 MW which could be tapped to meet current and future energy requirements but there were various technical, financial, infrastructural and management challenges that were impeding its optimum utilization. The project sites were far flung, isolated lacking basic infrastructural facilities and connectivity to transmission networks. They involved high capital cost and long gestation periods but, once in place, could be the cheapest sustainable energy source.

**Mr. Ejaz Ahmad Khan**, Secretary, Coal and Energy Development Department, Sindh, speaking on "Power Generation from Coal" said that government was focusing on developing indigenous coal resources on a "fast-track basis" to put coal-based power as a major portion in the overall energy mix. The Thar coal project could play an important role in the reduction of circular debt through cheap electricity and could save US$ 250 million per annum. He said this project could transform the Pakistan economy and bring in economic sustainability but all depended on a 'real' and effective energy policy.

**Barrister Aemen Maluka**, Advocate High Court, in her presentation on "Legislation for Energy Conservation" warned that Pakistan's energy sector would not work or progress unless the improved infrastructure was brought in line with the laws governing it. Discussing corrupt practices and power theft in particular, she said there was little scope for consumers using conservation practices and any effort by government to employ environmental taxation was likely to fail as other legal regimes were not supportive of this goal. The country needed a proper legal structure if the purpose was effective conservation and environmental health.

**Advocate Ameena Sohail**, Senior Associate IPS, discussed the "Impact of 18th Amendment on Energy Generation" and explained that the amendment was only partially concerned with energy matters as prior to it the sector was divided into power and hydrocarbons with different legal structures. She said that Article 172 which gives joint ownership rights to the Federation and the Provinces was problematic as to its implementation, while Article 161 was silent on royalty on crude oil requiring reversion to the revised Article 172(3). She said that the case of gas should also be treated in the same manner and Article 161 should be appropriately amended. Discussing Article 157 Ms Ameena said that it related to electricity but was marred as it needed appeal to the Council of Common Interests in case of dispute between the federal and provincial authorities. She identified many areas of policy which the Amendment did not address and said the missing links needed to be plugged and regulatory functions overhauled and developed for the promotion of an integrated energy sector.

**Dr. Nazir Hussain**, Associate Professor, QAU, in his paper on "Diplomacy and International Dimension of Energy Management" advocated fast track diplomacy in making use of the four trans-regional pipeline options that were on offer, i.e., the overland Iran-Pakistan (IP) gas-pipeline, the overland Turkmenistan, Afghanistan, Pakistan, India (TAPI) gas-pipeline, the underwater Qatar-Pakistan gas-pipeline, and the Liquefied Natural Gas (LNG) supply project through the sea. He said that out of the four external options, only one, the IP had no regional/international support or cooperation. In the remaining three options, financial support, investment opportunities and international cooperation were available but to benefit from them Pakistan would need to engage in proactive purposive diplomacy. .

**Mr. Muhammad Mustansar Billah Hussain**, ARO, IPRI, spoke on the "Role of Universities and Think Tanks in Energy Conservation." He said that Pakistani universities and think tanks should follow the example of research institutions in the West and other emerging economies which closely interact with policy makers and the power industry as far as scientific and technological advancements were concerned. He exhorted research bodies to share their findings with departments dealing with energy generation and conservation as well with the general public, the end users who can be the real beneficiaries of conservation in the shape of reduced power bills. He said the expert knowledge of the think tanks can be popularized through holding conferences, workshops and projections in the media.

**Mr. N.A. Zuberi**, MD Private Power and Infrastructure Board, in his presentation, "Private Power Generation & Infrastructure," said that the phenomenon of load shedding was first experienced by the nation in the early nineteen eighties and since then the demand for electricity had been increasing at an estimated rate of 7-8 percent per annum which the generation system had been unable to meet. He discussed the various reasons for this situation and suggested that unless government brought all its resources towards exploitation of the country's hydro and coal resources and brought uniformity in regulations at federal and provincial levels together with improvement in law and order situation things were not likely to improve.

**Mr. Salman Qaisrani**, Director, CWS Technologies, based his presentation, "Grids & Infrastructures: CWS Combustion Technologies," on the usage of Coal Water Slurry (CWS) technology which uses a paste of coal and water to fire thermal units in place of furnace oil to generate electricity. The process is in use in Russia and other coal rich countries for making electricity. It is also in use in India which imports coal for this purpose. Mr Qaisrani made a strong plea to try this fuel as its main ingredient was locally available in the fifth largest coal deposit of Thar and would therefore result in huge foreign exchange savings spent on importing furnace oil/petroleum; secondly the present thermal units could be easily converted for its use and thirdly, the process was environment friendly.

Presenting the **Energy Vision 2030** on the concluding day of the conference, **Dr. Shaukat Hameed Khan**, Vice Chancellor, Sir Syed-CASE (Center for Advanced Studies in Engineering) Institute of Technology, Islamabad, blamed planners for ignoring energy as a factor in the development strategy. Dr. Khan warned there were no easy and quick solutions to the power shortage problem which besides other constraints was complicated by grave dichotomy at the policy base, since the Planning Commission had been overshadowed by the Finance ministry and there was absence of continuity at the policy making centres with consequential lack of institutional memory. He said renewable energy could be a solution but only in the long term and that too only partially as solar, wind or tidal sources were not 24/7 solutions. He recommended that Pakistan should gradually reconfigure its energy mix to reduce dependence on costly thermal fuels like furnace oil, and move towards greater reliance on water, coal and nuclear fuel.

## Recommendations

At the end of the conference, IPRI's Ms. Maria Syed summed up key recommendations made by the speakers to address the problem of energy shortage.

- The energy crisis would require short term, medium term and long term measures as well as some hard policy choices like being able to catch the big fish engaged in power theft.
- Improve governance through power policies based on merit rather than vested interests, check power theft, ensure full revenue recovery, and curb corruption.
- A well deliberated, clearly articulated and sustainable policy based on least-cost options was the foremost requirement.
- Circular debt is by far the most serious problem that needs to be addressed urgently through creation of a circular debt retirement fund under an organization. The fund could be financed by a consortium of banks and financial institutions under guarantee of the government.
- The cost of generating electricity can be minimized by: optimal choice of technology of power plant and its thermal efficiency; type of fuel that the plant uses; size of the plant to exploit economy of scales; and location of plant in relation to the centres of consumption.
- Across the board subsidies are never a good policy option. Such subsidies not only result in wasteful use of valuable resources but also put unnecessary burden on other consumers and the public exchequer.
- Pigouvian taxes may not be the best solution for Pakistan's political and legal environment even though they may have, in the past, produced the desired results in many Western jurisdictions. In this context a policy review is warranted.
- The 18th Amendment touched upon electricity in a cursory manner, leaving behind a number of lacunas. However, the CCI could manage the affairs through a pro- active approach.
- Provincial governments should generate energy and start building power plants on their own.
- Renewable energy sources can be used instead of fossil fuels for many applications. Wind energy, solar energy, hydropower and biomass energy can be exploited for electricity generation instead of fossil fuel in the country. Overall, the renewable energy sources can meet 17 to 30 per cent of Pakistan's energy needs by 2030. However, the basic criteria should be their economic viability. It would be foolhardy to generate expensive electricity through these means if other cheaper options were available.
- Pakistan is blessed with rich hydro power potential of 60,000 MW which can be tapped to meet its current and future energy

requirements. It would be worthwhile to de-link energy generation from irrigation and focus on run of the river projects.

- A well planned policy shift should be made to correct the energy-mix by shifting our focus from oil-based thermal power to hydel and nuclear power.
- Pakistan must work expeditiously to complete all non-controversial hydel projects such as Dia Mir Bahsa, Dasu and Bunji Dams etc. Run of the river projects should be prioritized as they are relatively cheaper; take less construction time and are environment friendly.
- Vigorous and cost-effective measures should be taken for promoting the use of micro-hydel, wind and solar energy at the household level and in off-grid remote areas.
- Pakistan must make use of its abundant stocks of sugarcane molasses for making bio-fuels. At present around 2 to 2.5 million tons of molasses is being produced in Pakistan. However, 80 per cent of the molasses is being exported at a nominal price. This national waste must stop to make ethanol fuel from molasses.
- There are around 6000 bio-gas plants in Pakistan but their production cost is high, as presently decomposition is being done through slow natural process, if some catalyst is used the process would become cost effective.
- In the current energy scenario, nuclear power can play a vital role. Nuclear power is a safe, clean and reliable source of electricity. Nuclear power has a key significance in providing base-load electricity and minimizing imports of oil, gas and coal. It is essential to continue with the development of nuclear power, even at a modest pace, in order to develop local capabilities and to meet Pakistan's future electricity needs.
- The area near Gadani, Balochistan, is suitable for coal project with potential of producing 4000 MW. There is ample land available with very low population density. The environmental impact of the imported coal project at this location would be minimal. An Ultra Mega Power Park of at least 3600 MW can be built there.
- Coal Water Slurry (CWS) is a new type of liquid fuel that can, to some extent, replace petroleum as fuel in the energy conversion and process industries. It also has less infrastructure cost and high combustion efficiency.
- In order to meet the massive demand of energy, Pakistan has four external options: the Iran-Pakistan (IP) gas pipeline, Turkmenistan-Afghanistan-Pakistan-India (TAPI) gas pipeline, Pak-Qatar gas pipeline project and import of Liquefied natural gas (LNG). Out of

these options, only the IP gas pipeline project is without the regional or international cooperation. For the remaining three options, the financial support, investment opportunities and international cooperation are available. Therefore, Pakistan can fast-track the available options by involving other regional, international stake-holders through proactive diplomacy.

- Direct electricity purchase agreements may be concluded with neighbouring countries on the pattern of Central Asia South Asia Electricity Trade and Transmission Project (CASA 1000), if prices are affordable and economical.
- Conservation of energy is a huge source of adding to the energy supply. It aims at bringing the existing energy into efficient use by eliminating wasteful internal use, minimizing losses and theft. By a broad estimate we could add over 20 per cent to our energy availability through conservation.
- Steps should be taken to educate the public in power conservation by launching media campaigns against electricity wastage. Universities, think tanks and media can play an important role in energy conservation through innovative concepts and public awareness.
- Energy efficiency in buildings can be improved by incorporating design related best practices appropriate to our environment, coupled with traditional materials, technologies and craftsmanship. An energy efficient building could reduce annual energy bills by up to 40 per cent.
- Rebalancing the energy mix giving hydroelectricity and nuclear power greater share offers a way out of energy crisis.
- Public-private partnership in hydropower sector should be reinvigorated. This will help in raising financial resources for these projects.
- Political consensus on the big hydro projects should be developed.
- The formation of a single ministry in charge of the entire energy sector, the formulation of a long-term integrated policy and complete autonomy to regulators coupled with intense drive to increase public awareness about energy conservation offers a way out.
- In Pakistan, approximately 6.3 million hectares of agricultural land is salt-affected. Salt concentration in the soil does not allow any cash crop to grow; however, this type of land can be utilized for growing algae for biofuel production.■

# Welcome Address

**Dr. Noor ul Haq**

Honourable Chief Guest, Dr Masoom Yasinzai, Vice Chancellor Quaid-i-Azam University, Mr. Kristof W. Duwaerts, Resident Representative, Hanns Seidal Foundation, distinguished participants, guests, ladies and gentlemen!

It is my honour and pleasure to welcome this distinguished assembly of academicians, scientists, experts and students to this important international conference on "Solutions for Energy Crisis in Pakistan."

This topic is very much a burning issue of the day for Pakistan. The country is suffering from persistent energy crisis causing hardships for the people, adversely affecting industry and the economy. The purpose of the conference is to formulate policy recommendations which would be shared with the relevant ministries and departments.

I am sure the expert opinion of the participants of the conference will prove useful in the solution of the grave crisis that the country faces. If that happens we would have the confidence to say that the conference was a success.

I thank you all, speakers, chairmen of the four sessions, and respectable members of the audience among whom I see a galaxy of stars from the energy sector. I welcome you all on behalf of IPRI.■

## Opening Remarks

**Kristof W. Duwaerts**,
*Resident Representative, HSF, Islamabad*

Dear Chief Guest, Dr. Masoom Yasinzai, Vice Chancellor, Quaid-e-Azam University;
Dear Dr. Noor-ulHaq, Acting President of the Islamabad Policy Research Institute;
Respected Speakers,
Ladies and Gentlemen,
Dear Friends,

It is my great pleasure to welcome you all here today on behalf of the Hanns Seidel Foundation (HSF) and our dear partner, the Islamabad Policy Research Institute.

My name is Kristof Duwaerts, and I am the new Resident Representative of the Hanns Seidel Foundation to Islamabad, having arrived in town just last Thursday. After more than one year of absence, I am proudly succeeding people like Dr. HeinKiessling, Dr. Andreas Rieck, Mr. Richard Asbeck or Dr. Martin Axmann, all of whom I am greatly indebted to, and who you will surely be familiar with. The Hanns Seidel Foundation, which is commemorating its 30th year in Pakistan this year, is a German political foundation striving to enhance political understanding and education in over 60 partner countries worldwide. In Pakistan, we collaborate with think-tanks, such as IPRI, with Government institutions as well as with Universities and Civil Society to that very end.

My arrival coincides with some important milestones in Pakistani history. For the first time in the last 65 years, a democratically elected government could finish its term and give way to democratic elections. One of the reasons for the surprisingly clear victory of the PML-N was the soaring energy crisis in Pakistan, and the ability of Nawaz Sharif to convince the people that he would be the right person to end the era of load-shedding in the country. Whether or not he rightfully claimed to be the person to soothe the energy crisis shall not be our topic in the next four sessions.

Rather, we have gathered here today to systematically look for solutions to this very energy crisis. Not, of course in order to help any party securing or maintaining its majority, but rather in order to help Pakistan make an important step into a better future. At the end of our second conference day, we will be summarizing the ideas and inputs of all of you in a *National Energy Vision 2030*, which afterwards will be disseminated beyond this illustrious circle to even more professionals and politicians involved in energy policy making.

Six years ago, IPRI and HSF had a joint conference named "Quest for Energy Security in Asia". Let's turn to Pakistan today!

Being Resident Representative of a German Foundation, I would like to take the opportunity to briefly outline the Federal Republic of Germany's approach to securing its very own energy security in the mid and long term. Regional approaches of course play an ever more important role in a globalised world. Germany lies in the heart of the European Union and is among the central engines, if not the central engine, for a deepening regional integration, still I would like to confine myself to describing briefly our national approach.

Early in 2010, the German Government developed its so called Energy Concept with concrete steps to be taken. Its prime target lies within transforming the German energy system to a low-emission future. After the horrendous events in Fukushima, it was decided to speed up the process, and a new energy concept was passed in 2012. Next to phasing out nuclear power production at the fastest, it was decided to massively expand necessary infrastructure for doing so. Furthermore, it was convened, that by the year 2050 the amount of renewables in energy production should be brought up to at least 80 per cent of total power production. Last but not least, a massive improvement in energy efficiency was put at the core of short- and mid-term strategies. Whereas in Germany, we are trying to "green" the economy, Pakistan sees itself before the enormous task of not only greening it, but getting it to run first.

Over four sessions, which indeed sound very promising in this regard, we will be trying to bridge this gap. In the first session we will be looking at how to correct the Energy Mix, afterwards, how can Energy be both produced and consumed at an affordable price. Whereas Governance and Legislation, the topic of our third session, will have to build a framework for that, power suppliers and the industry will have to work on the 'efficiency of the whole infrastructure'.

One point, which I would like to stress and call your attention to is "Strengthening the sense of individual responsibility in every single citizen". Energy is a precious good, and we should not lavishly waste it.

With that I would end my remarks and thank you all again for being here today, and taking your time.

I wish a very successful conference with lots of profound insights and I am very much looking forward to your valuable inputs and seeing you more often in the future.

Thank you■

## INAUGURAL ADDRESS

**Dr. MasoomYasinzai**

I am thankful to IPRI and HSF for inviting me to this important conference on an urgent issue. We, as a nation, cannot survive on an economic growth rate of 3 to 4 per cent when the population was growing by more than 2 per cent. So, we must double the economic growth to counter the effects of a fast growing population. Pakistan has been blessed by Allah with natural resources of all kinds — wind, solar, coal and bio energy. We must tap these. The country has both physical and scientific resources to solve the energy problem but the policy makers just don't listen.

Dr. Samar Mubarakmand had been crying hoarse as far as coal is concerned. There are 175 billion tons of coal buried in Thar, Sindh. Russia, Australia, Europe and even Central Asian States have been generating electricity from coal. China is generating 81 per cent of energy from coal, India 64 per cent and US 56 per cent, Pakistan, on the other hand with one of the world's largest deposits is generating less than one per cent.

Pakistan is also blessed with more than 1000 kilometres of coastal belt, but it's a pity that we don't use windmills or wind turbines to make electricity. again, Pakistan has sufficient sun. Are we benefiting from it?

Let me mention molasses from the sugar industry of which 80 percent was being exported at junk market rates instead of being used as a source of energy generation. Making biogas and using biomass for energy generation was not rocket science that the country could not use as a sustainable and environment friendly source; but the academia's research work was being neglected and all of its research was going waste. We need to involve our academia in our development strategies, as we invest so much on this sector. According to UNESCO countries that made no use of their natural resources were bound to become poor. The present economic growth rate needs to be doubled and the allocation for education must be raised to four per cent if the country has to be saved from economic doom. We cannot enter into the knowledge economy era with just seven per cent of youth in higher education. We must increase that number on an emergency basis to at least 15 per cent so that energy research institutes could be opened.

I have high hopes from the coming elected government that it will give urgent attention to making use of resources that we have and listen to the advice of think tanks and experts in the field of energy who have solutions that are workable within our resources. I wish this conference success and hope it would make useful recommendations to the policy makers.

Thank you.■

# CHAPTER I

# AN OVERVIEW OF PAKISTAN'S ENERGY SECTOR: POLICY PERSPECTIVE

**Mirza Hamid Hasan**

## Introduction

Energy is lifeline of all modern societies. All productive and supportive activities in today's world are heavily dependent on assured supply of energy. Whether it is industry or agriculture, transport or communication, services or education, health care or entertainment, water supply or sanitation, it is unimaginable to pursue any of these activities without the availability of adequate and reliable energy in one form or the other. Electric power, which is the most widely used form of energy in today's world, is also dependent on other forms of energy inputs for its generation. Thus access to reliable, affordable and uninterrupted supply of energy is the key to economic growth and welfare of any society. While the appetite for energy is increasing by the day with rapid growth in population and development activities, known sources of energy are limited and fast depleting. Studies by International Energy Agency and other international organisations have shown strong correlations between access to energy, particularly electricity, and sustained economic growth, human welfare, governance and security, underscoring the need for ensuring energy security. Concerns for environment have added new pressures on energy users for the use of environmentally clean energy. Hence, all countries in the world are vying with each other to secure their energy supplies from known sources of traditional energy and also discover new, cheaper and cleaner sources of energy.

Pakistan has been facing severe energy shortage for the last few years, both of electric power and natural gas, which are two major sources of energy for our industry, domestic supply and transport sectors. The shortage of natural gas which is widely used in four sectors i.e. domestic supply, industry, power generation and transport, in descending order, has been caused by fast depleting gas reserves and rapidly increasing demand. However, the electricity shortage has not been caused by a lack of generation capacity which at the moment exceeds the peak demand by about 5000 MW. A number of factors such as excessive line losses caused by inefficient transmission and distribution systems coupled with high level of theft, low recovery of revenues by distribution companies (DISCOs) from public as well as private consumers, and inadequate and delayed payment of subsidy by the government owed on account of non-revision of tariff imposed by them for political considerations, result in a chain of defaulting entities making it difficult for the power generation companies (GENCOs) and IPPs to utilize their existing generation capacity due to financial crunch. This has also given rise to a huge circular debt which is currently at a level of Rs.400 billion. Excessively high power prices have also driven electricity out of reach of a large number of people and made it unsustainable for industrial consumers, resulting in closure or relocation of many industrial units. Frequent and sustained outages are also causing disruption in economic activity as well as daily lives of people. The electric power supply thus suffers from the multiple problems of availability, affordability and reliability at the consumer end.

While a large part of the blame for the current state of affairs lies with poor governance and management, lack of policy or bad policy choices have also played an equally big, if not bigger, role in bringing us to this pass. Before discussing in detail the causes of our current energy crisis, the issues and challenges requiring to be addressed and the actions required to be taken for a sustainable resolution of the crisis, it would be pertinent to have a review of Pakistan's current energy scenario.

## Pakistan's Energy Scenario

During 2011-12 Pakistan's total energy availability was 66.015 million tons of oil equivalent (mtoe), of which 45.251 mtoe (i.e. 68.54%) was indigenous production while 20.764 mtoe (31.46%) was imported. [1] The domestic energy sources comprised natural gas, hydel power, about one third of our crude oil supply, and small quantities of coal and nuclear energy. Imported energy mainly comprised petroleum and petroleum products. The share of various energy sources in energy supply was as follows: [2]

| | |
|---|---|
| **Natural gas** | 49.5% |
| **Oil** | 30.8% |
| **Hydel energy** | 12.5% |
| **Coal** | 6.5% |
| **Nuclear, LPG & Imported elect.** | 0.7% |

[1] Pakistan Energy Yearbook 2012, HDIP

[2] Ibid.

Pakistan's per capita energy consumption in terms of kilogram of oil equivalent (kgoe) in 2010 as compared to some other selected countries was as follows: [3]

| | |
|---|---|
| **Pakistan** | 510 |
| **India** | 510 |
| **China** | 2150 |
| **Malaysia** | 2420 |
| **USA** | 7885 |

Despite the very low energy consumption and demand as compared to other countries, our energy supply has not been able to keep pace with the demand, and the supply-demand gap is constantly increasing. In the words of Michael Kugelman in his commentary on Pakistan's energy situation in the 'National Bureau of Asian Research' of America, "Pakistan is mired in an acute energy crisis — one with immense implications for both the nation's floundering economy and its volatile security situation. According to some estimates, energy shortages have cost the country up to 4% of GDP over the past few years. They have also forced the closure of hundreds of factories (including more than five hundred alone in the industrial hub city of Faisalabad), paralyzing production and exacerbating unemployment. Additionally, they imperil much-needed investments in development and infrastructure."[4] Let us now have a look into each of the energy sectors in some detail.

## Electric Power

*Key Players in Power Sector*

i. WAPDA and KESC were vertical utilities and sole players in the power sector until a few years ago in all aspects —— from generation to transmission and distribution. But as a result of restructuring of the power sector and induction of private producers into power generation, the institutions have greatly proliferated. WAPDA has been split up into a number of entities. A new entity, PEPCO, was created as the controlling company of the various public sector generation (GENCOs), transmission (NTDC) and regional distribution companies (DISCOs) for thermal power in the country. PEPCO has since been wound up and replaced by Central Power Purchase Agency (CPPA). The power companies have all been made independent commercial entities. WAPDA is only concerned with

[3] Source: International Energy Information Agency (IEIA)

[4] Pakistan's Energy Crisis- *From Conundrum to Catastrophe,* Michael Kugelman, The National Bureau of Asian Research, USA.

hydel power generation now. KESC continues to be a vertically integrated utility but has since been privatized.

ii. Twenty seven Independent Power Producers (Thermal) and three public-private hydropower companies have also entered the field now. PSO, SNGPL and SSGP being fuel suppliers for thermal power, are also important players for the power sector.

iii. National Electric Power Regulatory Authority, NEPRA, is another important player. It regulates the power sector, determines the tariffs and efficiencies, technologies and performance standards and so many other aspects that govern the power sector and its functioning.

iv. Alternate Energy Development Board, AEDB, is a small player for alternate energy. As the energy crunch continues, there is more and more emphasis on developing alternate sources of energy such as solar, wind and micro-hydel etc.

## Generation Capacity

- Installed power generation capacity as in 2011-12 22797 MW
- Average dependable capacity in summer 15000 MW
- Average dependable capacity in winter 12000 MW
- Actual generation as on 14.6.2012 10658 MW
- Average shortfall fluctuation 3500 to 6000 MW

At one point of time of peak demand in June 2012, the shortfall was as high as 8000 MW. It is clear that the huge shortfall was not primarily caused by a lack of generation capacity. The causes for it lay elsewhere.

### The Following Table Shows the Source-wise Generation Capacity in the Country[5]

| **Public Sector** | | |
|---|---|---|
| **Source** | **MW** | **%** |
| Thermal (GENCOs) | 4434 | 19.4 |
| Hydel (WAPDA) | 6870 | 30.1 |
| Nuclear (PAEC) | 696 | 3.1 |
| **Sub Total** | **12000** | **52.6** |
| **Private Sector** | | |
| **Source** | **MW** | **%** |
| IPPs (Thermal) | 8395 | 36.8 |
| KESC (Thermal) | 1952 | 8.6 |

[5] Pakistan Energy Yearbook 2012

| | | |
|---|---|---|
| SPP and Rental (Thermal) | 450 | 2.0 |
| **Sub Total** | **10797** | **47.4** |
| **Grand Total** | **22797** | **100** |

The following figures show the fuel mixfor generating this power: [6]

| | | |
|---|---|---|
| **1.** | **Oil** | **35.2** |
| **2.** | **Gas** | **29.0** |
| **3.** | **Hydel** | **29.9** |
| **4.** | **Nuclear & Imported Elect** | **5.8** |
| **5.** | **Coal** | **0.1** |
| | **Total** | **100.0** |

Till late 1970s, the share of Hydel power in the fuel mix was about 70 percent and thermal power was about 30 per cent, subject to seasonal fluctuation in the availability of hydel power. Hydel power is much cheaper due to zero fuel cost and low O&M expenses. The significance of this energy mix was that it brought down average electricity price considerably and provided cheap electricity to the country. Since no major hydropower project except Ghazi Barotha was undertaken after that, our reliance on thermal power, which is much more expensive and subject to wide fluctuations in fuel cost, gradually increased. Now about 67% of our power is coming from thermal sources which are very expensive thus tremendously pushing up the average cost of electricity.

## Issues Faced by Power Sector

The issues faced by Pakistan's Power sector culminating in the current power crisis can be divided into four broad categories as below:

A. Policy Issues
B. Governance and Management Issues
C. Technical Issues
D. Cost Issues

Issues in each of the first three categories ultimately have an impact on cost and availability of electricity. The issues are briefly discussed in the following paragraphs.

[6] Ibid.

## Policy Issues

*Integrated Energy Policy*

A well deliberated, clearly articulated and sustainable policy based on least-cost options is the foremost requirement for the development of any sector. No attempt has ever been made to formulate a comprehensive and integrated energy policy for the country. The energy sector has long suffered with fragmented and adhoc policies and decisions. Important issues such as the close linkage between various forms of energy, the affordability and sustainability of energy supplies, the linkage between choice of technologies and resultant cost of energy etc. never received the attention of our policy makers and planners in the absence of a comprehensive policy. Piece-meal policies, as listed below, formulated to meet urgent short-term needs, were neither adequate nor effective for ensuring energy security for the country. Some of the policies floated from time to time are:

- Policy Framework and Package of Incentives for Private Sector Power Generation Projects in Pakistan, 1994 (Popularly known as 1994 Power Policy), formulated to meet the growing power shortage through private sector investment.
- Policy for Power Generation Projects 2002, formulated to improve upon the 1994 policy and to encourage private sector to invest in hydropower projects.
- Policy Framework for New Captive Power Producers, formulated by PEPCO.
- Policy for Development of Renewable Energy for Power Generation 2006.
- Draft Renewable Energy Policy of Pakistan 2012.
- Punjab Power Generation Policy 2006 (Revised in 2009).
- Petroleum Policies floated from time to time, including Petroleum Exploration and Development Policy 2012.

*Inadequate Institutional Arrangement*

The absence of a single energy institution and lack of coordination and synergy between various institutions dealing with different sub-sectors of energy is an important issue that has never been addressed. This situation adversely impacted on both policy and implementation. Since various forms of energy are either convertible into the other or substitutable by the other, which affect both cost and availability to the user/consumer, there should be an arrangement for dealing with energy at policy level either by an integrated single agency or by a common top level coordination body. Allocation of various forms of energy to different sectors of the economy is also an important policy issue that required to be handled by such a coordinating body.

*Hydel vs. Thermal Power*

Until 1970s, Pakistan's electric energy mix comprised 70% hydel and 30% thermal along with a small fraction of nuclear power. Hydel power provides the cheapest source of energy. Pakistan has been endowed with more than 45000 MW of potential hydropower resources by nature, which should have been exploited by us to provide affordable energy to our people. However, hydropower projects are more capital intensive and take a longer period to build. Partly due to lack of provincial consensus on building large dams and partly due to financial constraints, Pakistan gradually started shifting to constructing thermal power plants in this context donor financing was also easier to get for thermal projects. However, this policy shift raised the cost of power supply and exposed the power sector to vagaries of ever increasing international oil prices. Today, Pakistan produces 67% of electricity from thermal sources, 30% from Hydel and 3% from Nuclear.

*Choice of Fuel for Power Generation*

In case of thermal power choice of fuel and technology has a large impact on the cost of power generation—diesel power being the most expensive, followed by furnace oil; and coal being the cheapest. Pakistan was producing its thermal power mainly from furnace oil. Thus as the proportion of thermal power gradually increased the cost of electricity kept on increasing. However, as large reserves of natural gas became available and duel fuel technology also came in vogue Pakistan government decided to shift from oil to natural gas for a large part of power generation. However this conversion was carried out without a proper assessment of the gas reserves and determination of the extent of its availability for power generation. As domestic and industrial demand for gas increased and the gas reserves depleted with time we are back to a situation where most of our thermal power plants have to revert to oil based power generation, pushing up the cost of generation.

*Introduction of Independent Power Producers (IPPs)*

Resort to privately owned Independent Power Producers (IPPs) in the mid 1990s was another policy decision that had a considerable impact on the price of electricity in the country. Though the decision was inevitable in view of the looming shortage, lack of fiscal space in the public sector to finance such projects and the reluctance of the donor community to provide funding for power generation in public sector, we could have been more careful in sanctioning and negotiating such projects with the IPPs. The power supplied by IPPs was very expensive not only because they were all oil-based but, more importantly, because the agreements signed with them were not negotiated prudently, allowing them very high tariff and lavishing unnecessary guarantees. The same mistake was repeated while signing agreements for rental power in recent years. While approving projects for IPPs, no thought was given to keeping a cap on the capacity in line with demand projections, resulting in installation of excess capacity putting an extra burden on the consumer in the form of unutilized capacity charge.

*Across the Board Subsidy to Certain Categories of Consumers*

Across the board subsidies are never a good policy option. Such subsidies not only result in wasteful use of valuable resources but also put unnecessary burden on consumers or the public exchequer. Subsidised electricity provided to agricultural tube wells and free electricity allowed to WAPDA employees are two cases in point, requiring a review of the policy.

## Governance and Management Issues

*Quality of Governance*

In developing countries like Pakistan, supply of electricity is considered to be one of the basic public services. Therefore, it is managed by public sector utilities. In such a situation, quality of governance has a direct bearing on the access, reliability and pricing of power. On the other hand, if the power supply companies are owned and operated by private sector, an independent and effective regulatory mechanism becomes all the more important. In both the situations good governance and competent management are essential. Poor management, coupled with corruption and other factors related to governance results in poor delivery of electric power and puts it beyond the reach of low income groups due to excessive cost.

*Power Theft*

Pakistan's energy sector suffers from very high theft level euphemistically referred to as line losses. Inability of the power utilities to prevent unaccountable and unsustainable losses due to theft of electricity is a major manifestation of lack of good governance. The ultimate sufferer is either the consumer or, in case the government makes up the loss by subsidy, the taxpayer.

*Default in Revenue Recovery*

Power companies are often unable to recover their revenues in full both from consumers in the public as well as private sectors. Large consumers in the public sector such as municipalities, water and sewerage boards, railways and government offices default on payment to power companies. There is also a lack of support from government in revenue recovery from public sector organisations.

*Weak Regulation*

NEPRA, the regulatory body for power sector, does not enjoy requisite independence from the executive authorities. Tariff determined by NEPRA often remained unimplemented by the government resulting in a mismatch between cost and revenues of power utilities. This adversely affected the financial health of power companies and, in part, is responsible for giving rise to the problem of circular debt.

## Technical Issues

*Inadequate Maintenance and Repair of Power Plants*

Inadequate maintenance and repair of public sector power generation plants, either due to financial constraint or sheer neglect, have either drastically reduced the operating efficiency of the plants thereby increasing cost of generation to unsustainable levels or made them unserviceable. Many of the plants are therefore, not operating.

*Old and Dilapidated Transmission and Distribution Systems*

Lack of proper maintenance or replacement of old transmission lines and grid stations causes excessive line losses which in turn result in cost increase for power utilities and the consumer. It also provides an avenue for hiding electricity theft.

## Cost Issues

*High Cost of Power*

Affordability of energy is as important for the consumer as its availability. Greater reliance on thermal power, use of expensive furnace oil as fuel, non-availability of natural gas, poor governance and management resulting in large scale power theft and non-recovery of revenues, expensive power from IPPs and low efficiency of public sector power plants have all contributed to making the price of electricity unaffordable for average domestic user and unsustainable for industrial users. In fact, excessive high power prices directly contribute to high level of power theft and large scale payment defaults by consumers resulting in low recovery of revenues for the power utilities making them financially unsustainable.

*Circular Debt*

The excessively high cost of electricity has created a vicious circle in which payment default by consumers compels the power utilities to default on payment to power generators, which in turn has resulted in a chain of defaulters giving rise to a grave problem termed as 'Circular Debt'. According to some estimates, Rs.30.5 billion are added to the circular debt in the power sector every month, which has pushed up total circular debt to over Rs. 400 billion. The government has injected over Rs.1.2 trillion in the power sector in the shape of subsidies in the last four years but the situation has gone from bad to worse. The power generators, both public sector and IPPs, have no money for purchase of fuel and are running their plants on a day to day provision of relief by the government, which has put a huge burden on the budget, pushing up the budgetary deficit to unsustainable levels. This has resulted in a massive load shedding of 8-10 hours a day in urban areas and 16-18 hours in rural areas.

## Oil and Gas Sector

*Oil*

Pakistan's supply of crude oil for the fiscal year 2010-11 was 75.3 million barrels, equal to 10.1 million tons of oil equivalent (toe), out of which 68.1 percent was imported and 31.9 percent was locally extracted. Pakistan spent about US$10 billion i.e. about 24% of its total import bill on the import of petroleum crude and petroleum products. Oil caters for about 32% of our energy needs, one-fourth of which is utilized by power sector. Transport and Industry are the two other large users of oil. Import of oil is a huge burden on our economy and foreign currency reserves due to highly volatile and ever increasing prices in the international market. Despite very liberal incentives given by the government in the past as well as in recent Petroleum Exploration and Development Policy, it has not been able to attract many foreign investors for oil and gas exploration. It is thus clear that financial incentives alone are not enough to attract foreign investors. The prevailing security situation in the country is a big disincentive for any potential investor. Lack of continuity in policy, bureaucratic red tape, high level of corruption and multiplicity of institutions with whom the investor is required to deal for his project are other factors discouraging prospective investors.

*Gas*

Natural gas is a very precious natural resource bestowed by nature upon us. It meets more than 49% of our total energy requirements and 29% of our fuel supply for the power sector. Its price was kept much lower as compared to oil, for which it substitutes as a fuel, on account of it being an indigenous resource. However, increasing demand of gas for domestic use due to rising population and expanding coverage, large scale switch over from oil to gas by power sector and industry for reasons of cost control, and indiscriminate promotion of use of CNG for the transport sector on grounds of environmental protection and for providing relief to public suffering from rising prices of petrol and diesel has put a huge burden on the limited gas reserves causing their rapid depletion. New gas fields have also not been developed and brought into production. Consequently, the country is undergoing massive cuts in gas supply to industry, power sector and CNG stations. Domestic users are also suffering from low pressure and frequent outages of gas.

A major factor contributing to the crunch faced by our natural gas supplies is the adhoc allocation of this depleting resource to various sectors without reference to available supply and reserves. Indiscriminate extension of the network to far off rural areas for political considerations and liberal sanction of new CNG stations as a means of political patronage have put unnecessary pressure on gas supplies to new consumers. No credible scientific studies were conducted to assess the extent and life of existing reserves and regulate the supply accordingly. The decision to promote use of CNG in private transport at the cost of supplies to industry and power sector was highly imprudent from economic point of view. There is a section of opinion that considers the domestic use of natural gas as a waste of precious resource and the priority given to it as unwise. However, what is not taken into consideration in this matter is the fact that the population has to be provided an equally affordable alternative domestic fuel before the gas supply to them can be turned off. It is obviously not possible to make them go back to firewood or kerosene oil as domestic fuel. To attract investors for exploration and development of new gas reserves, the problems discussed in connection with oil are equally applicable in this case.

## Coal

Coal has traditionally been the most widely used source of energy in the world followed by oil and gas which are cleaner and more convenient fuels. However, the last two are much more expensive fuels compared to coal which is by far the cheapest, barring hydel and renewable energy. Technological development has also helped make coal a cleaner fuel and it is still being widely used in the world for power generation and other purposes. China, US and India respectively produce 63%, 36% and 47% of their electricity from coal. Australia and Germany also use coal to produce substantial amounts of electricity. Pakistan has not paid much attention to coal development as a fuel for industry and power sector although we have estimated reserves of 187 billion tons which are said to be the second largest in the world. Our mining practices are primitive and technological advances have not been utilized by us to tap this cheap source of energy.

The main reasons advanced for non-development and utilisation of our Thar coal deposits are its low quality and the difficulties involved in mining it. However, the actual causes are our inept handling of prospective investors, lack of agreement between federal and provincial governments about ownership and control of the project, lack of technical and administrative capacity to do it in public sector and non-seriousness in attaching due priority to it. It would be relevant to quote the views of an impartial American, Michael Kugelman in this regard. "Consider the vast Thar coalfields in Sindh Province, where 200 billion tons of reserves have lay dormant since their discovery more than twenty years ago (Thar constitutes the world's sixth-largest coal deposit)… However, what both the government and political opposition fail to articulate is how Pakistan will overcome the formidable challenge of developing the technological and labour capacity to exploit this potential bonanza. Another problem is purely political. Ever since the Thar coal was discovered, the central government has been locked in a disagreement with the Sindh provincial government about how to divvy up the spoils. Islamabad has proposed an 80/20 split, while Sindh has insisted that it retain full control of the coalfields. This 22-year-old disagreement has effectively put on hold the exploitation of Thar's resource treasures and crystallizes how Pakistan's energy woes are as much (if not more) a governance and political issue as one of supply and demand."

## The Way Forward

The ongoing energy crisis is a serious challenge which would require very serious and sustained effort on the part of the government to save the economy and provide relief to the suffering population. The problem has assumed such proportions that there is no quick fix available to resolve it fully in a short time. It would require short-term, medium-term and long-term measures as well as some hard policy decisions. These are briefly discussed below.

## Short Term Measures

*Resolving the Problem of Circular Debt*

Circular Debt is by far the most serious problem needing to be addressed on priority. If not resolved quickly and permanently it would not only continue to bleed the power sector but would also destroy many other energy organisations in the chain, most notably PSO and oil refineries. One possible solution that comes to mind is to create a Circular Debt Retirement Fund under a specially created organisation. The Fund may be financed by a consortium of banks and financial institutions under sovereign guarantee of the government. The Debt Retirement Organisation (DRO) should take over the entire debt of DISCOs and pay off their creditors out of the Fund. From then on the DISCOs should either be allowed to recover from the consumers full cost of supply plus an additional amount to pay to DRO each month so as to retire the whole debt within six months, which would be a hard political decision for the government. In order to keep the level of this additional levy to the minimum the government should also help the DISCOs in the recovery of past outstanding dues from the defaulters. Or alternatively, pay the difference between cost and revenue to the DISCOs by way of subsidy, which would depend on fiscal space available to the government. The government will have to make special effort to create such a fiscal space.

*Prompt Implementation of Tariffs Determined by NEPRA*

Partly the cause for initial creation of circular debt was government's decision not to pass on the cost increases based on fuel price increases to the consumers by not implementing NEPRA's tariff determinations fully and promptly, thus creating a gap between DISCOs' cost and revenues. Consequently a stage came when DISCOs were unable to sustain the losses and defaulted on their payments to power suppliers. It must be ensured for future that DISCOs recover their full cost of supply either from the consumer or through government subsidy.

*Ensuring Recovery of Revenues from Public Sector*

Ministry of Finance should ensure provision of adequate budget to federal government organisations to pay their electricity bills timely. In case of default, they should make a deduction at source and pass it on to DISCOs. Similarly, deductions should be made from grants to other defaulting Federal entities and Provincial governments.

*Checking Electricity Theft*

DISCOs should adopt both administrative and technical measures on priority to prevent large scale electricity theft by domestic as well as industrial consumers. The government should assist the DISCOs in this task by ensuring quick and heavy punishment to those caught stealing power.

*Power Conservation and Demand Management*

Steps should be taken to educate the public in power conservation by launching media campaigns against electricity wastage and for promoting the use of energy saver bulbs and other energy efficient gadgets. Demand should also be managed by introducing time-of day (ToD) tariffs to motivate people to defer non-essential and heavy energy uses to periods of lean demand having a lower tariff.

## Medium Term Measures

*Development of an Integrated and Comprehensive Energy Policy*

Early steps should be taken to formulate an integrated and comprehensive energy policy covering all aspects of exploration/ procurement, development and management in all forms and from all sources. The policy should particularly cover allocation, regulation and pricing of energy and identify least cost options for prioritization. The Integrated Energy Plan 2009-2022 prepared by the Energy Experts Group set up by the government in 2009 under Ministry of Finance could form a good basic document for formulation of such a policy. Although according to the comments provided by the ADB Board, the plan misses the issues of demand estimation and management from economic sectors as well as the true cost of supply of various sources of energy, their optimum mix in meeting country's energy needs as well as sufficiency, and most important the affordability angle, yet it contains a multitude of valuable and concrete recommendations. Some of the important recommendations of the plan are reproduced here.

- ( Oil and Gas sector) Security**:** To have a formula of making the local population as stakeholders.
- Gas Sector Downstream: Review of Load Management & Gas Allocation Policy and propose following changes in the priority list:
    - i) Power Generation
    - ii) Industry
    - iii) Commercial
    - iv) Domestic
    - iv) CNG

(It should only be used for buses in major cities).

- Power Sector: Expedite installation of IPPs 4500 MW already contracted until 2011 through a direct intervention from the government of Pakistan by the set up of a Long Term Capital Funding programme with multilateral institutions and major Pakistani banks.
- Hydro capacity of 17,392 MW to be inducted at any cost.
- Upgradation of existing plants and replacement of outlived and inefficient GENCOs plants.
- Reduction of peak demand through energy conservation and load management measures, as a MW saved is in fact better than a MW generated.
- Indigenous thermal power plant manufacturing expertise and capabilities should be increased in the first phase.
- Coal Sector: Exclusive agency for coal mining for power generation should be established to facilitate one-window operation for potential investors.
- Exclusive integrated coal mining and power generation policy should be developed to provide comfort to the investor.
- Regulatory Authorities:
    a) Governed by independent Board—The members of the Board should be professionals of private sector, representatives from consumer side as well as legal experts. The governing board should have the ultimate authority to provide direction for formulation of policy framework for regulating body.
    b) The regulatory body should not be prone to ministerial and government intervention.
    c) Their working should be transparent in the larger interest of the consumer as well as the industry.
    d) It should have the Power and Authority to intervene and should also be given quasi judicial power for enforcement of safety standards and protection of consumers against predatory pricing, cartels etc.
- National Energy Authority: Preference should be given to the formation of a single Ministry of Energy. The two main ministries related to energy i.e. Water and Power and Petroleum and Natural Resources do not necessarily have a collective and integrated country, regional or world view. If a Ministry of Energy cannot be formed then a high powered body with legislative powers, authority and necessary empowerment and resources should be established at the earliest to

drive Pakistan's energy development in the right direction and in the most optimum way possible.

*Efficiency Improvement*

Funds should be arranged on priority by the government for Power Generation Companies (GENCOs) in the public sector to repair and refurbish their old plants to bring them back into service and improve their efficiency to make them viable. Similarly, the old and inefficient transmission and distribution systems should also be refurbished.

*Promoting Alternate and Renewable Energy*

Vigorous and effective measures should be taken for promoting the use of micro-hydel, wind and solar energy at the household level and in off-grid remote areas. This would require development and manufacture of cheap solar panels and wind turbines domestically and providing incentives to those wishing to use alternate energy. It may, however, be kept in mind that wind and solar energies are still expensive options and would require substantial subsidy from government to induce the public to use these. Even in rich countries like the US the government provides substantial subsidy on these forms of energy. Other forms of alternate and renewable energy should also be promoted.

## Long Term Measures

*Correcting the Energy-Mix Imbalance*

A well planned policy shift should be made to correct the energy-mix by shifting our focus from oil-based thermal power to hydel power. Serious efforts should also be made for early development and utilisation of the huge Thar Coal deposits for power generation. Greater efforts should also be made for exploration and development of new gas reserves in the country, which should be dedicated to power generation. The proposed gas pipeline from Iran to Pakistan should be accelerated.

*Improving Governance*

It is imperative to improve governance in order to formulate power policies based on merit rather than vested interests, check power theft, ensure full revenue recovery, check corruption and reduce overstaffing.■

# Renewable Energy in Pakistan: Potential and Prospects

**Prof. Dr. Khanji Harijan**

## Introduction

Energy is an essential ingredient of socio-economic development and economic growth. Without sufficient energy in usable forms and at affordable prices, there is a little prospect of developments of improving the economy of a country and the living conditions of the people. About one-fourth of the Pakistan's population has no access to electricity and natural gas respectively and per capita consumption of energy is one of the lowest in the world. About 65% of the country's population lives in rural areas and most of them have no access to commercial energy and use biomass and kerosene for cooking, heating and lighting [1-2].

At present, the people are facing severe load shedding/blackout problems due to shortage of 5-7 GW power supply. The natural gas demand grows beyond the transmission/supply capacity and large users mainly industries, power plants, cement industries and transport sector (CNG stations) are curtailed specially during winter months to ensure supplies to domestic, commercial and small industries or fertilizer. The energy crisis in the country has forced thousands of industries to shut down operations, affecting industrial production and the livelihoods of thousands of families. It has been a major drag on the economy and a serious impediment to growth with an estimated cost of 10% of the GDP over the past 5 years. Pakistan's energy crisis, if not tackled at both operating and strategic level in the immediate future, might become a national security threat [1-3].

Pakistan depends heavily on gas and oil for meeting its commercial energy demand. The shares of different sources in primary commercial energy consumption (64.73 MTOE) in 2011-12 were: gas — 50%; oil — 30.8%; hydroelectricity — 10.5%; and nuclear electricity — 1.9%. Major consumers of primary commercial energy in Pakistan are power, transport, industrial and domestic sectors. The power generation sector utilizes about 40.7% of oil, 27.8% of gas and only 0.05% of coal consumption in the country. Fossil fuels, hydropower and nuclear energy have 64.5%, 30% and 5.5% shares respectively in the total electricity generation. The transport sector accounts for about 49.6% of oil and 9.2% of gas consumption in the country. The industrial sector utilizes about 7.6% of oil, 39.5% of gas and almost all of the coal consumption in the country. The residential sector consumes 20.3% of the total gas consumption in Pakistan [4].

The indigenous reserves of oil and gas are limited and the country is heavily dependent on the import of oil. With the present rate of production, the indigenous recoverable reserves of oil and gas will get exhausted after 13 and 16 years respectively. Though there is huge coal potential (185 billion tones) in the country but has not been utilized to its full potential due to poor quality, financial constraints, location disadvantage, and lack of experience in modern clean coal utilization technologies. The country is meeting about 85% of oil demand from imports by spending around US$ 14.5 billion per annum. The oil import bill is a serious strain on the country's economy and has been deteriorating the balance of payment situation. The production and combustion of fossil fuels also degrades the environment [4-5].

With the economic development and with efforts to provide enhanced access to commercial energy, the energy demand in the country is expected to grow rapidly. It has been projected that the primary commercial energy demand would increases at 4.3, 7.3 and 10.4% per annum average growth rates and would reach at 150, 320 and 670 MTOE by the year 2030 under LEG (low economic growth), BAU (business as usual), and HEG (high economic growth) scenarios respectively [5]. The government of Pakistan has planned to bridge the energy demand-supply gap (about 57% in 2030) by imported energy [6]. The development of options for importing gas has been constrained by the sensitive regional security environment, special technical issues, and complexities associated with commercial and operating arrangements typical of large projects requiring inter-country agreements.

If Pakistan chooses to rely on imported oil, gas and coal to meet its energy demand, it would be a constant burden on the country's foreign exchange reserves, and due to continuously increasing price of energy, our export surplus would become progressively more uncompetitive, goods for local consumption would become costlier, some industries could face closure/bankruptcy and the country could face economic stress on a wide scale. Therefore, there is an urgent need for a quicker switch over of energy systems from conventional to renewables that are sustainable and can meet the present and projected energy demand of the country. This paper presents the potential of renewable energy sources and their prospects for meeting growing and sustainable energy demand in Pakistan [1, 7].

## Potential of Renewable Energy in Pakistan

The conventional energy sources are fixed in stock, where as renewable energy sources (RES) are not limited, but usually are not in ready-to-use forms. To convert renewable energies into usable forms such as electricity, heat and mechanical energy, energy-converting systems are needed. The potential of renewable energies is dependent on the technical ability of this conversion. There are several renewable energy technologies (RETs) that can be selected and used to harvest renewable energies but not all of them appear promising for Pakistan. Based on the specific situations, the availability of renewable energy resources, technology level, social and environmental benefits, and financial conditions, several RETs were identified and selected as suitable for the country and are given in Table 1. Solar photovoltaic (PV), wind power, hydropower, and bagasse based cogeneration technologies were identified and selected as suitable RETs for power generation. Solar water heaters (SWH), improved cook stoves (ICS) and biogas plants were identified as suitable technologies for thermal applications. For transport fuel, ethanol production from molasses and hydrogen production from renewable electricity were identified as suitable technologies. Solar PV and windmill pumps were identified as suitable water pumping technologies for Pakistan. Based on data from different studies, potential of renewable energies in Pakistan has been estimated from a point of view of different promising available technologies[5].

**Table 1**
**Renewable Energy Technologies Selected for Pakistan**

| Resource | Technology | Output | | | |
|---|---|---|---|---|---|
| | | Electricity | Heat | Fuel | Mechanical energy |
| Solar | • Grid connected solar PV | √ | | | |
| | • Solar home system (SHS) | √ | | | √ |
| | • Solar PV pumps | | √ | | |
| | • Solar water heater (SWH) | | | | |
| Wind | • GC wind generators | √ | | | |
| | • Wind home system (WHS) | √ | | | √ |
| | • Windmill pumps | | | | |
| Biomass | • Bagasse based co-generation | √ | √ | √ | |
| | • Ethanol production from molasses | | √ | √ | |
| | • Biogas production from dung | | | | |
| | • Improved cook stoves | | | | |
| Hydro | • Large hydro turbines | √ | | | |
| | • Small/mini-micro hydro turbines | √ | | | |
| Renewable electricity | • Hydrogen production through water electrolysis | | | √ | |

*Source:* Harijan, K., "Modelling and Analysis of the Potential Demand for Renewable Sources of Energy in Pakistan", PhD Thesis, Mehran University of Engineering and Technology, Jamshoro, Pakistan, 2008.

*Potential of Renewable Energy for Power Generation*

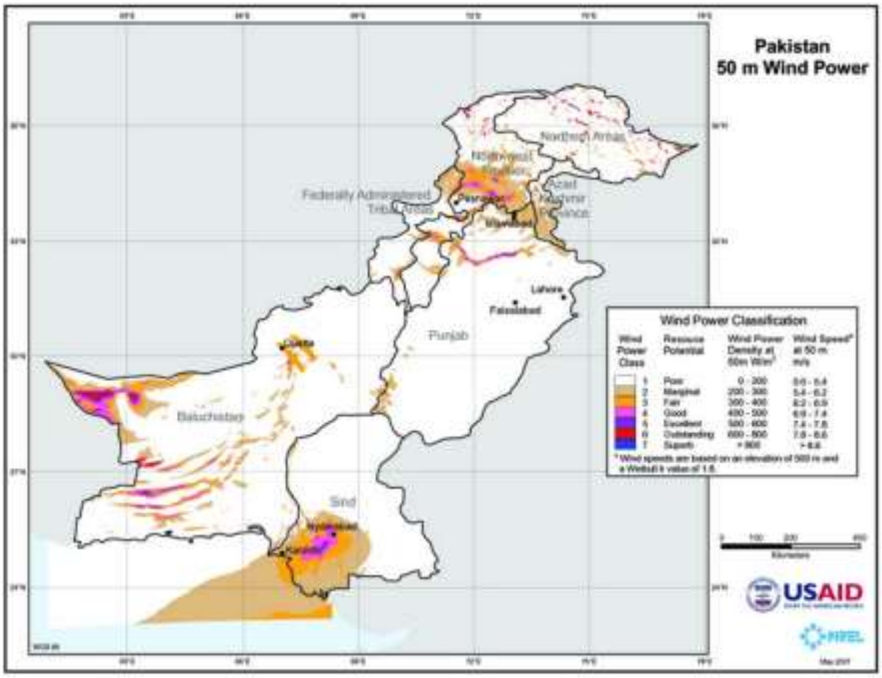
Wind power, hydropower, solar PV and bagasse based cogeneration technologies were identified and selected as suitable RETs for power generation. Pakistan has considerable potential for wind power generation in the southern and coastal areas of Sindh and Balochistan provinces. It's about 1050 km coastline has steady winds with average speeds of 5-7 m/s throughout the year. Pakistan Metrological Department (PMD) has measured and recorded the wind speed and direction at 45 locations in the coastal areas, under wind mapping project. Based on this data, wind power generation potential has been estimated using the Nordex N43/600 wind turbine as reference wind turbine. Most locations in the coastal area of Sindh and Balochistan have theoretical wind power potential of around 2000 – 3000 full load hours (FLH) and 1000 – 1400 FLH respectively. Wind power potential in terms of installed capacity has been estimated as 122.6 GW. The technical potential of grid connected (GC) wind power in the coastal areas of Pakistan has been estimated as 212 TWh per year, which is about 2.5 times the current total conventional power generation in the country [8-10].

The wind map of Pakistan has been developed after extensive analysis carried out by National Renewable Energy Laboratory (NREL), US in collaboration with USAID, PMD and Alternative Energy Development Board (AEDB) using data available from PMD met sites and satellite imaginary as shown in Fig. 1. The study has indicated that 9% of the country's land area possesses class 3 or better wind resource. The total potential of wind power in the country has been estimated as 346,000 MW. All of this wind resource lies in the province of Sindh, Balochistan and Northern areas of Pakistan [11-12].

Around 40,000 villages in Pakistan, comprising over 3 million households, are not connected to the grid and rely on firewood, cow dung, coal, kerosene, petroleum, LPG, cell batteries etc. 7876 of these un-electrified villages cannot be connected to the national gird for another 20 years due to their distance from the national grid, which rendered these villages technically and economically unavailable [12]. These rural villages can be electrified through standalone RETs such as wind home systems (WHS) and solar home systems (SHS). The total installed capacity of WHS for rural electrification in the coastal areas of Pakistan has been estimated as 425 thousand units or 63.75 MW. The technical potential of WHS in the coastal area of Pakistan has been estimated as 135 GWh per year [5].

Pakistan is blessed with tremendous hydropower potential. The identified theoretical hydropower potential is estimated to be about 41.5 GW. Only 16% of the total theoretical hydropower potential has been exploited so far. The Northern part of the country is also rich with small hydropower resources. Other than 12 big hydropower plants, there are a large number of sites in the high terrain where natural and manageable waterfalls are abundantly available. It is estimated that the total potential of small hydropower in the northern areas of Pakistan alone is above 500 MW. The recoverable potential in micro-hydropower up to 100 kW is roughly estimated to be about 300 MW on perennial water falls in northern Pakistan. Besides, there is an immense potential for exploiting water falls in the canal network particularly in Punjab and Sindh, where low head high discharge exists on many canals [5, 13-14].

**Fig 1: Wind Map of Pakistan**

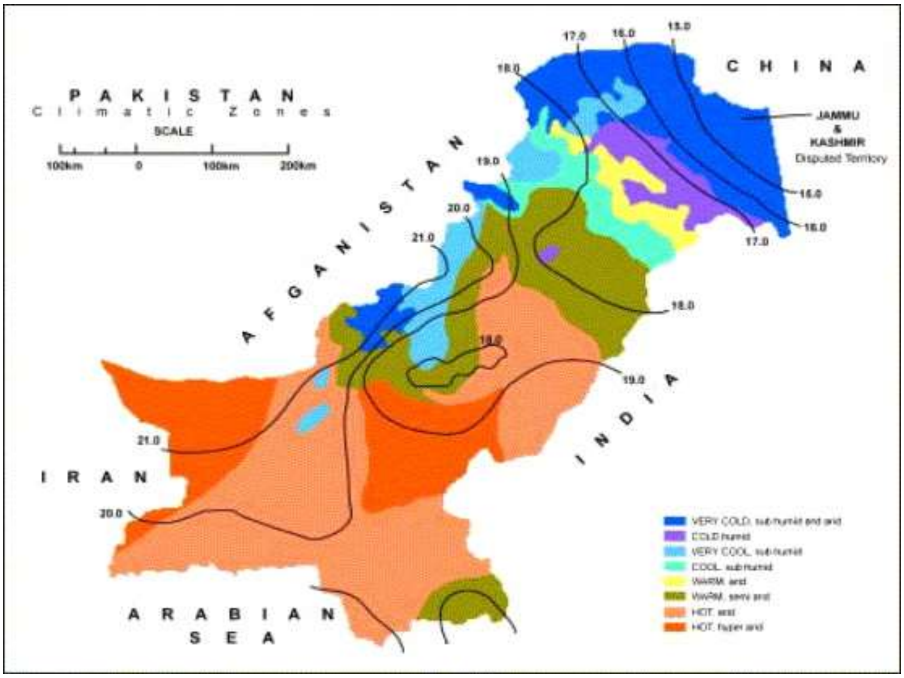



Source: National Renewable Energy Laboratory (NREL). Official website of NREL: www.nrel.gov/international/ra_pakistan.html

Pakistan receives 16-21 MJ/m$^2$ per day of solar radiation as an annual mean value, with 19 MJ/m$^2$ per day over most areas of the country as shown in Fig. 2. The annual mean values of sunshine duration lie between 8 and 10 hours per day all over the country, except for the northern parts. Among all renewable energy sources, the solar energy is the most abundant and widely spread in the country [15-16]. Pakistan receives approximately 15.525x10$^{14}$ kWh of solar energy every year, i.e. about 1715 times the current primary energy consumption in the country. The technical potential for GC solar PV electricity generation in Pakistan is estimated at 3.5 PWh per year which is about 41 times the current conventional electricity generation in the country.

Solar PV power potential in terms of installed capacity has been estimated as 1600 GW which is about 80 times the current installed capacity of conventional power generation in the country. The total installed capacity of SHS for rural electrification has been estimated as 2.3625 million units or 208 MW. The annual technical potential of SHS for rural electrification applications has been estimated to be 455.3 GWh [5].

**Fig 2: Climatic Zones for Pakistan Including Isoflux Contours of Annual-mean Daily Solar Irradiation, MJ/m²/day**




Source: Muneer, T., Maubleu, S., and Asif, M., "Prospects of Solar Water Heating for Textile Industry in Pakistan", *Renewable and Sustainable Energy Reviews*, Vol. 10, Issue 1, 2006: 1-23.

Presently there are 78 sugar mills in the country. These modern sugar industries employ high-pressure boilers and condensing turbines, generating electricity from bagasse more efficiently and cost-effectively. The technical potential of bagasse based cogeneration in terms of installed capacity has been estimated at about 1500 MW. Potential of electricity generation from bagasse has been estimated as 7,460 GWh, which is about 7.6% of the total conventional electricity generation in Pakistan [5, 17].

*Potential of Renewable Energy for Heat Production*

SWH, ICS and biogas plants were identified and selected as suitable technologies for thermal applications in the country. SWH have applications in industrial sector, thermal power generation, commercial sector and domestic sector. More than 90% of the households in Pakistan are located in solar rich areas and are suitable for SWH. The potential of SWH for the domestic sector only in terms of units has been estimated as 9.0 million units. The total potential of SWH in terms of energy has been estimated as 1.22 MTOE per year. About 95% of the rural households (RHH) and 35% of the urban households (UHH) rely on biomass for cooking and heating. Biomass is burned in inefficient traditional cook stoves (TCS) with efficiency of about 9 to 13%. The total number of households relying on biomass would be about 16.7 million. ICS are the fuel efficient stoves and have fuel saving potential of about 60% over TCS. The total potential number of ICS would be about 16.7 million, 14.22 million in rural areas and 2.46 million in urban areas. The total potential of biomass saving through replacement of all TCS with ICS has been estimated as 14 million tones [5, 18-19].

Pakistan breeds sufficient livestock to produce enough animal waste for the production of biogas. Animal waste is readily available and usually comes from cows, buffaloes, sheep, goats and poultries. These animals are large in number in the country and have also high fraction recoverable. The residue of these animals could generate 10.3 thousand million $m^3$ per year of biogas, which is equivalent to 63.2 TWh per year of energy. The biogas alone could supply 624 kWh per year of energy per capita to the rural population and could meet cooking and lighting requirements of about 9.7 million families, i.e. about 56% of Pakistan's rural population [5, 20].

Main sources of fuelwood supplies in Pakistan are forests (natural and plantation), other wooded land, and agricultural land. The natural forests, plantation forests, other wooded land and agricultural land could produce 20.16 million tonnes of fuelwood (sustainable) per year in Pakistan, which is equivalent to 7.14 MTOE of energy. Residues from logging and processing of wood contribute an important source of fuel wood. The recoverable energy potential of logging and processing wood residues in Pakistan has been estimated at 2.277 MTOE per year. Pakistan is an agrarian country and produces huge amount of crops like rice, sugarcane, cotton, wheat, maize, bajra, jowar, gram, tobacco, rapeseed, barley and mustard. These crops also generate large quantities of residues every year which can be used to produce energy. The energy potential of crop residues (available for energy production) has been estimated as 0.018 MTOE per annum [5, 21-22].

*Potential of Renewable Energy for Transport Fuel Production*

For transport fuel, ethanol production from molasses and hydrogen production from renewable electricity were identified and selected as suitable technologies for Pakistan. Pakistan stands fifth among the countries having a large tract of area under sugar cane crop. During crushing of the sugar cane, molasses is produced which can be converted into industrial ethanol through fermentation and distillation processes and then into fuel ethanol through molecular sieve technology. The potential of ethanol production from molasses has been estimated at about 500 million litres or 0.42 million tonnes, which is about 34% of the present gasoline consumption in the transport sector in the country. Only 30% of this potential is sufficient for blending the annual gasoline demand with 10% ethanol share [5].

Water electrolysis that can be driven by electricity producing RETs (wind turbines, hydropower or PV cells) is an important and the only commercially developed technology today suitable for hydrogen production from RES because of its high energy conversion efficiency, high product purity and its feasibility on small and large scales. The energy efficiency of water electrolysis varies widely. Typical industrial electrolysers have electricity consumption between 4.5 and 6.0 kWh/Nm$^3$, corresponding to the efficiency of 65 to 80%, and advanced electrolysers have been reported with an efficiency of 90%. If all the electricity generated from hydropower, GC wind farms and solar PV systems is used to power electrolysers having 75% conversion efficiency, about 3123 TWh (269 MTOE) hydrogen can be produced annually, which is about 27.7 times the current total energy consumption in the transport sector of Pakistan [5].

*Potential of Renewable Energy for Water Pumping*

There are around one million agriculture tube-wells presently in operation and approximately 30% are electric-operated with the installed capacity of 2500 MW and consumes approximately 15-20% of the total energy delivered by the national grid. Government is heavily subsidizing electric tariff for agriculture tube wells in many areas putting additional burden on national exchequer on one hand and inducing inefficiencies in water and energy usage on the other. Agriculture sector having groundwater as the irrigation source is worst hit by present energy crises as the availability of grid electricity in remote areas is around six hours per day on an average. Therefore, a reliable, efficient, sustainable and cost effective energy option for agriculture sector in Pakistan is direly needed. Replacing/supplementing existing source of power (grid electricity) for driving tube wells with renewable energy resources (solar and wind) can be a viable option. Both Solar PV and Wind technologies can be used for this application [12]. Potential of windmill water pumps for irrigation and domestic sector applications in the rural coastal areas of Sindh and Balochistan in term of units has been estimated at about 0.2 million units. The total potential of windmill water pumps in terms of annual useful (AUE) has been estimated to be 1.39 PJ per year. The potential of solar PV pumps for water pumping for irrigation and domestic sector applications in the rural areas of Pakistan has been estimated as 2.0 million units. The total potential of solar PV water pumps in terms of AUE would be about 6307 TJ per year [5].

Table 2 summarizes the technical potential of RES in Pakistan. This potential is about 9 times the current total final energy consumption in the country.

**Table 2**
**Potential of Renewable Energy Sources in Pakistan**

| Renewable energy technology | Capacity | Annual energy output (MTOE) |
|---|---|---|
| *Wind energy* | | |
| GC wind power | 346,000 MW | 52.200 |
| WHS | 63.75 MW | 0.012 |
| Windmill water pumps | 0.2 million units | 0.033 |
| *Solar energy* | | |
| GC solar PV | 1714,286 MW | 303.050 |
| SHS | 208 MW | 0.039 |
| SWH | 9.0 million units | 1.220 |
| Solar PV water pumps | 2.0 million units | 0.151 |
| *Biomass energy* | | |
| Crop residues | | 0.018 |
| Sustainable fuelwood and wood residues | | 9.420 |
| Biogas | | 5.967 |
| Ethanol | 0.42 million tonnes | 0.297 |
| Bagasse based cogeneration | 1500 MW | 0.642 |
| ICS | 16.7 million units | 5.354 |
| *Hydropower* | | |
| Large | 40,664.17 MW | 15.312 |
| Small/mini/micro | 858.00 MW | 0.323 |
| *Sum* | | *394.00* |

Source: Harijan, K., "Modelling and Analysis of the Potential Demand for Renewable Sources of Energy in Pakistan", PhD Thesis, Mehran University of Engineering and Technology, Jamshoro, Pakistan, 2008.

## Prospects of Renewable Energy in Pakistan

Finally, prospects for RETs are presented in this section. Thus the feasible deployment of these technologies is discussed by means of scenarios depending on the energy policies.

Pakistan has continuously progressed in disseminating hydropower systems after independence; however, due to inherent time lag and resource constraint the progress has been rather slow. In late 1970s and early 1980s, different programmes for new RETs dissemination started but these programmes have not succeeded due to lack of technical know-how and follow-up, limited financial support, operational difficulties, high cost of systems etc. Again by the start of the 21st century, considerable efforts have been made in the country towards large scale diffusion of RETs. Current efforts for development of RETs in Pakistan are influenced by a variety of techno-socio-economic factors including the financial and fiscal incentives provided by the federal and provincial governments. The diffusion of these technologies in future will also depend on further development and cost reduction through innovation and learning experiences.

Renewable energy technology diffusion (RETD) model was developed and used to forecast the future dissemination levels of RETs in Pakistan at different time periods assuming that all selected RETs becomes competitive in the future. The RETD model parameters were estimated by regression of the past time series data of RETs dissemination or by applying analogous approach. A number of scenarios were developed for various unseen futures by assuming different diffusion levels of RETs. The Standard Scenario (SS) describes a future in which the installation of RETs continues to drive by the same forces as were apparent, with no radical events, policy changes or major disruptions. The Optimistic Scenario (OS) assumes that in the past, if the diffusion of RETs had been driven by market forces instead of subsidies, then the cumulative capacity/number of RET systems installations would be three times greater than the actual level. The Moderate Scenario (MS) assumes that in the past, if the diffusion of RETs had been driven by combination of market forces and subsidies, then the cumulative capacity/number of RET systems installation would be double than the actual level. The MS and OS scenarios assume a policy environment favourable to renewable energy [5, 9].

It has been recognized for some years that there could be a significant contribution of RES in meeting the energy requirements of Pakistan. At present, the contribution of RETs is negligible except hydropower, which contributes to about 10.5% of the PCE or about 30% of the electricity requirements of the country [4]. The biomass which meets almost all the non-commercial energy requirements of the country is used with inefficient and environment unfriendly TCS. Since Pakistan is richly endowed with RES, which are also technologically feasible, it is necessary to introduce these readily available, environment friendly RES to the larger extent.

*Prospects of Renewable Energy for Power Generation*

It is projected that about 145, 200 and 252 GW of wind power projects could be installed up to 2030 under SS, MS and OS scenarios respectively. These forecasted installed capacities are about 42, 58 and 73% of the total technical potential of wind power generation in the country. By the year 2030, wind power systems would generate 320, 442 and 556 TWh of electricity under SS, MS and OS scenarios respectively. By the year 2030, hydropower projects would generate more than 110 and 150 TWh under SS and OS scenarios respectively. Under MS scenario, about 130 TWh of electricity could be generated by hydropower projects in Pakistan [5, 9].

It is forecasted that around 921, 1636 and 3060 MW capacity of solar PV plants could be installed up to 2030, the end of the energy demand forecasting period, under SS, MS and OS scenarios respectively. By the year 2030, solar PV systems would generate 2017, 3580 and 6700 GWh of electricity under SS, MS and OS scenarios respectively. The results indicate that in Pakistan, even using highly favourable assumptions, the dissemination of solar PV GC power generation systems is not likely to reach its maximum estimated potential for another 50 years. Around 1282, 1390 and 1448 MW capacity of bagasse cogeneration could be installed up to 2030 under SS, MS and OS scenarios respectively. By the year 2030, bagasse based cogeneration systems would generate 5.62, 6.10 and 6.34 TWh of electricity under SS, MS and OS scenarios respectively [5].

It is projected that around 4.37, 7.88 and 14.07 MW capacity of SHS could be installed up to 2020 under SS, MS and OS scenarios respectively. By the year 2020, SHS would generate 9.57, 17.25 and 30.83 GWh of electricity under SS, MS and OS scenarios respectively. Around 1.47, 2.66 and 4.75 MW capacity of WHS could be installed up to 2020 under SS, MS and OS scenarios respectively. By the year 2020, WHS would generate 2.91, 5.25 and 9.37 GWh of electricity under SS, MS and OS scenarios respectively [5].

At present hydropower has 33% share in electricity generation in Pakistan. The contribution of other GC electricity producing RES is negligible. The future main contributors would be hydropower and wind power followed by bagasse based cogeneration and solar PV power. The grid-connected electricity producing RETs could possibly meet all the electricity requirements of Pakistan by 2030 under various scenarios. The off-grid electricity producing RETs are found as the best options for rural remote households. In terms of total contribution, the SHS dominates the WHS in all the scenarios [5].

*Prospects of Renewable Energy for Heat Production*

It is forecasted that around 1.84, 3.02 and 4.5 million SWH could be installed up to 2030, the end of the energy demand forecasting period, under SS, MS and OS scenarios respectively. The results indicate that 20.6, 33.6 and 50% of the total maximum technical utilization potential of SWH could be installed by the year 2030 under SS, MS and OS scenarios respectively. By the year 2030, SWH would save about 1.17, 1.92 and 2.86 MTOE of energy under SS, MS and OS scenarios respectively. Around 9.2, 11.66 and 13.75 million ICS units could be installed up to 2030, the end of the energy demand forecasting period, under SS, MS and OS scenarios respectively. By the year 2030, biogas plants would save about 6.16, 7.82 and 9.22 MTOE of energy under SS, MS and OS scenarios respectively. It is forecasted that around 0.174, 0.30 and 0.5 million biogas units could be installed up to 2030 under SS, MS and OS scenarios respectively. By the year 2030, biogas plants would save about 0.61, 1.1 and 1.8 MTOE of energy under SS, MS and OS scenarios respectively. The heat producing RETs could meet from 17 to 38% of the cooking and heating thermal energy needs of the domestic sector. The main contributor would be ICS followed by SWH and biogas [5, 18].

*Prospects of Renewable Energy for Water Pumping*

It is projected that about 2.8, 10.2 and 34.4 thousand solar PV pumps could be installed up to 2030 under SS, MS and OS scenarios respectively. By the year 2030, solar PV pumps would save about 460, 1690 and 5725 TOE of energy under SS, MS and OS scenarios respectively. The results indicate that in Pakistan, even using highly favourable assumption, the dissemination of solar PV pumps is not likely to reach its maximum estimated potential for another 70 years. It is forecasted that around 3890, 7945 and 16600 windmill pumps could be installed up to 2030, the end of the energy demand forecasting period, under SS, MS and OS scenarios respectively. The results indicate that in Pakistan, even using highly favourable assumption, the dissemination of windmill pumps is not likely to reach its maximum estimated potential for another 60 years. By the year 2030, windmill pumps would save about 2000, 40000 and 8450 TOE of energy under SS, MS and OS scenarios respectively. The contribution of water pumping RETs could meet less than 1% the energy requirements of the agriculture sector of Pakistan by the year 2030. In terms of total contribution, solar PV pumps dominate the windmill pumps in all the considered scenarios throughout the period under investigation [5].

*Prospects of Renewable Energy for Transport Fuel Production*

It is forecasted that 0.342, 0.462 and 0.556 million tonnes of ethanol fuel could be utilised by the year 2030, the end of the energy demand forecasting period, under SS, MS, and OS scenarios respectively. The results indicate that 50, 68 and 82% of the maximum technical potential of ethanol fuel in Pakistan could be utilised in the transport sector up to 2030 under SS, MS and OS scenarios respectively. By the year 2030, ethanol fuel would save about 0.242, 0.327 and 0.394 MTOE of energy under SS, MS and OS scenarios respectively. The ethanol fuel could meet around 1% of the energy requirements of the transport and agriculture sector of Pakistan in the year 2030.It is expected that hydrogen would not significantly contribute to the energy requirements of Pakistan before 2030. However, in long term, renewable hydrogen would contribute significantly to the energy requirements specially in the transport sector of the country [5].

Table 3 summarises the contribution of RES to the final energy requirements of Pakistan. Under SS scenario, RES could meet from 7.4 to 20.2% of the final energy requirements of the country in 2030. In case of MS scenario, RES could meet final energy requirements in the range of 6.9 to 26.2% in the year 2030. RES could meet final energy requirements of Pakistan from 11.54 to 31.36% in the year 2030 in the scenario most favourable to RETs. At present, hydropower is the only RES that has significant contribution in the energy requirements of Pakistan. The future main contributors would be wind energy and biomass followed by hydropower and solar energy. Overall, RES could meet between 7 and 30% of the final energy requirements of Pakistan by 2030. The exploitation of these RETs would reduce many of the current environmental and economic problems as well as national energy insecurity associated with the production and use of fossil fuels[5].

**Table 3**

**Contribution of all selected renewable energy sources to the future total energy requirements of Pakistan (%)**

| | 2020 | | | 2030 | | |
|---|---|---|---|---|---|---|
| | LEG | BAU | HEG | LEG | BAU | HEG |
| *SS Scenario* | | | | | | |
| Solar energy | 0.2057 | 0.1573 | 0.1183 | 1.2237 | 0.7571 | 0.4540 |
| Wind energy | 0.6042 | 0.4620 | 0.3472 | 6.2562 | 3.8708 | 2.3028 |
| Biomass | 2.0920 | 1.5988 | 1.2023 | 6.4540 | 3.9931 | 2.3755 |
| Hydropower | 5.6854 | 4.3452 | 3.2675 | 6.2381 | 3.8600 | 2.2961 |
| Total | 8.5873 | 6.5633 | 4.9353 | 20.172 | 12.4810 | 7.4284 |
| *MS Scenario* | | | | | | |
| Solar energy | 0.3586 | 0.2740 | 0.2061 | 1.7928 | 1.1092 | 0.6600 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Wind energy | 1.0432 | 0.7973 | 0.6000 | 8.6085 | 5.3261 | 3.1685 |
| Biomass | 3.3165 | 2.5347 | 1.9060 | 8.4362 | 5.2195 | 3.1052 |
| Hydropower | 7.3016 | 5.5804 | 4.1963 | 7.3483 | 4.5464 | 2.7047 |
| Total | 12.020 | 9.1864 | 6.9084 | 26.186 | 16.2012 | 6.9364 |
| *OS Scenario* | | | | | | |
| Solar energy | 0.6642 | 0.5076 | 0.3817 | 2.8846 | 1.7847 | 1.0618 |
| Wind energy | 1.8185 | 1.3898 | 1.4520 | 10.825 | 6.6972 | 3.9842 |
| Biomass | 3.6372 | 2.7798 | 2.0903 | 9.1384 | 5.6540 | 3.3636 |
| Hydropower | 9.4976 | 7.2587 | 5.4583 | 8.5124 | 5.2667 | 3.1332 |
| Total | 15.618 | 11.936 | 9.3823 | 31.360 | 19.4023 | 11.543 |

Source Harijan, K., "Modelling and Analysis of the Potential Demand for Renewable Sources of Energy in Pakistan", PhD Thesis, Mehran University of Engineering and Technology, Jamshoro, Pakistan, 2008.

## Conclusion

Pakistan is facing electricity and gas shortfalls. Oil and gas supply the bulk of the country's energy needs. The indigenous reserves of oil and gas are limited and the country is heavily dependent on the import of oil. On the other hand, there is abundant potential of hydropower, wind energy, solar energy and biomass energy in the country. The technical potential of GC electricity producing RETs is estimated to be about 57 times the current electricity consumption in the country. The off-grid electricity producing RETs are found as the best options for rural remote households. The potential of heat energy producing RETs is estimated to be 12.53 MTOE. The potential of water pumping RETs is about 25% of the commercial energy consumption in the agriculture sector of the country. The potential of TF producing RETs is estimated at 28 times the commercial energy consumption in the transport sector.

More than half of the estimated technical potential of bagasse cogeneration, wind power, hydropower and ICS could be exploited by the year 2030. The dissemination of solar PV GC power generation systems is not likely to reach its maximum estimated potential for another 50 years. The cumulative dissemination level of SWH and biogas plants is forecasted between 20 and 50% of their technical potential respectively. Less than 10% of the technical potential of SHS, WHS, solar PV pumps and windmill pumps could be disseminated up to 2030. More than 50% of the estimated potential of ethanol fuel could be utilized by the year 2030.

The GC electricity producing RETs could possibly meet all the electricity requirements of Pakistan by 2030. The heat producing RETs could meet from 17 to 38% of the cooking and heating thermal energy needs of the domestic sector. The water pumping RETs could meet less than 1% of the energy requirements of the agriculture sectors of Pakistan. The ethanol fuel could meet around 1% of the energy requirements of the transport sector of Pakistan. Overall, RES could meet from 7 to 30% of the final energy requirements of Pakistan by the year 2030. The main contributors would be wind energy and biomass followed by hydropower and solar energy. These renewable energy sources should be developed for managing the present energy crisis and meeting the future energy demand in the country.

## Recommendations for Deployment of Renewable Energy Technologies

The current policy environment in Pakistan is favourable to RETs. The 2006 Renewable Energy Policy offers an attractive package of fiscal and financial incentives to private sector investors. The setting up of PCRET, AEDB, Private Power and Infrastructure Board and National Electric Power Regulatory Authority (NEPRA) are important steps towards having a sound institutional infrastructure. However, there still exist barriers to renewable energy deployment in the country. Following recommendations are made to accelerate the dissemination of RETs in Pakistan [5, 23].

- The government, power and gas utilities, and regulators should adopt and properly implement least-cost planning in resource acquisition. Transmission, distribution, reliability, and other cost savings associated with decentralized power generation through RES should be identified. Environmental benefits of RES should be considered in resource planning and acquisition processes. The Energy Wing in the Ministry of Planning and Development and WAPDA should enhance capacities to ensure that the long-term economic and environmental benefits of RES are captured in the national planning process, and time-based targets designed for exploitation of available renewable energy potential.
- Methods for determining energy output, financial return, estimating local externalities, and increased local employment should be standardized, that will allow a fair comparison among projects. Innovative and sustainable financing programmes for RETs should be instituted. The government should consider setting up a renewable energy development fund, especially for lending to small investors attractive terms and conditions.
- NEPRA should work closely with Alternative Energy Development Board (AEDB) to define criteria and limits for tariffs for purchase of power from non-utility generators. NEPRA should develop the expertise to be able to evaluate tariffs for the purchase of power from RES. The institutional capacity of NEPRA should be strengthened by

streamlining staffing procedures to ensure that capable and qualified staff can be hired on permanent positions.

- Ministry of Environment (MOE) should support the development of RES by helping the public and private sectors benefit from financial instruments, such as GEF and CDM. Enabling actions, such as resource mapping, technology transfer, and training should be conducted under environmental technical assistance programs coordinated by MOE with international donors.
- Pakistan Council for Renewable Energy Technologies (PCRET) should enhance its capacity to include wind and PV systems along with micro-hydro, solar thermal and biogas systems in its portfolio, and to coordinate its activities with the provincial governments. Also it should work closely with the NGOs and rural support organizations to ensure that technology packages offered are compatible with the local conditions in which the technologies are to be applied. Product standardization is one of the measures that PCRET can take to promote RETs. The commercial success of RETs is vitally dependent on adoption and enforcement of appropriate standards and codes. Minimum performance standards in terms of durability, reliability, and thermal performance are also necessary for market penetration.
- Some legislative measures e.g. making it obligatory for every (new) building to install a solar water heater and for every power generation company to generate at least 20% electricity from RES should be taken to accelerate the diffusion of RETs in the country.
- Information specific to viable RETs needs to be made easily accessible both to increase general awareness and acceptability as well as to aid potential investors and sponsors of such projects. A media campaign should also be launched to convince more people about the advantages and gains of renewable energy systems installation.
- Technical assistance programmes should be designed to increase the planning skills and understanding of RETs by utilities, regulators and other institutions involved. Technical infrastructure should be developed to achieve the expansion of RETs. The indigenous industry should be encouraged as well as technology transfer from abroad. Workers should be skilled and trained to construct, operate and maintain the RETs.■

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# ECONOMICS OF ENERGY MIX: THE CASE OF PAKISTAN

**Dr. Vaqar Ahmed**

GLobally, the average usage for oil of energy generation stands at five percent compared with Pakistan where the same number stands at a whopping 32 percent (2011). While the world uses on average 21 percent gas for energy generation, Pakistan continues to drain its gas reserves as the same number is at 48 percent. As the world searched for cheaper and more reliable sources of energy the reliance increased towards coal (contrary to what environmental experts would have suggested). Today, due to its low price global average usage of coal in energy generation stands at 40 percent and the same number for Pakistan is seven percent. Additionally, Pakistan has also been slow at harnessing the true potential of hydro, nuclear and various forms of renewable energy.

What does the above mentioned indicate? First, there has been a chronic lack of planning. Second, the energy sector of Pakistan has not been agile to meet the growing demands of its stakeholders. Third, changing the energy mix towards a more certain supply line and affordable price may imply institutional reforms. Finally, there is an utter lack of capacity in the energy sector which is amplified by the fact that despite of having coal and nuclear sources, the country remains unable to bring such inputs to use.

Can the energy mix be changed? The simple answer in the short to medium term is 'no'. There are some reform measures that are institutional in nature which when put into place may trigger small changes ultimately leading to a change in the energy mix over the longer run. Here we are referring to a change which is cost-effective, reliable, greener and sustainable.

## What are these Institutional Reforms?

**First** and foremost, there are 29 different departments dealing with energy sector in Pakistan. Most of these departments are bigger than the holding entities such as the Ministries of Water and Power and Petroleum and Natural Resources. This is certainly not the way countries implement an integrated energy framework. There should be a single ministry or authority under which these 29 departments should fall and report to. The provincial energy departments now in each of the four large provinces of Pakistan have a very lose communication channel with the federal government.

**Second**, the regulators National Electric Power Regularity Authority (NEPRA) and Oil and Gas Regularity Authority (OGRA) need serious business process reengineering. Their capacity to regulate and hold the government and non-government entities accountable has come under serious criticism. The postings of retired civil servants in these regulatory bodies implies a direct conflict of interest. Even the Supreme Court had to intervene on occasions due to gravity of regulatory crisis in the energy sector. Appropriate legislative changes should be carried out to protect the autonomy of both these institutions. Similarly, both should be equipped with strong professional workforce that can stay ahead of policy implementation and has the capacity to monitor and evaluate the performance of energy sector on real-time basis.

**Third**, private sector investment in energy will continue to remain laggard until effective deregulation of distribution and price mechanism is carried out. The government must let go its inefficient role in the distribution of power and gas. The distribution market should be allowed to flourish on competitive basis. This may well imply privatization of existing distribution companies (DISCOS). Any move in this direction has the potential not only to lure local and foreign direct investment in energy sector but also to introduce new technologies which are more efficient, reliable, greener and sustainable. The private sector's involvement will also improve the receivables in this sector (which currently has substantial bad debts).

**Fourth**, after the 18$^{th}$ Amendment, the provincial governments should also be held accountable for administrative losses (e.g. direct theft of electricity). A structure of bottom-up accountability by the provincial governments is now need of the hour. At the federal government level a smart metering system was proposed by the Planning Commission. The proposal is still pending with the Ministry of Water and Power since past 12 months.

**Fifth**, existing thermal generation units need to be challenged for greater efficiency. The gas allocation mechanism can be an appropriate tool to bring about such efficiency. Gas allocation should be reduced for plants that are operating below certain (benchmarked) efficiency levels. Similarly the more efficient ones may get an increased supply of gas. The pricing of oil supplied to thermal units also needs to be reconsidered. Currently, a single price is paid for all qualities of oil provided in the production process. This price should vary in line with the quality of oil supplied.

**Sixth**, there is a need for a clear framework on energy conservation. This applies to both public and private sector. A recent study in India reveals that just changing the building codes for improved energy conservation at the state level could save over USD 50 billion to the energy sector. In case of Pakistan, there are some estimates that reveal a loss of 30-35 percent energy due to lack of properly insulated windows in built buildings.

**Finally**, the potential of coal water slurry as an input in power generation should be studied. Several energy sector experts have advocated that this is a much cleaner and cost effective substitute of conventional oil being used in thermal plants. Similarly, Pakistan along with western India enjoys a joint shale gas plate whose potential needs to be evaluated.

The above mentioned reforms have been reiterated on several occasions in the recent past and some have even made it to the manifestos of political parties. Pakistan has voted for change in Elections 2013 and one hopes that voters will hold their elected representative accountable – particularly in case of energy sector which stands as a lifeline for this country. Pakistan's average GDP growth rate for the past five years is lowest in the South Asian region; in fact it is lower than the average of sub-Saharan African countries. One of the critical factors in this depressed growth has been the lack of energy. This argument links energy with national security. A lack of growth in the economy can imply lack of jobs which in turn can hint towards social unrest in the country. A careful reform of energy sector now stands overdue.■

# LEAST COST POWER GENERATION

**Dr. Gulfaraz Ahmad**

Dr. Gulfaraz Ahmad, former Secretary Petroleum, gave presentation on Least Cost Power Generation. He said that Pakistan had gas based energy economy, it had country-wide power and gas infrastructure. He said that, strategically speaking, Pakistan was located close to regional energy export sources in West and Central Asia. He said that policy failure was the main issue as energy sector had heavy reliance on gas and this was because of the policy distortion. One of the factors was natural decline in the production of energy fields. Projects like IP, TAPI, LNG and LPG, since early 1990, were initiated but still these were in the process. Vision was already there but implementation was the most important factor in order to overcome the energy crisis. Pakistan's markets were not feasible; there were unattractive economic and financial returns for the exploration companies, he explained.

The cost of generating electricity could be minimized by optimal choice of technology of power plant and its thermal energy, by the type of fuel that plant uses, by the size of plant to exploit economies of scale, and by locating plants in relations to the center of consumptions. We should buy maximum capacity (90%-95%) from efficient power plants to reduce per unit tariff to save power cost. Gas should be diverted from inefficient captive power plants to more efficient IPPs which would add 40% more electricity from the same amount of gas. This would also cut the cost of power. Efforts were being made to acquire technology for economy of scales 1000 MW nuclear power plants that would give a boost to power sector. In the end, he concluded that conservation of energy was a huge source of adding to energy supply; it could add over 20% to our energy consumption within the present energy supply.

He illustrated his detailed presentation with the following slides:

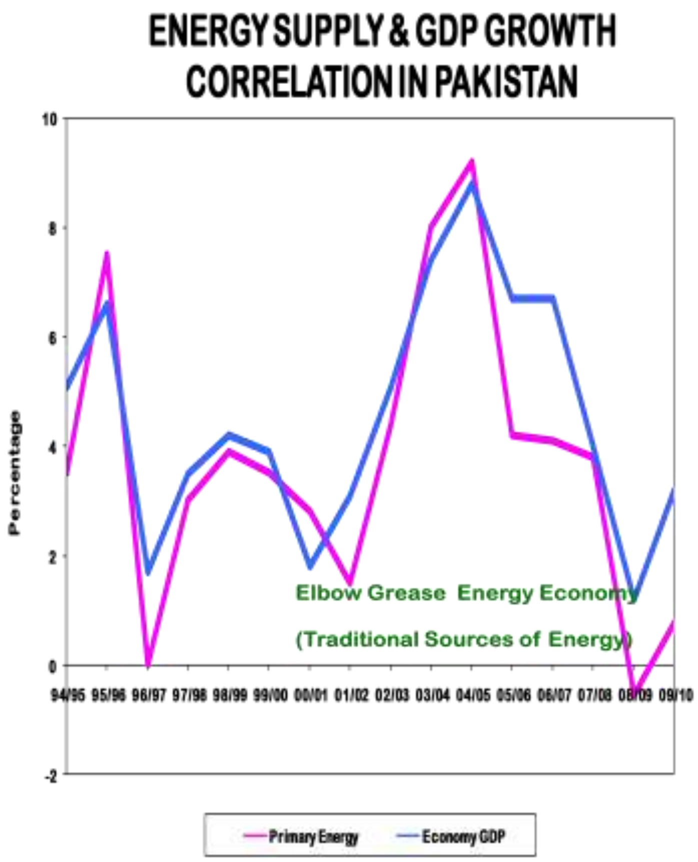
## Energy Challenges and Strengths

### Challenges

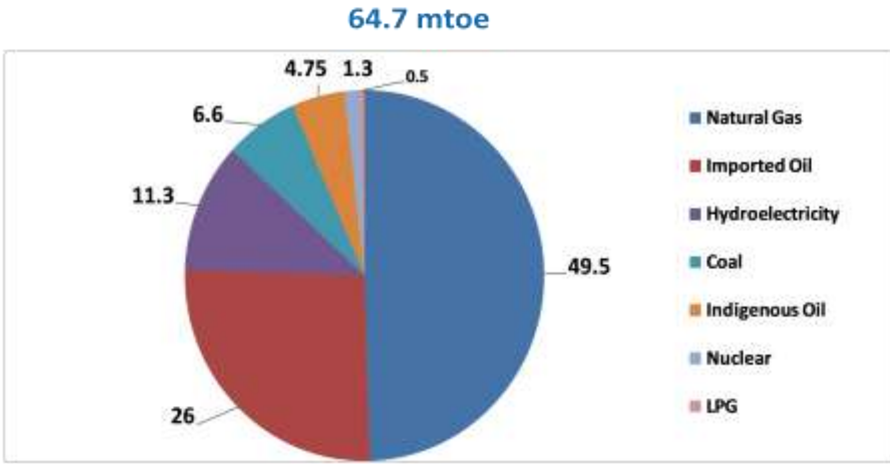
- Low per-capita energy consumption
- Energy import as a percentage of total exports
- High cost power generation
- Shortfall in power and gas supply
- Power and gas theft and heavy losses
- High energy intensity

### Strengths

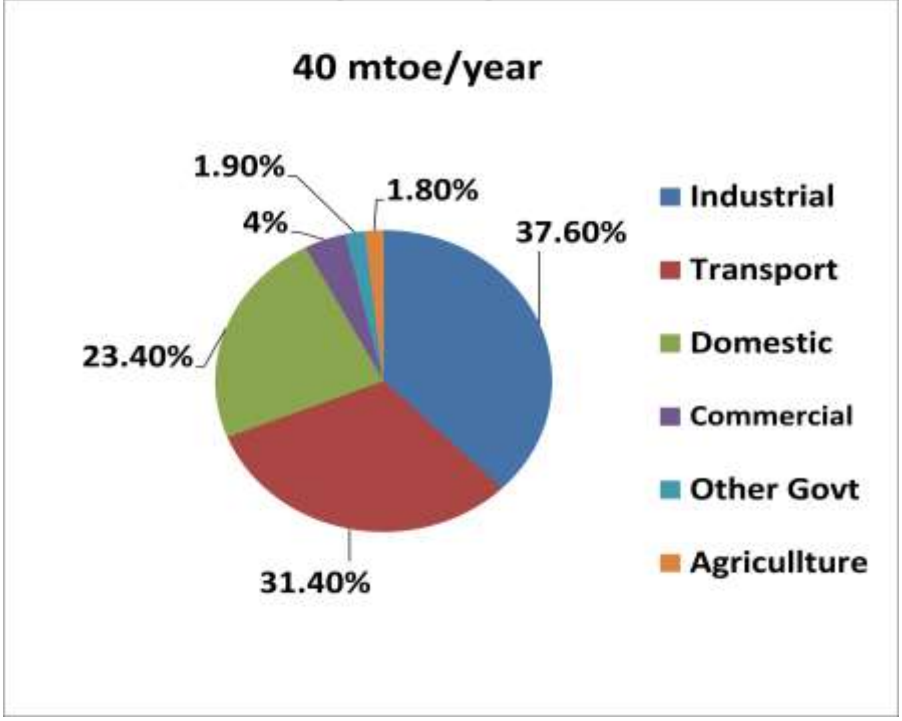
- Gas-based energy economy
- Country-wide power and gas infrastructure
- Large untapped Hydro-electricity potential
- Strategically located close to regional energy export sources in West and Central Asia

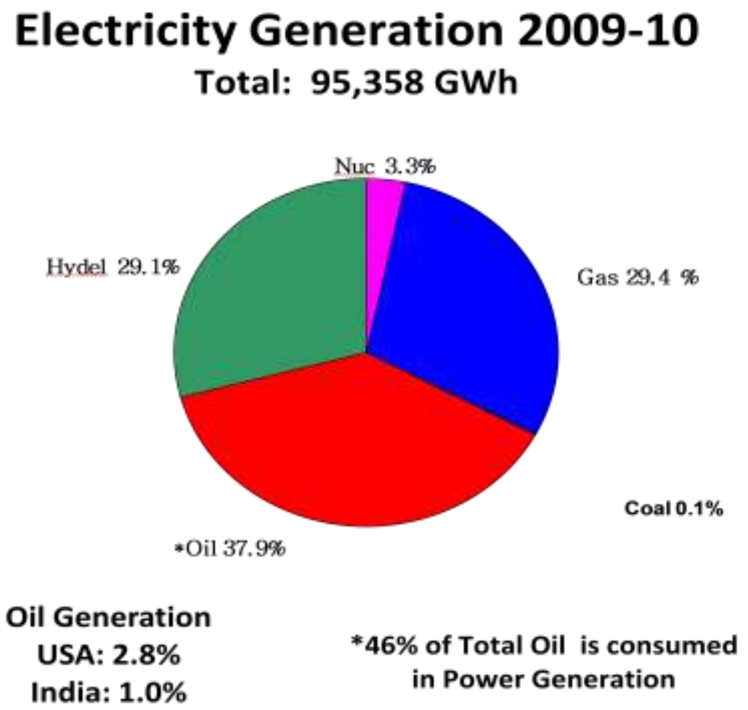


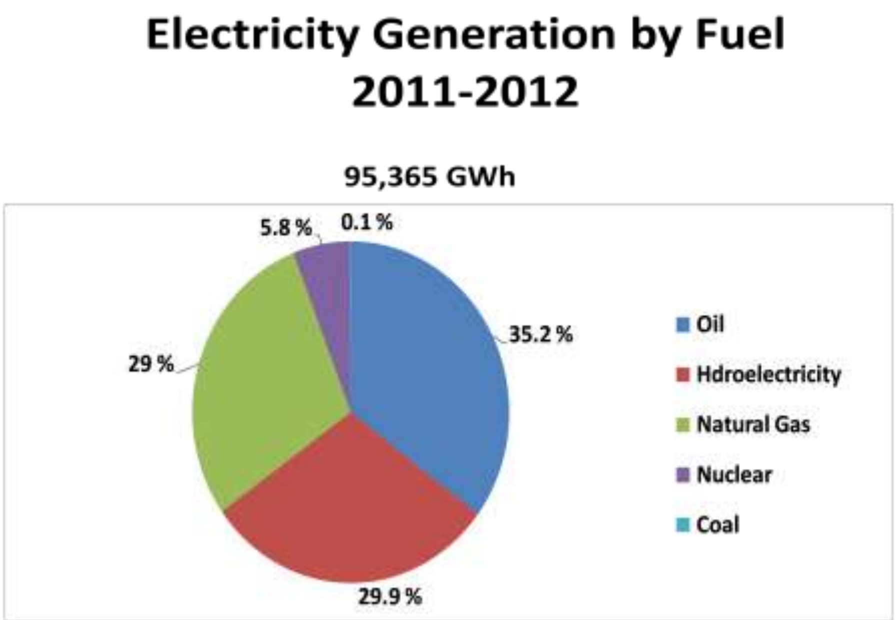
## Energy Supply Mix 2011-2012

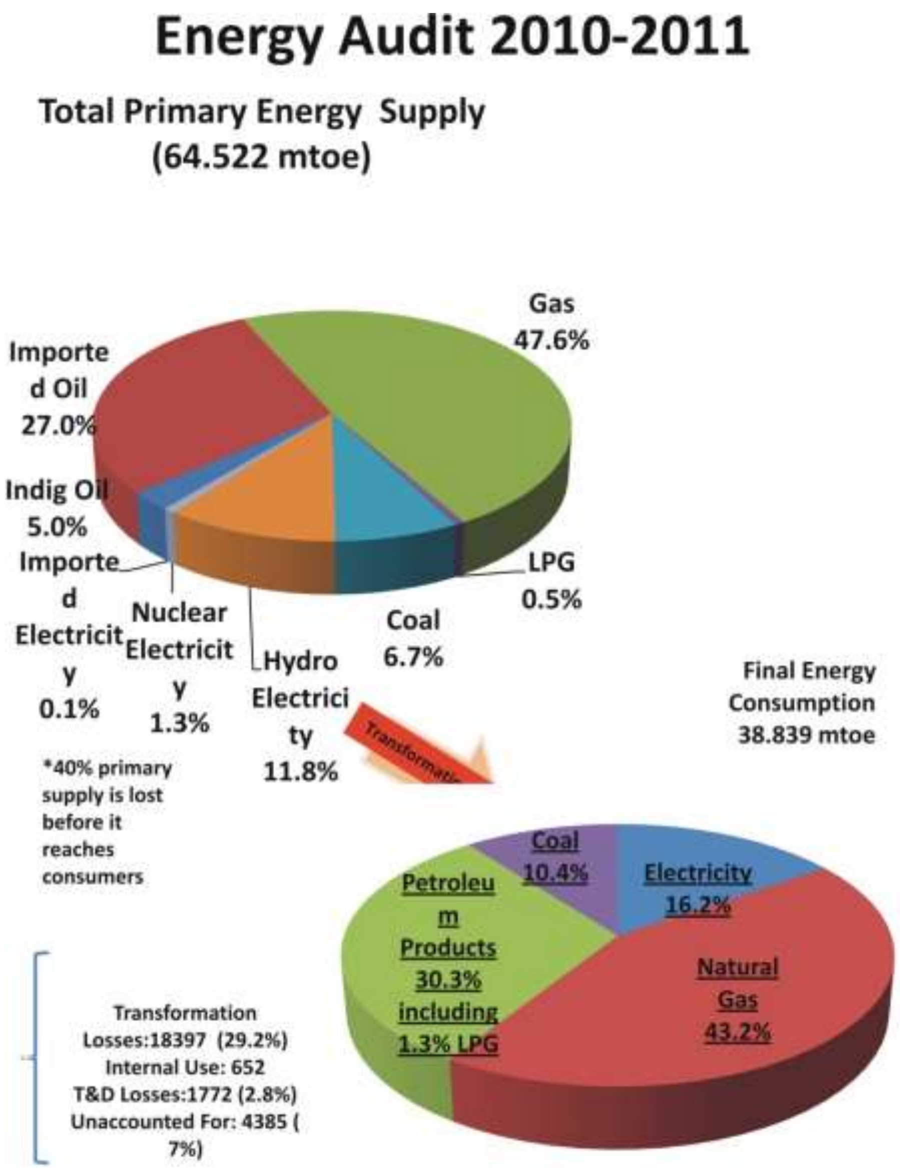


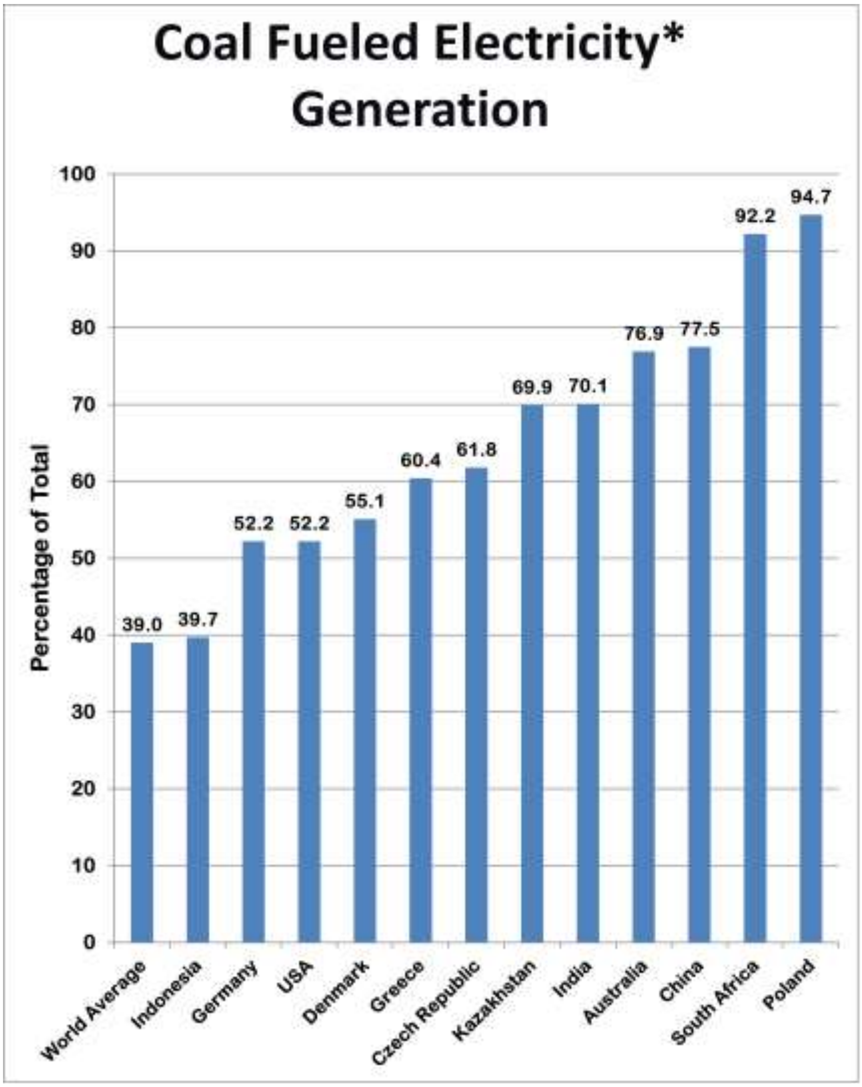

## Energy Consumption by Sector 2011=2012




Electricity Generation 2009-10
Total: 95,358 GWh
Nuc 3.3%
Hydel 29.1%
Gas 29.4 %
Coal 0.1%
*Oil 37.9%
Oil Generation
USA: 2.8%
India: 1.0%
*46% of Total Oil is consumed in Power Generation


Electricity Generation by Fuel 2011-2012
95,365 GWh
5.8 %
0.1 %
35.2 %
29 %
29.9 %
Oil
Hdroelectricity
Natural Gas
Nuclear
Coal


Energy Audit 2010-2011
Total Primary Energy Supply
(64.522 mtoe)
Gas 47.6%
Imported Oil 27.0%
Indig Oil 5.0%
Imported Electricity 0.1%
Nuclear Electricity 1.3%
Hydro Electricity 11.8%
Coal 6.7%
LPG 0.5%
*40% primary supply is lost before it reaches consumers
Final Energy Consumption 38.839 mtoe
Coal 10.4%
Electricity 16.2%
Petroleum Products 30.3% including 1.3% LPG
Natural Gas 43.2%
Transformation Losses:18397 (29.2%)
Internal Use: 652
T&D Losses:1772 (2.8%)
Unaccounted For: 4385 ( 7%)

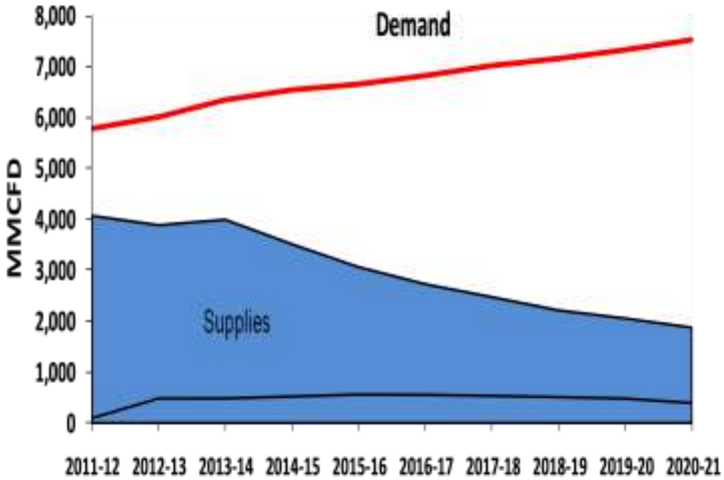



**Pakistan 0.1%** ***Cheaper than oil and LNG gas**

# Gas Demand-Supply Projections

**MMCFD**

| | 2011-12 | 2012-13 | 2012-14 | 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 |
|---|---|---|---|---|---|---|---|---|---|---|
| Supplies | 4,172 | 4,372 | 4,479 | 4,035 | 3,623 | 3,282 | 3,007 | 2,723 | 2,535 | 2,269 |
| Demand | 5,777 | 5,995 | 6,358 | 6,531 | 6,661 | 6,823 | 7,007 | 7,147 | 7,333 | 7,516 |
| Shortfall | (1,605) | (1,622) | (1,880) | (2,495) | (3,038) | (3,542) | (4,000) | (4,424) | (4,799) | (5,247) |



# Measures to Augment Gas Supplies (Imports)

| Project | Volume (MMCFD) | First Flow |
|---|---|---|
| **Transnational Pipelines** | | |
| Iran-Pakistan | 750 | 2015 |
| TAPI | 1,325 | 2016 |
| | 2,075 | |
| **Liquefied Natural Gas (LNG)** | | |
| Fast Track | 200 | June-2013 |
| Long Term-1 | 400 | Q1-2015 |
| Long Term-2 | 400 | Q2-2015 |
| | 1,000 | |
| **LPG Air-Mix (SNG)** | | |
| SSGC | 100 | Q2-2013 |
| SNGPL | 150 | Q3-2013 |
| | 250 | |
| **Total** | 3,325 | |

### Issues In Gas Sector

- Natural decline in production of existing fields
- Heavy reliance on gas because of policy distortion
- Delays in import projects – LNG, IP, LPG
- Delays in linking new discovered fields with the supply network
- Massive and uneconomic expansion of distribution network in domestic sector
- Unattractive economic and financial returns for the exploration companies
- Pricing of competing fuels
- Theft, sabotage and UFG
- Circular debt

### Least Cost Electricity Generation Principle

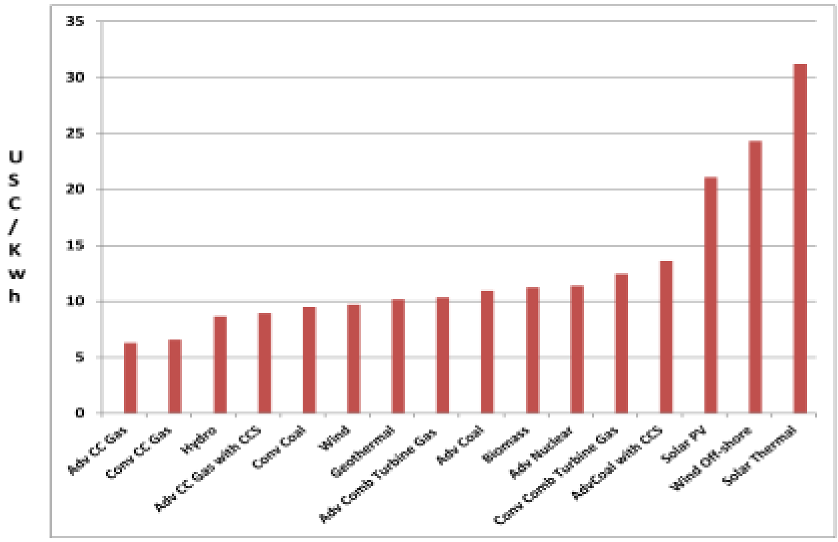
Cost of generating electricity can be minimized by optimal choice of:

1. Technology of power plant and its thermal efficiency
2. Type of fuel that the plant uses
3. Size of the plant to exploit economies of scale
4. Location of plant in relation to the centres of consumption

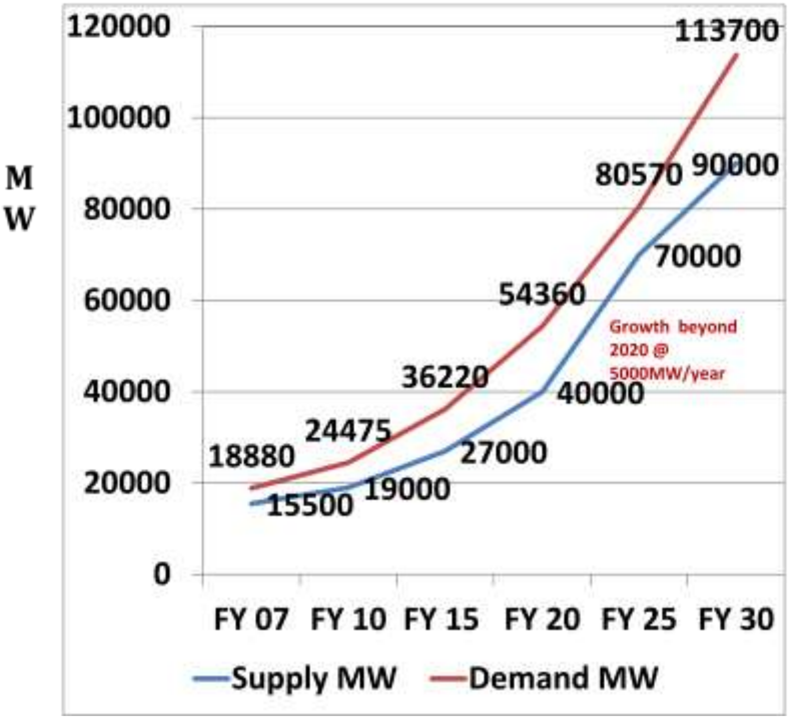
## Economic Dispatch of Power on Relative Cost

1. Purchase/dispatch power strictly on tariff/fuel cost
2. Buy maximum capacity (90%-95%) from efficient power plants to reduce per unit tariff to save power cost
3. Power to be purchased by DISCOs in cash from own recoveries and distributed by feeders based on theft and recoveries.
4. DISCOs should eventually make each feeder as a cost unit and supply power linked with theft and recoveries
5. Inter-fuel substitution to reduce cost
6. Divert gas from inefficient captive power plants to more efficient IPPs which will add 40% more electricity from the same amount of gas. This will also cut the cost of power.

**Average Levelized Costs of New Generating Technologies for 2016 (US C/Kwh of 2009)**



## Generation Capacity Supply Demand Forecast Low Economic Growth Rate of 5.0%



## Civil Nuclear Power Status

- CHESNUP-1 of 325 MW commissioned in 2001
- CHESNUP-2 of 325 MW commissioned in 2010
- CHESNUP-3 of 340 MW is under construction and scheduled for commissioning by 12/2016
- CHESNUP-4 of 340 MW is under construction and scheduled for commissioning by 10/2017
- Efforts are being made to acquire technology for economy of scales 1000 MW plant that will give a boost to power sector.
- Nuclear power target of 8500 MW by 2030 is dependent on getting access to 1000 MW or bigger plants in short to medium timeframe.

## Energy Conservation

- Conservation of energy is a huge source of adding to energy supply.
- It aims at bringing the existing energy into efficient use by eliminating wasteful internal use, minimizing losses and theft and reducing the energy intensity.
- By a broad estimate it could add over 20% to our energy consumption within the present energy supply.
- Japanese made an appeal in the Fikoshima power disaster and power demand went down by 20%.

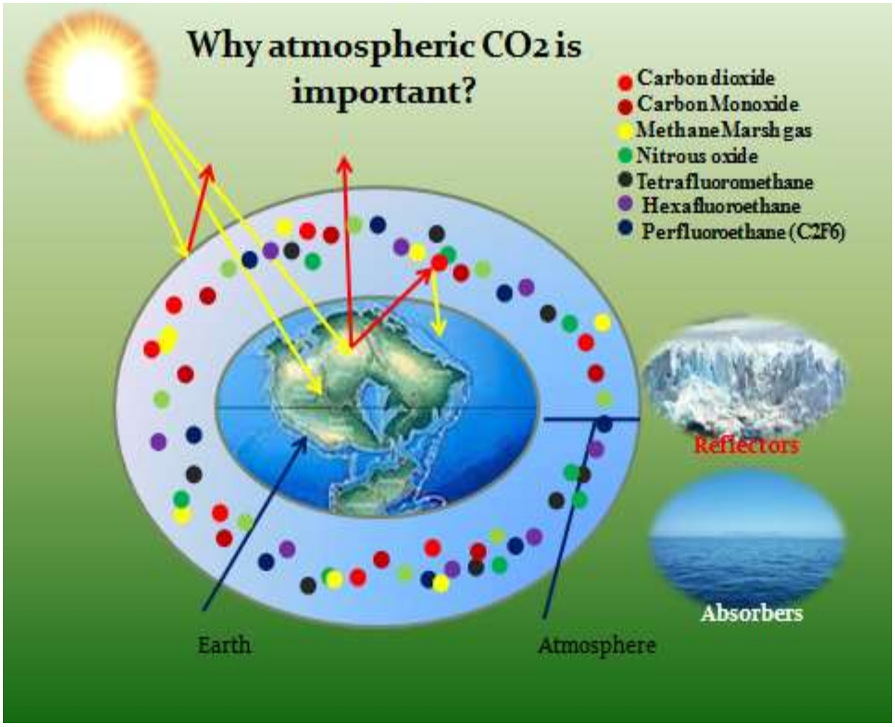
# CHAPTER II

# Prospects of Biofuel in Pakistan

**Dr. Ehsan Ali**

## Introduction

Biofuels are a need of sustainable world nowadays and produced from different oil producing plants like jatropha, caster bean and algaeetc, and has a significant potential to replace fossil fuel and reduce




greenhouse gas emissions. Constant availability and supply of cost-effective energy for consumers and industry is termed as energy security for a country.

The production of biofuels from locally grown sources and utilizing them to replace the petroleum products is a requirement for the management of existing energy crisis. Biofuel production is an emerging technology but extremely important to meet the challenges of fossil fuel depletion and global warming threats. Different countries, specially developed countries have designed their policies of subsidies to promote biofuel and environmental conditions. This article encompasses the importance and types of biofuel while focusing on prospects in Pakistan.

If we look at the history of mankind, the simple life style was not polluting the atmosphere much, and the ecosystem provided by nature was quiet healthy and human friendly. It is the result of manmade activities which has polluted our environment with harmful pollutants poisoning our planet and all living things on it. During our journey towards industrialization and development, the natural resources of gas and oil were used extensively producing number of greenhouse gases that reflect extra energy towards the earth leading to global warming. Oceans are the best absorber and glaciers the best reflector; the glaciers area being melted and oceans are rising, ultimately resulting in greater absorption on the planet. Greenhouse gas emissions directly and indirectly are related to the severe consequences and irreversible damages if left unattended. Most abundant greenhouse gases in the Earth's atmosphere are water vapours (H2O), carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O) and ozone (O3).

## Potential Biofuel Feedstock in Pakistan Biomass to Energy

Biomass can exist in the form of agricultural waste residues or as dedicated energy crops grown on marginal and saline lands. Pakistan has abundance of both, agricultural wastes such as rice husk, straw etc., and availability of marginal and saline lands which, if utilized to grow energy crops have huge potential as a renewable energy.

Biomass has been recognized as a clean, reliable, renewable source of energy. Unfortunately in Pakistan this source of energy has not been utilized for power generation purposes. However, in recent years, waste-to-energy technologies have been developed to produce clean energy through the combustion of crop residues like wheat straw, rice husk, and cotton straw in specially designed power plants equipped with the most modern pollution

**Annual Crop Production in Punjab**

| Crops | Production in Punjab (000 Tonnes ) | Total production by Pakistan(000 Tonnes) | **Production by Punjab (%)** |
|---|---|---|---|
| Rice | 3277.0 | 4823.3 | 67.94 |
| Wheat | 19021.0 | 25213.8 | 75.44 |
| Cotton | 1335.88 | 1966.26 | 67.94 |
| Sugarcane | 37481.0 | 55308.5 | 67.76 |
| Corn/Maize | 2959.2 | 3707.0 | 79.82 |

Source: Pakistan Bureau of Statistics, Punjab Bureau of Statistics 2010-11 control equipment to clean emissions. It has been reported that about 25 per cent of Pakistan's land is cultivated with many different agricultural crops. Wheat, Rice, Corn, Sugarcane and Cotton are the major crops grown in the country. Pakistan's energy needs are expected to double in the next 20 years while the current dependence on fossil resources cannot meet this increased demand in any sustainable manner in the future.

Centre for Energy Systems-NUST in cooperation with IFC-World Bank has designed a comprehensive study for mapping of available biomass in Punjab-Pakistan using WISDOM approach. The "Woodfuel Integrated Supply/Demand Overview Mapping" (WISDOM) is a spatial-explicit method for highlighting and determining priority areas of intervention and supporting biomass energy/bioenergy planning and policy formulation. The WISDOM approach along with field and industry surveys will be used to study the biomass availability or biomass hotspots, annual seasonal variations in production, industrial & household usage, and net $CO_2$ emissions from its burning in province of Punjab. A survey has been designed by the research associates to visit different locations in Punjab to obtain biomass data and subsequent verification of data obtained using GIS.

Biomass or cellulosic material can also be used to produce a number of fuels using conventional technologies including biomass liquefaction caused by pyrolysis of biomass followed by condensation leading to synthesis of targeted products. A range of biofuel including biogas (CH4), ethanol, butanol, acetone and hydrogen can be produced by biodegradation of cellulosic material in the presence of microbes.

## Ethanol from Molasses

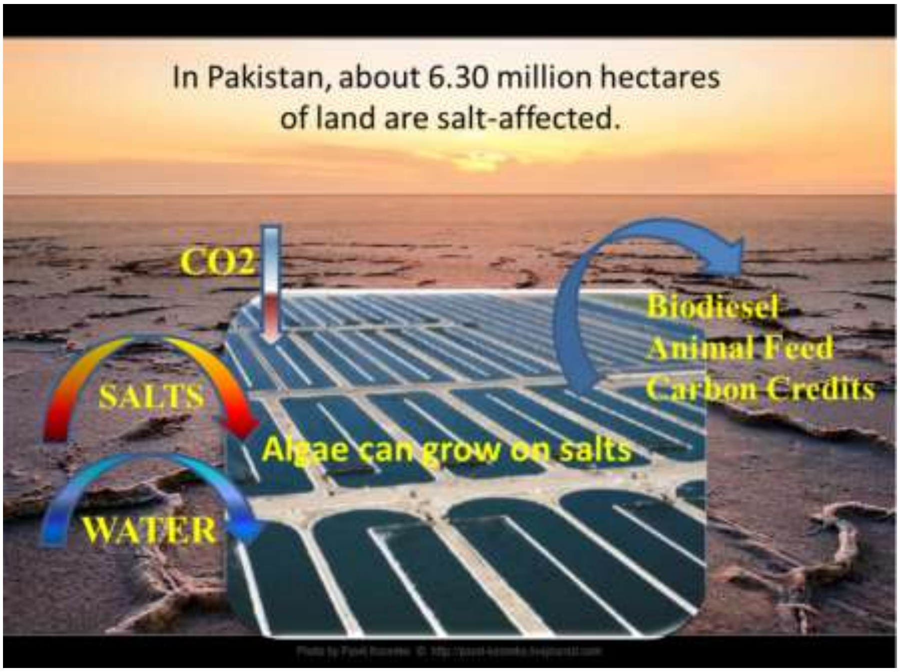
In the manufacturing sector, sugar industry is the second largest after textile and contributes 13 per cent to the manufacturing sector. Pakistan has 87 sugar mills but only 22 distilleries are producing ethanol with an annual production capacity of 400,000 tones plus. As per world statistics Pakistan holds, 5th position in terms of area under cane cultivation, 7th position in terms of cane sugar production. Out of these 22 distilleries, 7 have the capacity to produce fuel grade ethanol, the molasses to ethanol ratio is 5:1. These distilleries are operating at 60 per cent of their installed capacity. There are two main types of Ethanol produced in Pakistan, Hydrous Ethanol (min 94% ~ 96%) and anhydrous Ethanol, fuel grade (min 99% or more). Ethanol is produced generally from molasses and corn. In Pakistan, this is produced from molasses which is a waste product of sugar industry.

Pakistan is producing about 2-2.5 million tons of molasses every year and 80 per cent of the molasses are being exported every year. The usual price of molasses in Pakistan is Rs. 6000-6500/ton but the price of ethanol is $1100/ton. Pakistan needs to design and implement strategies to utilize available molasses for production of fuel grade ethanol to replace the fossil fuels. All sugar mills in Pakistan may extend their facilities to produce ethanol, and the ethanol production may lead them to produce biogas for power generation using spent wash or wastewater. The final effluent to be discharged from sugar mills can also be used to produce algae fuel/biomass as a treatment to meet the environmental disposal standards in Pakistan.

## Algae: As a potential source of Biofuel/Biodiesel

*Background*

This concept is proposed to address two most serious issues of Pakistan, i.e. Salinity and Alternative fuel production. In Pakistan, approximately 6.3 million hectares of agricultural land are salt-affected. Salt-affected soils are either abandoned or provide low crop yields. Almost all salt-affected area is underlain with brackish ground water. In addition, several more million acres in coastal areas and in non-saline areas are also underlain with brackish water. Infact, water being pumped from more than 70 per cent of national tube wells is brackish and unfit for conventional agriculture. Economic loss due to




salinity problem in some areas in Pakistan is estimated as more than Rs.20 billion per year. Unfortunately Pakistan is also an energy starving country.

The overall objective of this concept is to introduce some unique marine and freshwater algal species in Pakistan, which can grow on salt-affected soils and brackish water. These algal species remain highly productive at high salt-concentrations converting sunlight and inorganic carbon from air or soil $CO_3/HCO_3$ into biofuel and the biomass which can be used in a variety of commercially important ways. A number of media are available which can enhance algal growth in saline environments. Salt concentration in the soil is likely to reduce with cultivation of algae, because addition of organic matter and other algal metabolites would trigger leaching of salts, possibly leading to cultivation of cash crops after a few years. Carbon dioxide so sequestered in soil and biomass will be estimated as carbon credits which can be sold in international carbon trading markets.

However, a number of inputs are required to achieve the targets of saline algae farming for optimum outputs, these may include

1. A physiological part to optimize growth of algal species with variables like salinity, alkalinity and soil moisture, and if possible nutrition also.
2. To enhance efficiency extraction of fats from algal species and conversion to fuel.
3. Time course estimation of improvement in salt-affected soils
4. Comparison of reclamation efficiencies of algal species and standard reclamation methods.
5. Cultivation of test cash crops

*Biofuel Production using Saline Lands in Pakistan*

A number of attempts have been made to utilize the barren saline lands in Pakistan; most of the attempts include growing salt resistant plants like Eucalyptus, Acacia and Prosopis (Khalid Mahmood and et al 2001). Salinity is a worldwide problem, with more than 3 per cent of the world's total land mass affected by salinity and over half the world's countries having at least some quantity of land affected. In Pakistan, approximately 6.3 million hectares of agricultural land are salt-affected. Of this area, 2.0 million hectares in the canal command areas have been abandoned due to severe salinity and waterlogged conditions(Corbishley & Pearce, 2007). The main causes of the spread of water-logging and salinity in Pakistan are, the arid climate, flat topography, poor water-management practices, inadequate provision of drainage, insufficient irrigation-supplies for leaching of salts, not restricting irrigation-supplies during periods of no demand, inadequate use of chemical amendments to reclaim sodic and saline soils and use of poor-quality irrigation water without proper management-practices(Ahmed & Qamar, 2004) Salinity imposes direct economic costs through reduced crop yields and the halt to production on abandoned land, and indirect costs through the substitution away from the most economically efficient crop into other, less-profitable crops. In Pakistan, salinity is one of the country's most serious environmental problems. Of the 25 per cent of all irrigated land affected by some level of salinity, approximately 1.4 million hectares of all agricultural land has now been abandoned(World Bank, 2006). The total annual cost of crop losses from salinity in Pakistan has been estimated at between 15 and 55 billion rupees (Rs) (A$340 million to A$1.2 billion) per year. This is in addition to the Rs.15 billion (A$340 million) estimated to have been lost from the land that has been rendered unproductive. Taking the average cost of reduced yields as Rs.35 billion (A$790 million) per year, the costs of salinity in Pakistan are equivalent to 0.6 per cent of gross domestic production in 2004 (World Bank, 2006)

There is a need for innovative measures by introducing potential species of algae as a crop for saline lands to cultivate the saline land beneficially in Pakistan. Because of its salt-tolerant nature, marine algae have potential to be cultivated on saline lands in Pakistan. This would serve following important needs of Pakistan:

i. Reclamation of precious fertile land by using salts/salty water from the surface and underground. It might be possible to use that land for other cash crops after a specific number of algae growing cycles.
ii. The algae treated salty water may also be used for irrigation purposes but the final recommendation may be made after experimental verification if it may not need any more treatment before being utilized for irrigation purposes.
iii. A number of people/farmers may get back on their jobs to cultivate the saline lands using standard procedures after completion of this project.
iv. Algae cells usually contain 15-30 per cent oil which may be converted into biodiesel to reduce the CO2 emissions
v. Production of biodiesel may earn number of carbon credits for Pakistan
vi. Environmental issues like brackish water, salinity and greenhouse gas emissions may be addressed properly using saline land for biofuel production.
vii. Algae have long been recognized as potentially good sources for biofuel production because of their high oil content and rapid biomass production. In recent years, use of microalgae as an alternative biodiesel feedstock has gained renewed interest from researchers, entrepreneurs, and the general public (Wen & Johnson, 2009)

In the current scenario, if these needs could be made possible to be fulfilled, this would open doors of prosperity for Pakistan. In addition, this practice would also contribute in sequestration of carbon dioxide from air, and salts from the saline lands giving jump to the economy and cleaning the environment along with a package of enough carbon credits to Pakistan.

*Technology Aspects of the Saline Land Cultivation using Algae*

The reclamation process for saline soils normally requires an adequate rate of water-penetration through the soil, for leaching the excess soluble salts from the soil matrix. The proposed approach is to utilize the salts (causing infertility of soil) as a growth medium of algae to eradicate the excessive salinity. Common methods of land reclamation are classified into three categories as briefly discussed below (Corbishley & Pearce, 2007) and compared with the proposed approach to highlight the advantages of this project:

1. Physical methods: The physical methods include sub-soiling, deep ploughing, sanding, horizon mixing, profile-inversion and channeling. These treatments increase the permeability of the soil, which is generally a limiting factor during the reclamation of sodic and saline-sodic soils. Deep ploughing is very useful where the sub-soil has gypsum or lime. In case of algae cultivation, none of these laborious methods are required but a simple pond system or raceway system can be established to collect saline water for growing algae.
2. Chemical Process: The chemical methods include application of chemicals, such as gypsum, sulphur, sulphuric acid and hydrochloric acid. Gypsum can be applied to all sodic and saline-sodic soils, whilst sulphur, sulphuric acid and hydrochloric acid are only effective for calcareous saline-sodic soils. These amendments finally lower the soil pH, react with soluble carbonates and replace the exchangeable sodium with calcium. While growing algae, these type of chemicals are not required and pH can be maintained as required for algal growth using respective agents.
3. Biological methods: The biological methods include growing of crops on problem-soils and/or their incorporation at the stage of maximum biomass- production. The addition of large amounts of organic matter during reclamation is also a common practice. These methods increase the soil- permeability through root-action, production of aggregating agents during decomposition and the release of carbon dioxide (for dissolving) during respiration and decomposition. Algae cultivation is a tool for CO2 sequestration and a source of carbon credits by contributing towards better environment for coming generations.
4. While physical and chemical methods are effective at improving soil conditions, they are generally more expensive than using saline agriculture to treat degraded and abandoned land affected by water-logging. Saline agriculture, however, requires that salt tolerant and

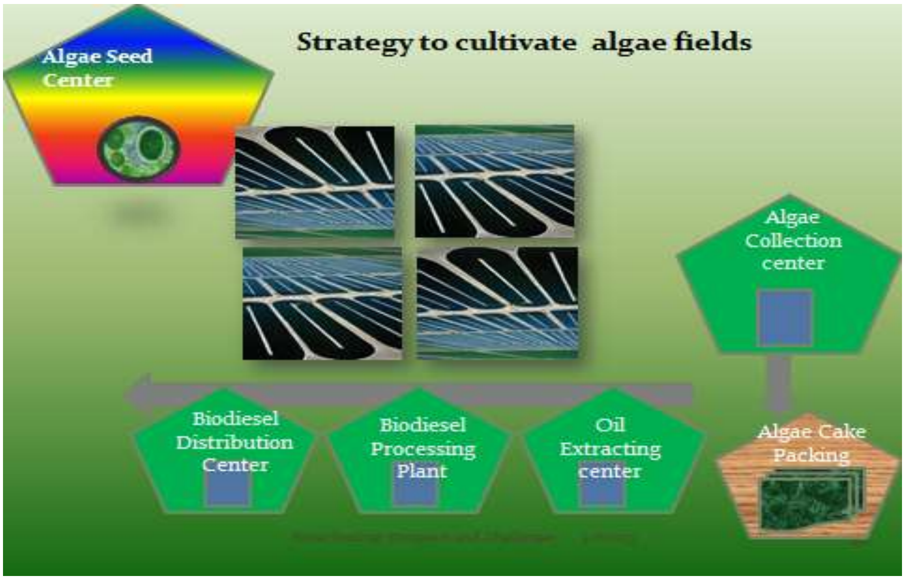
other appropriate species be previously identified as suitable for particular environments. There are a number of elements that need to be considered and trials must be conducted to determine the appropriateness of a particular species in a particular region. This ranges from climatic conditions to water use and salinity tolerance (Corbishley & Pearce, 2007). The application of soil treatment before cultivation of any crops is expensive and algae does not need any soil treatment but have the potential to utilize the problematic components as feed for biofuel/biomass production.

5. Algae are organisms that grow in aquatic environments and use light and carbon dioxide (CO2) to create biomass. There are two classifications of algae: macro-algae and microalgae. Macro-algae, which are measured in inches, are the large, multi-cellular algae often seen growing in ponds. These larger algae can grow in a variety of ways. The largest multicellular algae are called seaweed; an example is the giant kelp plant, which can be more than 100 feet long. Microalgae, on the other hand, are measured in micrometres and are tiny, unicellular algae that normally grow in suspension within a body of water.
6. It is a known fact that the cultivation of algae does not need prime agricultural land and will, therefore, not compete with food crops. Many studies have been carried out to show that arid and desert like regions that are usually not conducive to crop cultivation can now be used for algal biofuel production (Wen & Johnson, 2009).

*Procedure of Algae Cultivation on Saline Land*

a. Screening of Algal strains for better oil contents and suitability to grow on saline lands.
b. Optimization of a cheaper medium to grow algae on saline lands using saline land water.
c. Cultivation of selected Algal strains at laboratory scale leading to field/pilot trials on saline lands.
d. Standardization of harvesting and oil extracting techniques to get maximum oil yield.
e. Standardization of processing of extracted oil into biodiesel while maintaining universal biodiesel standards.
f. Soil analysis and possible recommendation for other cash crops.
g. Carbon dioxide sequestration and carbon credits application by Global Change Impact Studies Centre. Ministry of Climate Change.
h. Publication of a protocol on "Algae Farming on Saline Lands in Pakistan for biofuel production."

It is a visionary approach to address energy crises country wide to produce fuel and feed related products from barren saline lands. It may open the doors of employment, prosperity and self-sufficiency towards fuel generation.




## Conclusion

A lot of efforts are required to revive the energy sector which can smoothly meet the requirements of energy for domestic, commercial and industrial sector in Pakistan. All types of renewable energy may be used at both domestic and industrial level. Biofuel is an important alternative fuel to keep running the existing transport and industrial system smoothly. Currently, Pakistan may focus to utilize available biomass in the form of residual crops as an industrial fuel in combination with fossil fuel. It may replace the fossil fuel partially and reduce emission of greenhouse gases. Strategies should be designed to extend the capacity of sugar mills to utilize huge amount of available molasses for fuel grade ethanol production. Pakistan's 6.3 million hectares of saline land can be used to cultivate with salt resistant algae at the expense of residual salts and saline water for biofuel/biomass production. In this article, it has been clearly justified that Pakistan has a potential to produce Biofuel using algae without creating any conflict with the edible crops and fertile land utilization. A 100-hectare (247 acres) algae farm would consume about 50,000 metric tons of carbon dioxide per year. A 100-hectare algae farm can produce 13 million litres of oil per year and 20 million Kg of algae cake along with sufficient carbon credits for Pakistan.■

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# NUCLEAR POWER GENERATION: CHALLENGES AND PROSPECTS

**Syed Shaukat Hasan and Afia Noureen**

## Introduction

Energy is something which has always been a coveted goal for mankind. Even before the advent of civilization, individuals or a group could overpower their adversaries by utilizing the energy stored in their body — the so called 'muscle power'. Later on using different properties of the four known 'elements' of that time, that is earth, water, wind and fire, several feats for survival and for better living conditions were performed. Today the human civilization is excessively dependent on energy in one form or the other. Without reliable, affordable and sustainable energy sources a country cannot survive economically in the world and enjoy security.

The quest for sustainable supply of energy is the driving force for the modern nation-states to devise immediate and long-term policies for the economic and social uplift of their people and for providing security against an adversary. Today's modern societies require every form of energy including energy in the form of electricity. Electricity is the most utilized and direly needed form of energy. Several diverse sources of electricity generation including the non-renewable (coal, oil, gas and nuclear) and the renewable (hydel, solar, wind, geothermal and bio-mass) have been utilized to produce electrical energy.

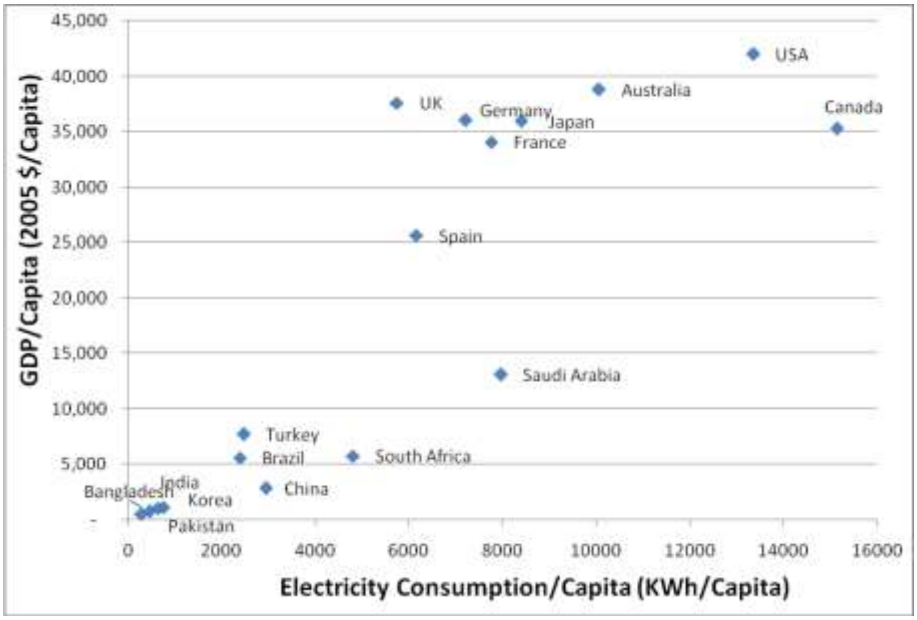
Pakistan is an energy deficit country which requires different options to be exploited for the generation of electric power. There are several options available for electricity generation, each having their own strengths and weaknesses. The energy policy planners of Pakistan need to evolve an energy policy for the continued progress and development of the country where a judicious energy mix policy is adopted. Nuclear energy having its promising characteristics for Pakistan and the associated challenges and opportunities need to be analysed in a professional manner.

## Energy-Economy Relationship

The development of a country can usually be measured by the yardstick of its energy/electricity consumption. For an economy to flourish, uninterrupted and affordable supply of commercial energy is vital. For sustainable economic growth, reliable and affordable supply of energy is a necessity. Figure 1 shows a graph of energy-economy relationship. The developed countries with high

GDP/capita, consume more electricity per capita which reflects the enhanced use of electric energy commensurate with their economic prosperity.

**Figure 1**
**Relation between Economic Prosperity and Electricity Consumption [1]**




## Energy Security

According to the World Bank definition, "Energy security is the sustainable production and use of energy at reasonable costs to ensure a certain quality of life".

Energy security comprises "4 A's" i.e. Availability, Accessibility, Acceptability and Affordability. The uneven distribution of energy supplies among countries has led to significant vulnerabilities. To achieve energy security, a country should try to exploit its indigenous energy sources, renewable energy sources and diversify its energy mix so that there is no major dependence on any one of the sources. To avoid energy shortfalls proper and long term planning is unavoidable.

## Electricity

The most convenient form of energy which has made human life extensively comfortable is electricity. The bulk of the primary energy supplies is consumed for producing electricity globally. Table 1 shows the global energy statistics for some countries along with population, total primary energy supplies (TPES) and electricity consumption. Table 2 depicts the global electricity demand projections up to 2035. From 2009 to 2035 the global electricity demand is estimated to almost double, with average annual growth rate of 2.7 percent, while for Pakistan the demand goes six fold with the average annual growth of 7.4 percent.

**Table 1**
**Global Energy Statistics[1]**

| Country/ Region | Population (million) | TPES (Mtoe) | Electricity Consumption (TWh*) |
|---|---|---|---|
| China | 1,338 | 2,417 | 3,938 |
| USA | 310 | 2,216 | 4,143 |
| Russia | 142 | 701 | 916 |
| India | 1,171 | 693 | 755 |
| France | 65 | 262 | 503 |
| UK | 62 | 202 | 357 |
| Australia | 23 | 125 | 227 |
| Pakistan | 174 | 85 | 79 |
| Malaysia | 28 | 72 | 117 |
| Middle East | 205 | 606 | 715 |
| **OECD** | **1,232** | **5,406** | **10,246** |
| **World** | **6,825** | **12,717** | **19,738** |

* One TWh is equal to one billion kilowatt-hour (kWh), whereas kWh is a unit of electricity consumption charged to the consumer by the electric utilities.

**Table 2**
**Global Electricity Demand Projections[2][3][4]**

| Country/Region | 2009 | 2035 | Avg. Annual GR (%) |
|---|---|---|---|
| **OECD+** | **9,193** | **12,554** | **1.2** |
| USA | 3,725 | 4,898 | 1.1 |
| Europe | 3,088 | 4,244 | 1.2 |
| Japan | 950 | 1,225 | 1.0 |
| **Non-OECD** | **8,025** | **21,498** | **3.9** |
| Russia | 791 | 1,401 | 2.2 |

| | | | |
|---|---|---|---|
| China | 3,263 | 10,201 | 4.5 |
| India | 632 | 2,590 | 5.6 |
| Middle East | 600 | 1,525 | 3.7 |
| Brazil | 408 | 792 | 2.6 |
| Pakistan | 91.8 | 595 | 7.4 |
| **World** | **17,217** | **34,352** | **2.7** |

+ OECD: Organisation for Economic Cooperation and Development based in Paris, France.

## Energy Scenario of Pakistan

Currently, Pakistan is facing severe energy crisis resulting in frequent periods of electricity and gas load shedding. The duration of power outages remains 14 to 18 hours in many cities. Currently, there is a shortfall of more than 4,000 MW, while the peak summer season is yet to come when the shortfall is foreseen to reach the level of 7,000 MW. Pakistan has scarce fossil fuel resources and is forced to import almost one-third of its oil and gas to meet its energy needs. Table 3 shows the indigenous fossil fuel resources.

**Table 3**
**Estimated Energy Resources[5]**

| | **Fossil Fuels** | | | **Nuclear** | **Renewable** | |
|---|---|---|---|---|---|---|
| | Solid | Liquid | Gas | Uranium | Hydro | Wind |
| Total amount in specific units | 3,450 | 45.9 | 22.7 | n.a.* | 55.0 | 50.0 |
| Total amount in exajoule (EJ#) | 68.3 | 2.0 | 21.6 | n.a.* | 2.5 | 1.39 |

# Exajoule (EJ) is a unit of energy equal to $10^{18}$ joules

* not available

Notes:-

(i) Specific units for solid & liquid: million tonnes, gas: trillion cubic feet, hydro and wind: GW
(ii) Solid consists of only coal. It has been converted to energy at 19.8 GJ/tonne.
(iii) Liquid consists of crude only. It has been converted to energy at 44.2 GJ/tonne.
(iv) Natural gas has been converted to energy at 950 GJ/million cubic feet.
(v) Hydro power potential has been converted to energy at 50% plant factor and 10,550 GJ/GWh.
(vi) Wind power potential has been converted to energy at 30% capacity factor and 10,550 GJ/GWh.

Renewables including hydro, solar, and wind are also among the options for electricity generation. The major resource is that of coal (185 billion tones) which is not yet exploited and is in the research and development phase. Using coal will also create environmental problems which will need to be addressed. The coal production in 2011-12 was 3.6 million tonnes while 4.1 million tonnes of coal was imported to meet the industrial requirement. The development of coal mining industry in Pakistan, particularly for power generation is hampered by many constraints relating to the quality of coal, mining difficulties and organizational constraints.

The hydro power potential is reported to be 100,000 MW with identified sites of 55,000 MW. However, the areas in Pakistan for exploitation of nuclear-hydel energy are located in the mountainous regions, away from load centres which requires high investment cost (for electricity generation and transmission). Other issues such as socio-political, water allocation among the provinces and resettlement of people are some of the reasons which have hindered the exploitation of the hydro potential to its full capacity. During the year 2011-12, hydropower provided 29.0 per cent of electricity in Pakistan. Although, Pakistan has relatively high endowment of hydropower potential, only 6,716 MW (12%) of the identified resources have been exploited so far. Some small, mini and micro hydro projects are under construction and a number of medium and large size hydroelectric projects have been planned/proposed.

The sun shines bright in the country but it is not yet economical enough to be commercialized and will need huge subsidies to make them attractive for public.

The air-corridor in the southern part of the country is also quite attractive but the wind power technology is yet not fully developed in Pakistan. The economically exploitable wind potential is estimated to be about 50,000 MW.

The World Bank estimates that the worldwide electricity production comprised of 40 per cent coal, 19 per cent gas, 16 per cent nuclear, 16 per cent hydro and 7 per cent oil while for Pakistan it was 35.8 per cent oil, 33 per cent hydro, 27 per cent gas, 3.6 per cent nuclear and 0.1 per cent coal and 0.28 per cent electricity was imported in 2011.

Table 4 reports the data of electricity production and installed capacity in the country over the last four decades.

**Table 4**
**Electricity Production and Installed Capacity[6][7]**

| | 1970 | 1980 | 1990 | 2000 | 2005 | 2010 | 2012 | Average annual growth rate (%) 2000 to 2012 |
|---|---|---|---|---|---|---|---|---|
| Grid installed capacity (GW) | | | | | | | | |
| Thermal | 1.05 | 1.79 | 4.83 | 12.44 | 12.42 | 13.32 | 16.04 | 2.1% |
| Hydro | 0.67 | 1.57 | 2.90 | 4.83 | 6.50 | 6.56 | 6.72 | 2.8% |
| Nuclear | * | 0.14 | 0.14 | 0.14 | 0.46 | 0.46 | 0.79 | 15.7% |
| Total | 1.72 | 3.50 | 7.86 | 17.40 | 19.38 | 20.34 | 23.54 | 2.5% |
| Grid electricity production (TWh) | | | | | | | | |
| Thermal | 3.54 | 6.17 | 20.72 | 46.06 | 57.16 | 64.37 | 65.15 | 2.9% |
| Hydro | 2.92 | 8.72 | 16.93 | 19.29 | 25.67 | 28.51 | 28.64 | 3.3% |
| Nuclear | * | - | 0.29 | 0.40 | 2.80 | 2.89 | 4.87 | 23.2% |
| Total | 6.46 | 14.89 | 37.94 | 65.75 | 85.63 | 95.77 | 98.66 | 3.4% |
| Grid electricity consumption (TWh) | 4.62 | 10.35 | 28.77 | 45.59 | 61.33 | 74.35 | 73.08 | 4.0% |

* Nuclear power was introduced after 1970.
- Less than 0.01 TWh

**Notes:-**

(i) Years in this Table are fiscal (1st July – 30th June).
(ii) Electricity transmission and distribution losses are not deducted.

## Nuclear Power

In the current energy scenario, nuclear power can play a vital role. Nuclear power is a safe, clean and reliable source of electricity. Nuclear power has a key significance in providing base-load electricity and minimizing imports of oil, gas and coal. It is essential to continue the development of nuclear power, even at a modest pace, in order to develop local capabilities and to meet Pakistan's future electricity needs.

The nuclear power generation contributed 4.9 per cent to the total electricity generation of Pakistan in 2011-12. Pakistan has three operating nuclear power plants (NPPs): KANNUPP (137 MW) at Karachi which started commercial operation in 1972, C-1 & C-2 (325 MW each) located at Chashma--started commercial operation in 2000 and 2011, respectively. Two nuclear power plants C-3 & C-4 (340 MW each) are under construction at Chashma site.

The status and performance of NPPs in Pakistan is shown in Table 5. KANUPP, which completed its design life of 30 years in 2002, is now operating on 15-year extended life at a reduced power level of 98 MW. The second nuclear power plant, C-1 has completed twelve years of safe commercial operation in September 2012. The third NPP C-2 is also operating well since its commercial operation in May 2011. The three operating NPPs KANUPP, C-1 and C-2 produced respectively 14.07 billion KWh, 25.96 billion KWh and 3.09 billion kWh electricity from first grid connection up to 31st December 2012. The availability factor of these NPPs during (January to December) 2012 were; KANUPP (87.41%), C-1 (94.45%) and C-2 (89.53%).

## Table 5: Status and Performance of Nuclear Power Plants

| Station | Type | Net Capacity (MW) | Status | Operator | Reactor Supplier | Construction Started | Criticality Date | Grid Connection Date | Commercial Operation Date | Shut-Down Date | Gross Capacity Factor in 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| KANUPP | PHWR | 125 | Operational | PAEC | CGE | 1966-08-01 | 1971-08-01 | 1971-10-18 | 1972-12-07 | - | 52.65% |
| C-1 | PWR | 300 | Operational | PAEC | CNNC | 1993-08-01 | 2000-05-03 | 2000-06-13 | 2000-09-15 | - | 94.11% |
| C-2 | PWR | 300 | Operational | PAEC | CNNC | 2005-12-28 | 2011-02-22 | 2011-03-14 | 2011-05-18 | - | 83.69% |
| C-3 | PWR | 315 | Under Construction | PAEC | CNNC | 2011-03-04 | 2016-08-01 | 2016-09-30 | 2016-12-31 | - | |
| C-4 | PWR | 315 | Under Construction | PAEC | CNNC | 2011-12-18 | 2017-06-01 | 2017-07-30 | 2017-10-31 | - | |

* First Concrete Pour

\# Target

The Energy Security Plan as approved by the Government of Pakistan (GoP) envisaged the construction of 8,800 MW nuclear power generation capacity by 2030. The target has now been raised to more than 30,000 MW of nuclear power by 2050 to meet the electricity needs of the country. The PAEC strategy for nuclear power programme is the development of indigenous capability in NPP technology to reduce dependence on imported plant and fuel, conserve the foreign exchange component and to reduce the total cost, by expanding the level of the country's industrial and technological base.

To materialize the goal of nuclear power expansion, there are many challenges both internal and external. The first challenge is financing of nuclear power plants as they are capital intensive and Pakistan being a developing country has to depend on loans for that purpose. Secondly, the industrial infrastructure to support nuclear power generation is not yet well-established in the country. Nuclear technology is unique in the sense that it requires special material, equipment and industrial infrastructure for its establishment and sustainability.

Internationally, Pakistan has been a victim of embargoes and sanctions from the very start of its nuclear power programme. Pakistan was the fifteenth country in the world to utilize nuclear energy for power generation when in 1972 it started the commercial operation of its first nuclear power plant — the Karachi Nuclear Power Plant (KANUPP). Two years later due to significant nuclear-related events in the region, the vendor support for KANNUPP was abruptly withdrawn along with denial of other technical support as a consequence of embargoes put on Pakistan for those events for which it was not responsible. PAEC scientists, engineers and technicians were, however, determined to keep the plant operational. KANUPP has been operating since 1972, albeit not at the power level for which it was designed. The entire infrastructure to keep the plant operational was developed indigenously. It is a matter of pride for PAEC scientists and engineers that Pakistan is perhaps the only country operating a turn-key nuclear power plant without the vendor support.

## Challenges

Pakistan is, currently, facing a number of challenges to increase the generation of nuclear electricity. These challenges are of two types: internal and external. The internal challenges are due to current financial crisis and yet to be fully developed indigenous industrial infrastructure. Nonetheless, notwithstanding the financial crunch, the GoP is fully committed to provide the necessary finances for running the nuclear power programme.

The external challenges are the embargoes and sanctions and denials regarding supply of nuclear equipment and components — in some cases even those which are related to the safe operation of nuclear power plants. The

Nuclear Suppliers Group (NSG) of which Pakistan is not a member does not allow any civil nuclear trade with non-member countries. The exemption given to India by the NSG exacerbates the problem for Pakistan. Currently, China is the only nuclear power plant supplier for Pakistan and is facing much international criticism for having bilateral trade agreement with Pakistan. In the realm of nuclear safety and security, although Pakistan follows international practices for safety and security of its nuclear installations, there are unfounded concerns often raised by the international media regarding the security of Pakistan's nuclear installations. Nonetheless, over the years Pakistan has proved that it has the capability to establish and execute its nuclear programme safely and securely and that challenges can be met by careful planning, determination and support from the government.

## Opportunities

The opportunities for nuclear power generation in Pakistan are extensive and increasing. Nuclear power is one of the most suitable options for base-load electricity production. Pakistan has invested substantially in the nuclear sector during the past several decades. Rather than sowing the "seeds", now is the time to harvest the "crop". The IAEA has identified 19 infrastructure issues which a country needs to consider and assess while planning for nuclear power pragramme or for its expansion [8]. These issues relate to, inter-alia, governmental policy and support for nuclear power; nuclear legislation and regulatory infrastructure; site evaluation studies; nuclear safety, security and safeguards; radiation protection; radioactive waste management; human resource development; etc. Pakistan has already mastered all these 19 infrastructure issues as its nuclear programme is at a much advanced stage than those of the new comer countries. Engineers and scientists from PAEC and the national nuclear regulatory body — the Pakistan Nuclear Regulatory Authority (PNRA) are assisting many developing countries in diverse areas under different IAEA programmes.

Over the years, Pakistan has established a solid human resource base in almost all areas of nuclear science and technology. PAEC has established five institutes, namely, Pakistan Institute of Engineering and Science (PIEAS), Karachi Institute of Power Engineering (KINPOE), CHASNUPP Centre of Nuclear Training (CHASCENT), National Centre for Non-Destructive Techniques (NCNDT) and Pakistan Welding Institute (PWI). PIEAS is a degree awarding institute offering various programmes in engineering education, e.g. nuclear, system, material, metallurgical, mechanical and chemical engineering; physics, as well as nuclear medicine, radiation and medical oncology and medical physics, leading to Masters and Doctorate programmes. PIEAS has twice been declared by the Higher Education Commission (HEC) as the Number 1 engineering institute in Pakistan — once in 2006 and the second time in 2012. So far, more than three thousand scientists, engineers and doctors have graduated from PIEAS. KINPOE and CHASCENT focus more on training in nuclear power technology and have been producing the core engineers and scientists for running the nuclear power plants. NCNDT and PWI provide the engineering support to the NPPs and also cater to the needs of the industrial sector in Pakistan. PNRA has also established a few training centres such as the School for Nuclear and Radiation Safety (SNRS) and the School for Nuclear Security (SNS). All these institutes have been instrumental in providing a solid and robust human resource in nuclear science and engineering and nuclear safety and security to carry out the national nuclear programme successfully.

Pakistan is among those handful of countries which are dealing with the whole spectrum of applications of nuclear science and technology. PAEC scientists and engineers are not only running nuclear power plants but are also deeply involved in other areas as well such as nuclear medicine and oncology, development of new crop varieties and application of nuclear techniques in industry such as non-destructive techniques, irradiation of surgical goods and food , isotope hydrology, etc. The fuel cycle capabilities established in Pakistan give it an advantage to run its programme independently, including the operation of KANUPP which is fed with indigenous fuel and heavy water.

## Conclusion

The energy requirements of a progressive and thriving Pakistan demand an aggressive investment of resources, financial as well as technological for nuclear power development. This is more so to overcome the current deficit of electricity generation. Pakistan has a solid base of engineering and technology and time-tested human resource which can handle the challenges and benefit from the opportunities which are available in the nuclear arena. Notwithstanding the challenges associated with nuclear power generation, there had never been such an opportunity in Pakistan, albeit due to many reasons, for exploiting the benefits of nuclear power for sustainable growth of the country. Energy brings economic prosperity and nuclear power is one of the major options to bring energy to Pakistan.■

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## HYDEL POWER: CONFRONTING DWINDLING RESOURCES

**Dr. Shaheen Akhtar**

Dr. Shaheen Akhter said that Pakistan was currently facing a critical energy crisis which was resulting in frequent and long power breakdowns, shutting down of industrial units, affecting economic growth and creating social chaos and political instability. In 2011, according to World Bank Report 'estimated production loss to the economy is two percent of the GDP per annum, and may be more'. A recent report by the State Bank of Pakistan says, "the peak shortfall for the system of the Pakistan Electric Power Company (PEPCO) rose from 2,645 MW in 2007 to 8,398 MW in 2012 which indicates a deepening of the energy crisis in the country." It was estimated that the national demand of electricity would keep on growing rapidly, at about 10 per cent annually, owing to growing population and economic activities. The energy crisis was generated by variety of reasons, in particular, widening demand-supply gap, increased shift to oil-based expensive energy mix, and lack of integrated energy strategy and energy governance. She said that Pakistan needed to diversify its energy options; rebalance its energy mix with preference to cheaper energy sources; and improve energy governance by fixing the management issues, increasing energy efficiency and conservation.

Dr. Shaheen said that hydropower was the cheapest and cleanest, renewable source of energy. Pakistan was endowed with rich hydro power potential of 60,000 MW which could be tapped to meet its current and future energy requirements. She discussed the potential of hydropower resources and hydropower development in the country. Various technical, financial, infrastructural and management challenges that were presented were impeding the optimum utilization of the hydro resources of the country. It argues that the country needs to reverse the energy mix in favour of hydropower, prioritize run of the river power projects and try to remove all the hurdles in way of hydro development.

Dr. Shaheen illustrated the presentation with the following slides:

## Main Argument

- Pakistan is endowed with rich hydro power potential of 60,000 MW which can be tapped to meet its current and future energy requirements.
- The country needs to rebalance the energy mix in favour of hydropower, prioritize run of the river power projects and make efforts to overcome all the technical, financial, infrastructural and management challenges to the hydropower development.

## Questions Raised

- What is the hydel power potential of Pakistan?
- What is the trajectory of hydropower development in the country?
- What are the technical & infrastructural challenges in way of hydropower development?
- What are the financial, management & political challenges in hydro energy development?
- Can run of the river projects provide a way out?

## Worsening Energy Crisis

- The power generating capacity in Pakistan is only 21036 MW (2011) with the demand growing at 10% annually.
- The current power generation is 9,500 MW against a demand of about 13,500 to 14,000 MW with an average gap of about 4,000 MW.
- Estimated cost of power crises to the economy is approximately Rs. 380 billion per year, around 2 % of GDP.
- Current Energy Mix: Oil 35.1%; Hydel 33%; Gas 27%; Nuclear 6%; Coal 0.1%.
- The percentage of hydroelectric power in the energy mix has fallen from 60% in 1962, to only 29% in 2009-10, but marginally increased to 33.6% in 2010-11.

| Type of Generation | Installed Capacity (MW) | Derated/ Dependable Capacity (MW) | Availability (MW) | |
|---|---|---|---|---|
| | | | Summer | Winter |
| WAPDA Hydro | 6444 | 6444 | 6250* | 2300* |
| GENCOs | 4829 | 3580 | 2780 | 3150** |
| IPPs (incl Nuclear) | 6609 | 6023 | 5309 | 5662** |
| Rental | 285 | 264 | 250 | 250** |
| Total | 18167 | 16311 | 14589 | 11362 |

* Hydro availability based on 5 years average.
** Excludes 12% (as per actual 2007-08) Forced Outages for GENCOs and 6.0% (contractual) for IPPs and Rental. Rental subject to availability of gas.

**Source**: http://www.wapda.gov.pk/htmls/power-index.html

## Hydropower Potential of Pakistan

- Hydropower is the cheapest and cleanest renewable source of energy.
- Globally, there are over 11,000 hydroelectric power plants operating in 150 countries, contributing about 20% share to total energy-mix.
- Per unit cost of hydel electricity in Pakakistan is Rs 1.59 while oil-based per unit cost is Rs 18.
- The life-time of a hydropower station is b/w 40 to 80 years. Annual operational & maintenance cost is 1-4% of capital cost.
- Pakistan total hydropower resources have been estimated at 59,796 MW gross, out of which 41,045MW is considered exploitable potential.
- At present installed capacity for hydropower generation is only 6,792 MW or just over 11% of gross, or about 16% of exploitable resources, far from being realized.

# Hydropower Resources in Pakistan

| Province/ Territory | Projects in Operation (MW) | Projects Under Implementation | | | Solicited Sites (Projects with Feasibility Study Completed) (MW) | Projects with Raw Sites (MW) | Total Hydropower Resources (MW) |
|---|---|---|---|---|---|---|---|
| | | Public Sector (MW) | Private Sector (MW) | | | | |
| | | | Province Level | Federal Level | | | |
| Khyber Pukhtoonkhaw | 3849 | 9482 | 28 | 2370 | 77 | 8930 | 24736 |
| Gilgit Baltistan | 133 | 11876 | 40 | - | 534 | 8542 | 21125 |
| Punjab | 1689 | 720 | 308 | 720 | 3606 | 238 | 7291 |
| AJK | 1039 | 1231 | 92 | 3172 | 1 | 915 | 6450 |
| Sindh | - | - | - | - | 67 | 126 | 193 |
| Balochistan | - | - | - | - | 1 | - | 1 |
| Total | 6720 | 23309 | 468 | 6262 | 4286 | 18751 | 59796 |

- Most of the hydro power potential sites lie in the mountainous areas in northern region in the
  - **Khyber Pakhtunkhwa: 24736 MW**
  - **Gilgit-Baltistan: 21725 MW**
  - **Azad Jammu & Kashmir: 6450 MW**
  - **Punjab: 7291MW**
- Hydropower resources in the south are scarce; mainly comprise of small to medium schemes on barrages & canal falls.
- River wise identified hydro potential is:
  - **Indus 39717 MW Jhelum 5624 MW**
  - **Swat 1803 MWKunhar 1480 MW**
  - **Poonch 462 MW Kandiah 1006 MW**
  - **Others: 9704 MW**

**Hydropower Development**

- Hydropower development in the area now in Pakistan started in 1925, with the construction of the Renala 1 MW hydropower station. After a decade, the 1.7 MW Malakand-I hydropower station was built, which was later upgraded to a 20 MW capacity.
- At the time of creation of WAPDA in 1958, the country's total hydel potential capacity was enhanced to 119 MW. 240 MW Warsak was completed under the Colombo Plan in two phases (1960, 1980-81) and financed by the Canadian Govt.
- Under the IWT in 1960, 1000 MW Mangla and 3478 MW Tarbela Hydropower Projects were constructed.
- Hydropower Projects completed so far: 1450 MW Ghazi Barotha, 184 MW Chashma, 81 MW Malakand-III, 30 MW Jagran, 18 MW Naltar, 121 MW Allai Khwar, 130 MW Duber Khwar.
- Jinnah project (96MW) & Gomal Zam dam (about 18MW) are near completion. Raising of Mangla & 1410 MW Tarbela 4th ext is also underway.
- Currently, hydropower projects, of cumulative capacity of
  - 23309 MW are under implementation in the public sector
  - 6730 MW in private sector.
- Major big hydro projects: 4600 MW Diamer Bhasha, 3000 MW Dasu; 7000 MW Bunji- a run of the river project.
- Diamer Bhasha project would increase the share of hydropower in the electricity supply to almost 54 % from the current 33.6 % and drop thermal share to less than 15% from the current 35 %.

## Pakistan's Hydro Energy Policy

**Energy policy 1995,1998:**

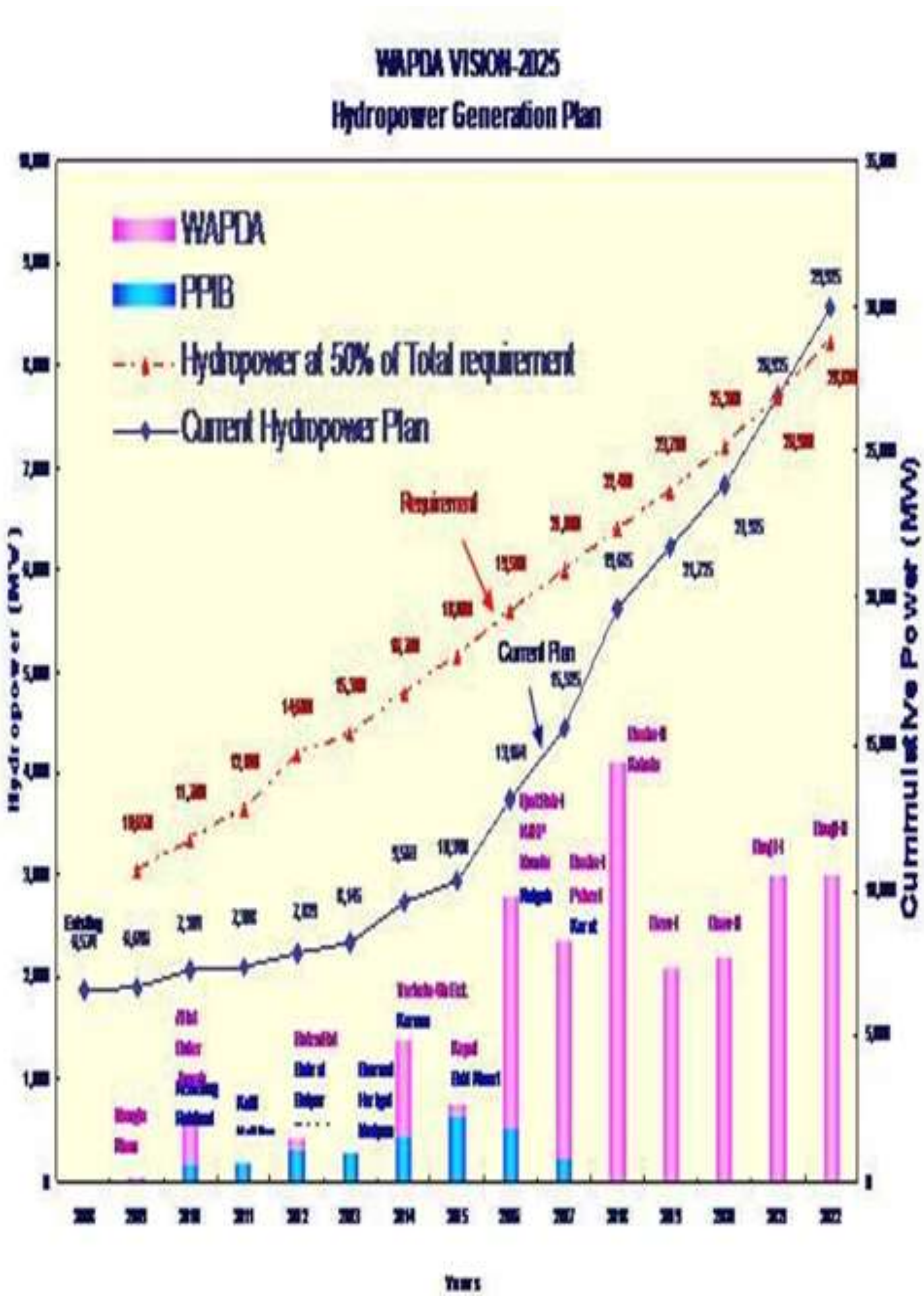
- Federal government launched a policy framework and package of incentives for private sector hydropower generation projects, but none of the projects could materialise.
- Led to the creation of Private Power and Infrastructure Board (PPIB), with the purpose to serve as a 'One Window' facilitator on the behalf of GOP and its entities.
- The 1994 and later, the 2002 power policy, did not discriminate on the fuel source being employed and made Pakistan hostage to fluctuations in international oil prices.

**Energy Policy 2002:**

- Offers maximum incentives and assurances that an investor can expect.
- WAPDA has prepared a 'Hydropower Development Plan --- Vision 2025' . Identified projects will be implemented by the public sector, private sector, or by public-private partnership

**Energy Policy 2006:**

- Reinforced private investment into power sector.
- After the completion of the identified projects the installed capacity would rise to around 42000 MW by the end of the year 2020.
- Wapda expects that in 2025, the country's hydel generation share may peak to 60% of the total power production.


WAPDA VISION-2025
Hydropower Generation Plan
WAPDA
PPIB
Hydropower at 50% of Total requirement
Current Hydropower Plan
Required
Current Plan
Hydropower (MW)
Cummulative Power (MW)
Years

## Challenges to Hydel Power Generation

- While there are many benefits, development of hydropower, projects pose numerous technical and economic challenges to the investor and developer.
- Infrastructural constraints: The projects are site-specific; sites located in far-flung, isolated and high-altitude areas lacking basic infrastructural facilities and connectivity to transmission network.
- Detailed studies of topography, hydrology, site geology and engineering geological conditions are required. Hydropower project thus involves high capital cost and long gestation period.

## Financial Constraints

- Financial constraints: Big hydro projects involve huge cost and delays further increase the cost manifold.
- Major water and power sector projects, which are in different stages of construction, need a total of Rs 1.67 trillion b/w 2014 and 2020. this require financing of over Rs 960 bn from int. lenders which is yet "un-committed".
- Cost of 4,500MW Diamer-Bhasha has gone up from $6.5 bn in 2005 to $12.5 bn in 2012 & now stands at $14. 5 bn. project originally est. to be completed by 2016-2017 is now expected to be delayed till 2023.
- The government has prepared a funding plan for Diamer-Bhasha with resources coming from external & internal sources.
    - ADB: $ 4 bn; USAID: $2 bn over eight years
    - Japan & EU : $1.5 bn; Islamic Development Bank: $ 1.5 Bn
    - GOP: $1.5 bn; WAPDA: $1 bn; PSDP: $ 1bn.

- 969 MW Neelum Jhelum (NJ) hydropower project is also facing serious financing problems and even finding it difficult to pay for the services being provided by foreign contractors.
- The estimated cost of the project has increased from the original Rs 84 bn to about Rs 275 bn as a result of change of its design after the earthquake, involvement of tunnel boring machine and overall project delays.
- Leading Pakistani industrialist and Entrepreneur Mian Muhammad Mansha has said that he is considering buying the Neelum-Jhelum Project.
- NJ is re-scheduled for commissioning by 2016.

## Environmental & Displacement Challenges

- Displacement and ecosystem integrity are emerging as big issues. Displacement caused by Terbela (about 96,000 people) and Mangla-raising dislocating 50,000 persons.
- Diamer-Bhasha dam would require resettling 24,000 people; and Akhori dam about 50,000 people.
- Climatic impact on hydel resources:
- Issue of sedimentation of big dams: The Indus & Jehlum Rivers carry a very high sediment load. Siltation has reduced the capacity of Terbela by 30% & Mangla. Warsak is almost completely silted up because of high rates of sedimentation in river Kabul. Presently, it is operating like a Run of River Project.

## Political Constraints

- Big dams, especially Kala Bagh dam have become politically unviable unless consensus is build around benefit sharing for all the stakeholders.
- Many in KP are opposed to future big dams in their area.
- Downstream, many in Sindh province believe that dams have reduced their access to Indus water and have organized to oppose further dam building.
- Diamir-Bhasha has evoked some local opposition. India is also lobbying against the dam & has tried to block ADB funding for the project saying it is located in the dispute territory.

## Inordinate Delays

- There was delay in completion of 15 run-of-river projects with a capacity of 1,258 MW scheduled to be commissioned by June 2007 has aggravated energy crisis.
- There has been delay in the completion of 1,848 MW Neelam-Jhelum and Chakothi-Hattian and Kohala projects on the Jhelum, which were scheduled to be commissioned in June 2010.
- If these projects have been completed, it would have had added 4,210 MW of cheap hydroelectricity in the system mitigating energy crisis.
- State Bank of Pakistan, in its Annual Report 2011-12 pointed out that the energy crisis 'reflects the lack of a coherent policy.'

## Run-of-the-River Hydel Projects

- Instead of fighting over construction of massive dams, Run-of-the-river hydel projects
- **7000 MW Bunji - a** run of the river project. Wapda has recently completed engineering design of Bunji.
- In KP out of 142 project identified sites, 19 projects are in operation, 27 sites are under implementation in the public sector, whereas 10 sites are under implementation in the private sector. Most of these are run-of-river sites, with small daily pondage for peaking.
- In AJK about 68 hydropower sites with a total potential of 6450 MW have been identified with high, medium and small heads. Out of these 68 hydropower sites, 9 projects with a capacity of 1039 MW are in operation, 23 sites are under implementation in the public sector and 22 sites in the private sector - many of them are run-of-river sites.
- In GB, about 278 projects sites with a total capacity of 21125 MW have been identified having high, medium and small heads. Out of these, 98 projects are in operation, 31 projects are being processed/implemented under the public sector through NAPWD and one in the private sector. Except Diamer-Basha (4500 MW), and Skardu dam, most of these sites are run-of-river.

## Public-Private Partnership

- KP government plan envisages the completion of 24 hydropower projects across the province to produce 2,100 MW of electricity over the next 10 years at a cost of Rs 330 bn under public and private partnership.
- Wapda and the KP government have decided to implement 665 MW - Lower Palas Valley and 496 MW Lower Spat Gah projects under Public-Private Partnership mode associating South Korean companies.
- Laraib Energy/New Bong Escape 97 MW is the first and sole IPP project, which is scheduled for commissioning this year
- WAPDA Chairman has said that more than 20 projects with cumulative power generation capacity of 20,000 MW and water storage capacity of about 12 MAF offer excellent investment opportunities to the foreign as well as local firms because of their high rate of returns.

## Conclusion

- Rebalancing in energy mix with increased focus on hydroelectric offers a way out of energy crisis.
- Run-of-the river projects should be prioritized as they are relatively cheaper, take less construction time and environment friendly.
- Public-private partnership in hydropower sector should be reinvigorated. This will help in raising financial resources for these projects.
- Political consensus on the big hydro projects should be developed.
- The formation of a single ministry in charge of the entire energy sector, the formulation of a long-term integrated policy and complete autonomy to regulators coupled with intense drive to increase public awareness about energy conservation offers a way out.

# POWER GENERATION FROM COAL

**Ejaz Ahmed Khan**

## Introduction

Energy plays an important role in industrial and economic growth of nations. Power production through furnace oil is costly and coal being cheaper, abundant and safe seems to be the prime candidate of energy production as it caters to over 40% of the world's power generation. Its reliance is increasing day by day specifically in developing countries. According to World Energy Outlook (WEO), future energy demand in emerging Asian countries will increase to 60% by 2020 as compared to 26% in 1980.

Pakistan faces a number of critical challenges in energy sector such as energy and power resource deficit, power shortages, and a greater dependency on imported oil to meet the energy demand-supply gap. Realizing these challenges, the governments of Sindh & Pakistan are focusing on the huge potential of developing indigenous coal resources on 'fast-track basis' and put coal based power as a major portion in overall energy mix.

Coal resources in Sindh, particularly Thar Coal forms an integral part of this planning. Development of Thar coal is focused to emerge through a partnership of government and the private sector, wherein the private sector would undertake long-term investment and the government would provide enabling environment through building institutional and physical infrastructure.

## Global Coal Based Power Generation Scenario

Coal is one of the world's most important sources of energy, fuelling almost 40% of electricity worldwide. In many countries, this figure is much higher: Poland relies on coal for over 94% of its electricity; South Africa for 92%; China for 77%; and Australia for 76%. Coal has been the world's fastest growing energy source in recent years — faster than gas, oil, nuclear, hydro and renewable sources.

## Power Generation Mix in Pakistan

The current energy supply matrix is a composite of various technologies. Oil and gas form the bulk of primary commercial energy supply mix of Pakistan, contributing in the following ratio: Oil 37%, Gas 30%, Coal 0.1%, Hydroelectricity 30% and Nuclear electricity: 1.8%.

Oil that is an extremely expensive mode of developing energy is depleted at a very rapid speed. Moreover, its import is a heavy burden on the exchequer. Its rate heavily fluctuates throughout the year and is being cartelized by the Organization for Economic Cooperation and Development (OECD) countries that make a windfall profit from its sale. It is clear that Pakistan needs to shift its paradigm from concentrating heavily on oil to indigenous resources.

## Case Study-Lignite Based Power Generation in India

Lignite mining all over the world is being carried out under complex hydro geological and geotechnical environments causing a range of problems affecting the production method and utilization of run-off mine coal. There are many practical examples of large lignite deposit developments in the world. Neyvelli lignite deposit in South India is among those with similar geological conditions at Thar Pakistan. There are no technical difficulties in developing this lignite field and producing lignite from a deep place.

The lignite seam in Neyvelli lignite deposit was first exposed in August 1961, and regular mining of lignite commenced in May 1962. Neyvelli Lignite Corporation Ltd. is producing approximately 2.4 million tons of lignite from four open cast pits, and feeds the lignite to mine-mouth power plants (Total capacity 2740 MW).

## Potential Benefits of Coal Based Power Generation

Large-scale development can provide considerable contribution to local economic development, including:

*Monetary Benefits*

The province (Sindh) will receive royalties (resource rent for the use of a non-renewable resource), local taxes, and licence fees (for renting the large areas of land to developers).

*Employment*

The development will generate direct employment, and indirect employment (providing works, services and products to the mine and power plants).

*Infrastructure*

The mine and power development will require infrastructure, such as roads, rail, water, power, communications networks, all of which will be shared under agreements with the local non-mine and non-power related uses.

*Social and Education*

Corporate Social Responsibility (CSR) of sponsors will require their direct participation, contribution and facilitation of activities that will assist local economic growth and development (from training and education to provision of health services).

## Efforts and Achievements of Government of Sindh to Make Thar Happen

The 'road map for the development of Pakistan coal reserve' needs to be built on recognizing coal as an integral part of future energy mix and devising strategy to develop it as 'core resource' in energy mix. This approach requires an enabling environment, which can be achieved by investing exclusively in building physical and institutional infrastructure. The government of Sindh has taken many initiatives and following benchmarks have been achieved to provide enabling environment:-

i. Thar Coal Projects declared as Projects of National Importance and development of Thar coal as a matter of national security.
ii. Creation of one window organization viz. TCEB having both federal and provincial governments sit together to facilitate collective decisions making regarding Thar Coal Development.
iii. Provision of Fiscal Incentive Package for attracting FDI to Thar-Thar Coal & Energy Board and ECC approved a comprehensive Incentive package.
iv. There is no customs duty on Coal Mining Machinery and Equipment and 20.5% IRR has been guaranteed by ECC to those projects, which achieve financial close before December 2014.
v. Promotion of Joint Venture Partnership in Coal Development has been introduced and bold initiative of entering into a unique joint venture agreement, with one of the largest industrial groups of the country, viz Engro Group for Thar Coal Development is one of the key proactive steps taken by the Government of Sindh.
vi. Detailed exploration and geological assessment of 12 Blocks measuring 1483 Sq Km with total lignite resources of more than 20 billion tons sufficient to meet power requirement of the country for next 100 years.
vii. Construction of Thar Airport to facilitate investors-Thar Coalfield is located 410 km away from nearest airport. Air port Construction works are in full swing and by December 2013 Thar Airport will be available to facilitate travel of local and foreign investors to coalfields and for transportation of light machinery and equipment.

viii. Improvement of Road Network leading to Thar Coal field for movement of heavy Mining Machinery- Government of Sindh has initiated the project for Improvement & Widening of Road Network from Seaport Karachi to Thar Coalfield Area via Thatta, Badin, up to Wango (Phase-I 200 KM) and Wango More to Thar Coalfield Area (Phase-II 134.86 km). The Project will be completed in 2014.

ix. Construction and successful operation of Reverse Osmosis Plants in Thar for supply of potable water to people of Thar Region-the Government of Sindh as part of infrastructure development undertook the task for providing long-term and economical solution of potable water to the inhabitants living near coalfield area of Thar Desert. Brackish/saline groundwater converted into potable water through sophisticated Reverse Osmosis (water desalination) technology. Government of Sindh has installed 110 RO plants in Tharparkar, Thatta, Badin, Umarkot areas catering the population of approx 850000 in four districts.

x. Construction of Thar Lodge-Keeping in view the requirements of decent accommodation for investors near Coal Mining site at Islamkot, the Government of Sindh has constructed a high standard accommodation facility by the name of Thar Lodge. Thar Lodge is consisting of five chalets each having two bed rooms and a main building having 10 rooms, drawing/dining hall, kitchen, dormitories, lobby, porch, mosque, garage and servant quarters.

## Conclusion

Thar Coal is gateway to the Energy Security for Pakistan. He illustrated his thesis in the following presentation slides:

# Outline of Presentation

- Introduction
- Global Coal Based Power Generation scenario
- Power Generation Mix in Pakistan
- Case study - Lignite based Power Generation in India
- Potential of Coal based Power Generation
- Efforts & achievements of Government of Sindh to make Thar happen
- Conclusion

# Energy Scenario

## Energy issues in Pakistan

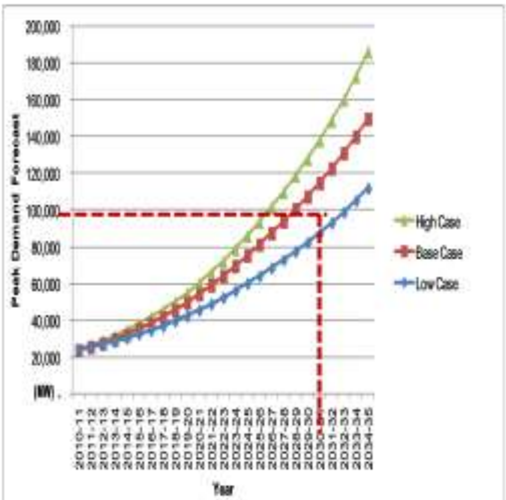
- Rising energy demand
- Significant energy shortage
- Energy Mix out of step with world norms
- Continuing long term trend of rising oil prices
- Natural gas demand exceeding supply mainly due to use by industry & transport sectors

## Desirable Scenario

- Should provide reliable and predictable supplies
- Should be more indigenous and less dependent on foreign supplies
- Should be cheap and affordable
- Should provide energy security

## Demand/Supply Scenario

- According to the power forecast by NTDC, the peak demand will be increased to 100,000 MW in 2028-2029 for the Base Case.
- Present Planned Power projects;
    - Hydro Projects - 5923 MW (Diamir Bhasha, Munda, Akhori & Kurran Tangi)
    - Thermal IPPs - 9053 MW (PPIB Planned Projections upto 2020)
- There is a clear need of exploitation of all possible Energy Sources




High Case 8.9% p.a.

Base Case 7.9% p.a.

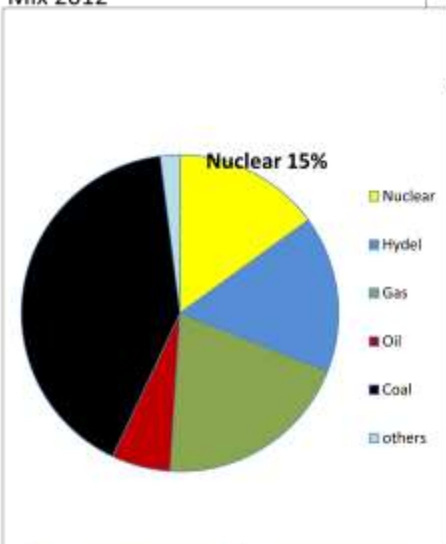
Low Case 6.7% p.a.

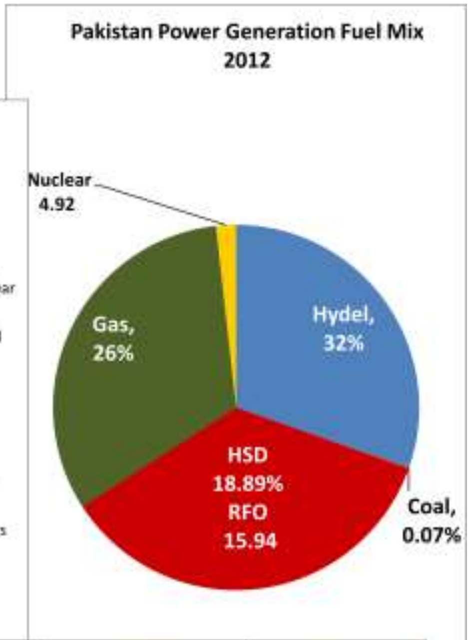
Source : JICA Survey Team prepared based on NPSEP (NTDC)Peak Demand Forecast for High, Base, and Low Case

# A Comparison of Power Generation fuel Mix

| World | Pakistan |
|---|---|

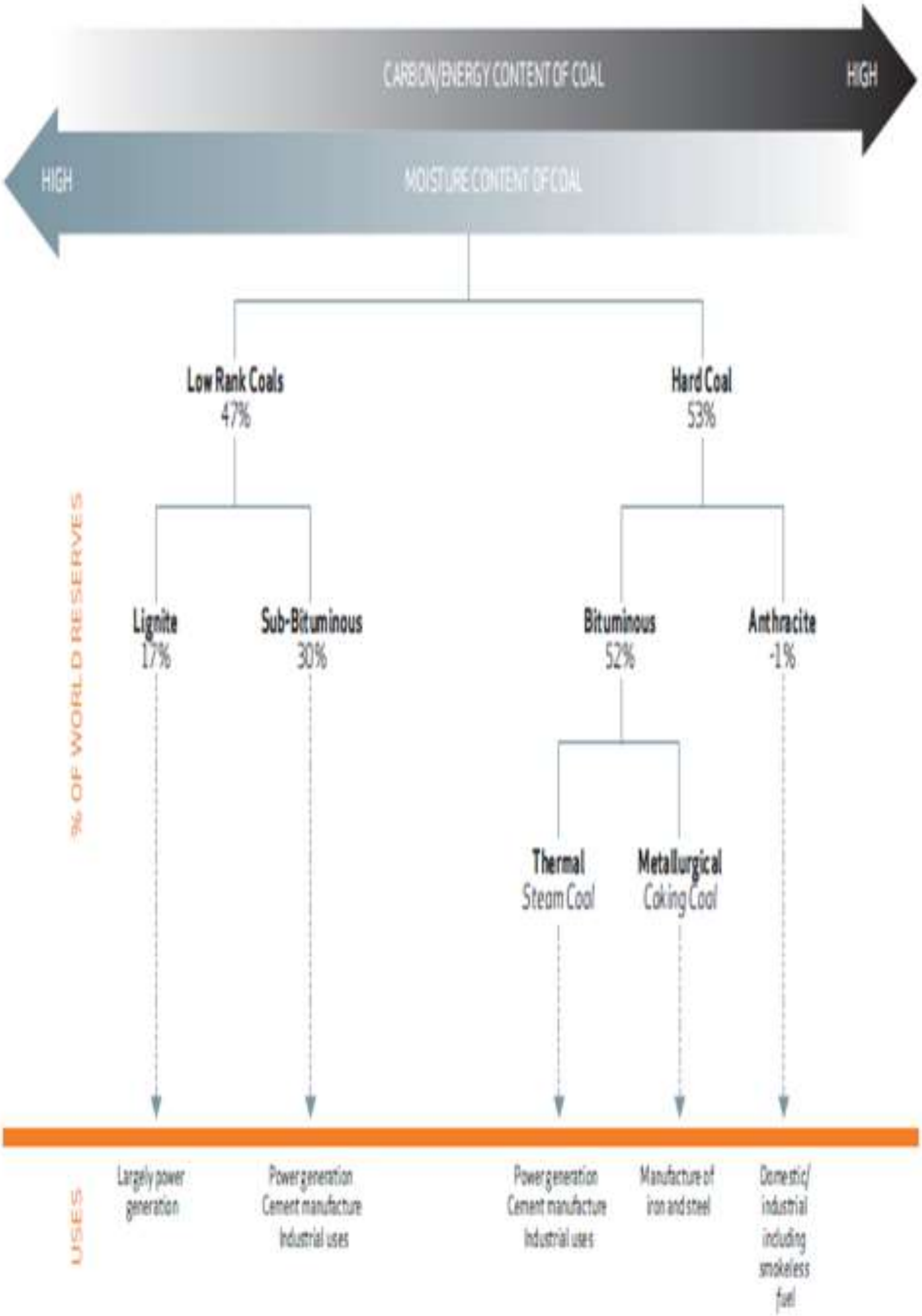
World Power Generation fuel Mix 2012



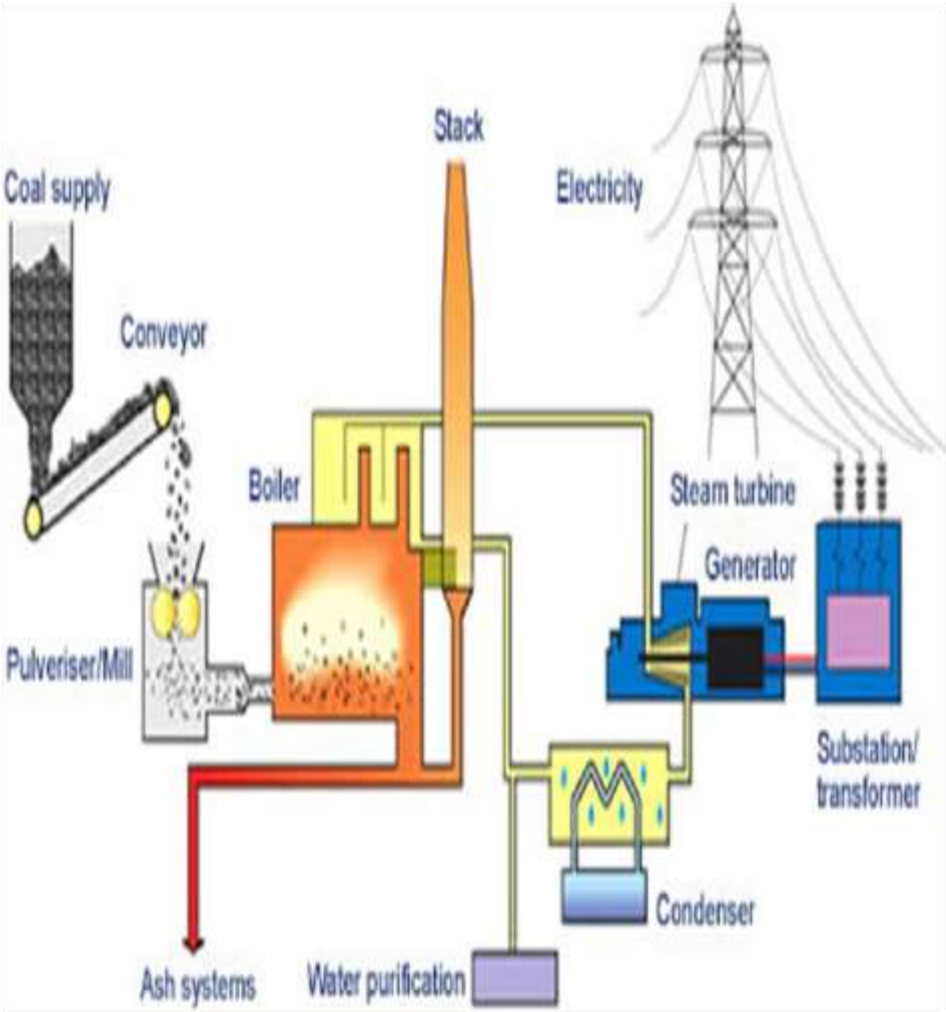

| Installed Capacity (MW) | Generation Available (MW) | Peak Demand (MW) | Gap (MW) |
|---|---|---|---|
| 23,578 | 13,733 | 20,058 | -6,325 |

# Types & Uses of Coal




Source: Coal Resources Overview - World Coal Association Publication

# How Coal is converted into Electricity




Source : http://www.worldcoal.org/coal/uses-of-coal/coal-electricity/

# Coal Used in Electricity Generation & Lignite Reserves

| | % age of Electricity Generated from Coal | Lignite produced 2011 |
|---|---|---|
| Poland | 90 | 63 Mt |
| China | 79 | 136 Mt |
| Australia | 76 | 69 Mt |
| India | 69 | 41 Mt |
| Greece | 55 | 59 Mt |
| USA | 49 | 74 Mt |
| Germany | 44 | 176 Mt |
| World average | 42 | 1.041 Bt |
| Pakistan | 0.1 | <5 Mt |

Thar Coal Resources are estimated at 175 billion tons and 12 explored Blocks alone carry proven reserves of 39 billion tons

Source: http://www.worldcoal.org/resources/coal-statistics/

# Global Lignite Quality Comparison

| Country | Moisture % | Ash % | Volatile Matter % | Sulphur % |
|---|---|---|---|---|
| Australia | 65.5 | 0.6 | 17.6 | 0.1 |
| Bosnia | 51 | 2.0 | 30.3 | 0.05 |
| Germany | 55 | 10 | 19.2 | 0.2 |
| Greece | 52 | 15.1 | 18.8 | 0.2 |
| India | 48 | 6.1 | 25.6 | 0.6 |
| Kosovo | 51 | 15 | 20.8 | <1.0 |
| Pakistan (Thar) | 46 | 7.0 | 28.0 | 0.7 - 1.1 |
| Poland | 52.8 | 9.8 | 20.0 | 0.6 |
| Serbia | 45.5 | 17.0 | 22.5 | 0.49 |
| Thailand | 30-35 | 10-28 | 32 | 0.8-1.5 |
| Turkey | 50 | 16 | 22.8 | 1.7 |

Source: World Coal Institute Report

# Power Generation from Lignite in India

- Neyveli lignite deposit in South India is among those with similar geological conditions of Thar deposits.
- There are no technical difficulties in developing this lignite field and producing lignite from a deep place.
- Discovered in 1961
- Mining commenced in 1962.
- Neyveli Lignite Corporation Ltd. is producing approximately 24 million tons of lignite from four open cast mines, and feeds the lignite to mine-mouth power plants (Total capacity 2,740 MW).


Source: JICA Report 2013

# Case Study - Comparison of Neyveli Lignite Mining

| | Thar Lignite Coalfield (Pakistan) | Neyveli Lignite Deposit (Southern India) |
|---|---|---|
| Overburden condition | Upper strata: dune sand 14 – 93 m (ave. 50 m) sand silt clay<br>Lower strata: Alluvial deposit 11 – 209 m (ave.150 m) sandsone. siltstone | Cuddalore sandstone 45 m to 103 m<br>(lateric-clayey very hard sandstone ) |
| Annual production | (Planned)<br>5.0 million tons (Block I),<br>6.5 million tons (Block II),<br>2.4 million tons (Block VI) | Mine I 10.5 million tons,<br>Mine I - A 3.0 million tons,<br>Mine II 15.0 million tons,<br>Barsingsar 2.1 million tons |
| Strip ratio | 6.6 : 1 (m3 : t) | 7.0 : 1 (m3 : t) |
| Quality coal rank | Lignite A to Lignite B | Lignite (no coal rank data) |
| Moisture (AR) | 46.77% | 53.00% |
| Ash (AR) | 6.24% | 3.00% |
| Volatile matter (AR) | 23.42% | 24.00% |
| Fixed carbon (AR) | 16.66% | 20.00% |
| Sulphur (AR) | 1.16% | 0.6% |
| Heating value (Ar.) | 5,774 Btu/lb (3,208 kcal/kg) | 2,400 kcal/kg |

Source: JICA Report 2013

# Thar Coal Potential

- Thar Desert contains the world's 7th largest coal resources:

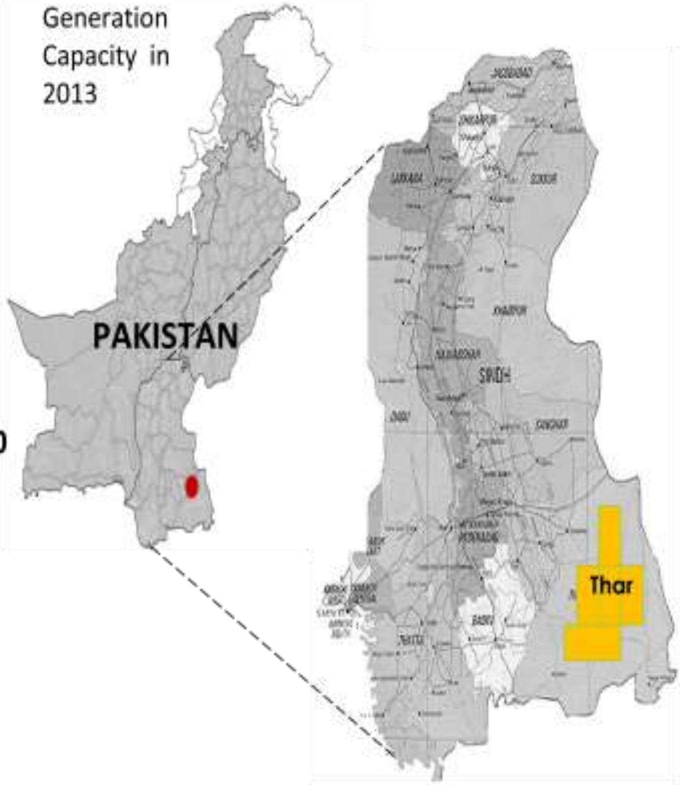
| | | |
|---|---|---|
| 175 Billion Ton<br>Total Thar Coal Resource | = 50 Billion TOE<br>More than Saudi Arabia & Iranian Oil Reserves | = 2000 TCF<br>68 times higher than Pakistan's total gas reserves |

1% = 25%

Thar Coal Resource

Pakistan's Power Generation Capacity in 2013

- Development of Block II alone would bring in investment of **10 Bn USD**
- Total potential of generating **100,000 MW** of electricity for over **200 years**

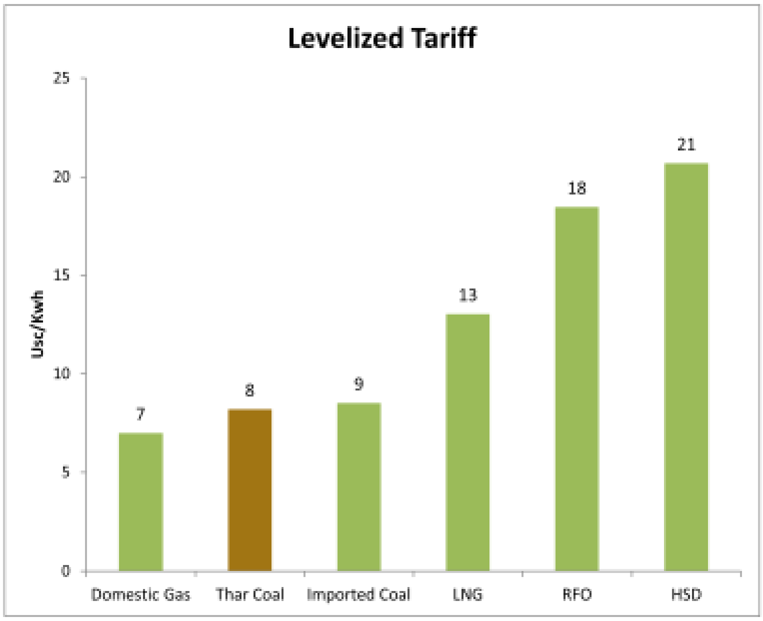



***Source: GSP data/report – Energy equivalent is based on Shenhua report/RWE***

# Thar Coal – the Ultimate Solution

## Bridging power generation gap via Thar

- For a mine size of 6.5 Mt/a an investment of USD 1 Bil is required, this capacity is sufficient to fuel 1200MW of Power Plants (investment of USD 1.7 Bil)
- With increasing mine size the power tariff will be lowered as coal price will be lower




Source: SECMC Feasibility report

**Paradigm Shift in Government Strategy :**
***"From Silent Spectator to Active Player"***

- Creation of Thar Coal and Energy Board - one stop organization
- Establishment of dedicated Coal & Energy Development Department
- Block allocation through international Competitive bidding process
- Block development to facilitate investors with authentic data on reserves
- Joint Venture Initiative: First Open Cast Mining Project ground breaking ceremony held on 14th March, 2013
- Excellent incentives, concessions & protections approved to promote Foreign Direct Investment to Thar
- Business friendly policies & environment in place

## Infrastructure Completed for Thar Coal

**Road Network**

- 70 tons load carrying capacity road is available up to Coalfield area.

**Communication**

- Telephone & Internet communication through Optic fiber cable is available up to Thar Coalfield area.

**Drinking Water**

- 110 Reverse Osmosis Plants in Thar are available for provision of potable water to the inhabitants of Thar as well as project staff free of cost.

**Thar Lodge**

- Thar Lodge at Islamkot with 20-bed accommodation to facilitate foreign and local investors has been constructed.

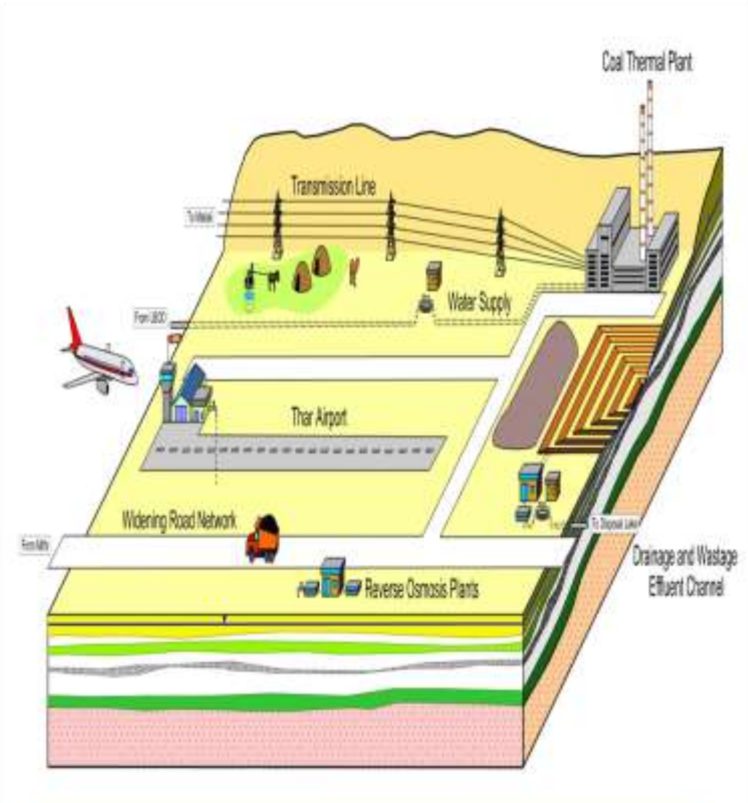
**Rescue Station**

- Rescue Station in coal mining area at Thar coalfield covering an area of 8,200 sq. ft. has been constructed.

**Library**

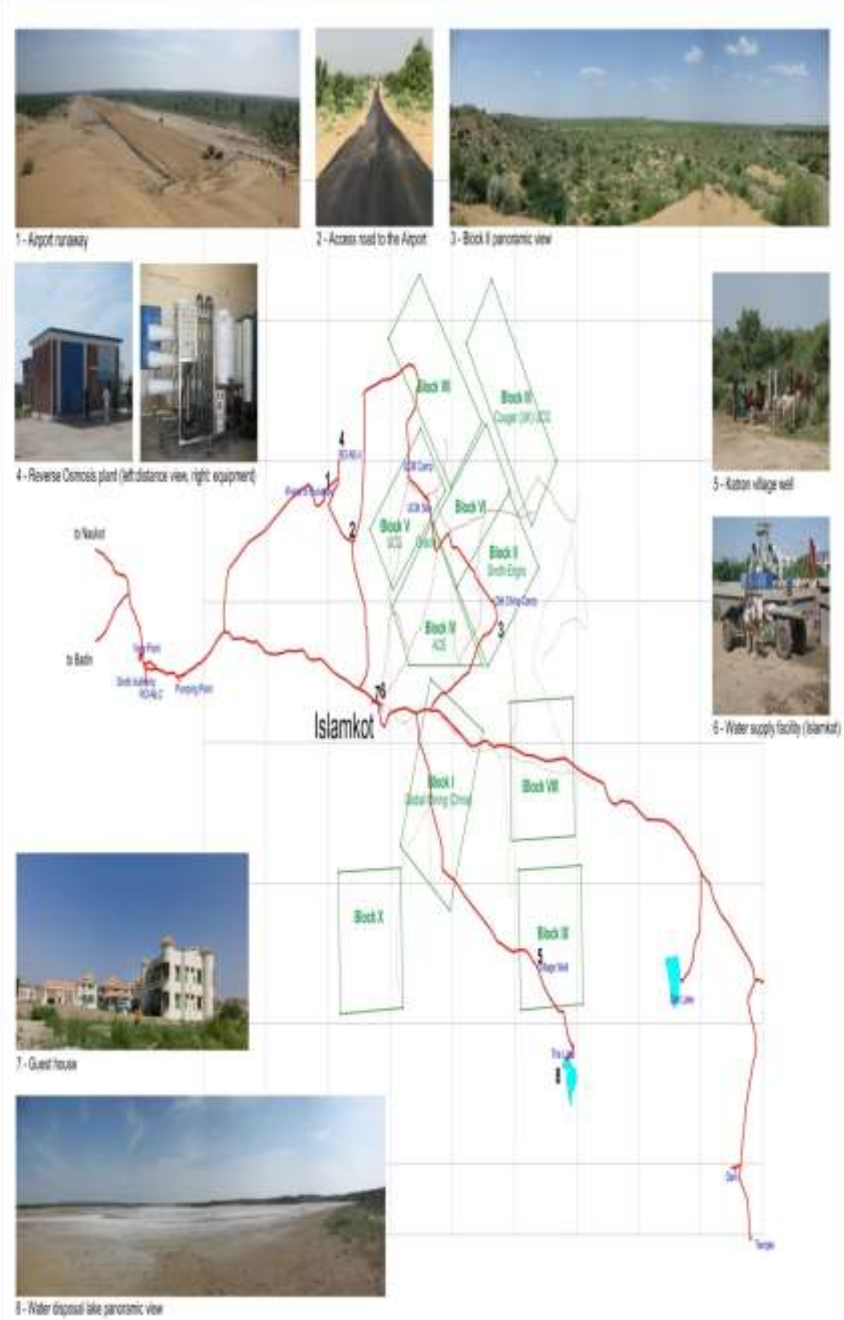
- A Coal library containing documents having relevant information on Thar Coal, is situated at office of Sindh Coal Authority.

## Infrastructures for Thar Coalfield




| Name of Scheme | Total Cost | 2012-13 Allocated |
|---|---|---|
| Improvement of Road | Rs 6.4 bn | Rs. 3.5 bn |
| Water Supply | Rs 9.1 bn | Rs. 3.0 bn |
| Mine Water Disposal | Rs 3.5 bn | Rs. 2.0 bn |
| Airport | Rs. 0.97 bn | Rs. 0.64 bn |
| Reverse Osmosis | Rs. 3,2 bn | Rs. 0.73 bn |

# Infrastructures Works in Progress



# Status of Mining & Power Projects at Thar Coalfield

| Thar Coal Blocks | Status/ Timelines |
|---|---|
| **Block-I**<br>**Global Mining Company of China**<br>Open cast Mining of 10 mtpa 900 MW<br>Coal supply to local thermal plants and cement industry | **Bankable Feasibility completed** — **March, 2012**<br>**Planned Coal Production** — **by 2015-16**<br>**Power Generation** — **by 2017-18** |
| **Block-II**<br>**Sindh Engro Coal Mining Company**<br>(JV: 51% GoS, 49% Engro)<br>Open cast mine of 6.5 mtpa & 600MW | **Bankable Feasibility completed** — **August 2010**<br>Project financing activity continued.<br>Sovereign Guarantees by GoP for Mining approved to facilitate lending by Chinese Financial Institutions<br>**Ground breaking ceremony held on 14th March 2013 to commence project activities on ground.**<br>Overburden removal to begin Jan 2014<br>Project plans to reach Coal seam in 3.5 years- 2017. |
| **Block-V**<br>**UCG Project**<br>Under Ground Coal Gasification Project<br>& Power Plant Planned | **36 bore holes have been drilled.**<br>Test Burn done in Dec. 2011 and Syn gas being produced.<br>Power Plant of 8-10 MW is being established |
| **Block-VI**<br>**Oracle Coalfields, PLC (UK)**<br>Open cast mine of 2.2 mtpa | **Detailed Feasibility Completed** — **April 2011**<br>Start of Mine development to begin by mid 2014<br>JDA signed with KESC for 300 MW |

## Potential Benefits of Success of First Project

- Reduction in Circular Debt through cheap electricity
- Development of indigenous mining industry
- 4000 direct/indirect jobs creation
- USD 165 M royalty over life of project
- Over USD 250 Million per annum saving in Forex vs. RFO import
- Energy Security – affordable Power
- Potential conversion of Coal to Gas, Oil & other Chemicals
- This Project can transform the Pakistan's Economy and bring in economic sustainability

## Conclusion & Way forward

**Where We Are:**

- Three Commercial Projects of Open-pit Mining are at take-off stage, struggling for financial close.
- One Pilot Project of UCG is at the execution stage.

**Main Bottlenecks:**

- Policies of International Lenders
- 'Circular Debt' issue

**What We Need:**

- Energy Policy – real and effective – based on energy security of the country and predictable outputs all year round
- Federal Government should finance Mining & Power Projects
- Early Conversion of plants from RFO to Coal with condition that the boiler design would be favorable to Thar Coal, as approved by the Prime Minister.
- Timely Completion of all infrastructure projects.


Block II in Thar Coalfield

# CHAPTER III

# LEGISLATION FOR ENERGY CONSERVATION

**Barrister Aemen Maluka**

## Context

In the case of Pakistan, the overall plan for energy independence has followed a disheveled path and this has severely affected our energy policy. Also, changing political regimes and competing, rather conflicting and contradicting political agendas have counteracted the intended effectiveness of tax credit and incentive programmes for energy efficiency.

This paper will hence, without an adnauseam, descriptive repetition of Pakistani law and policy, seek to comment upon the rather faulty and misinterpreted public sector's priorities in addressing the energy shortage. The author hopes to conclude at the end of this paper, based on these observations that Pakistan's energy conservation policy-makers and legislators, particularly those who are reviewing and constructing the regime for environmental taxation based on the very much-overrated Pigouvian taxation theory, need to take another look at the current legal framework that aims at promoting energy conservation. Also, it needs to be seen that Pigouvian taxes may not be the best solution for Pakistan's political and legal environment even though they may have, in the past, produced the desired results in many Western jurisdictions.

## Introduction

Till date, many tax credits and incentives as well as fines and taxes continue to be ineffective due to policy disruptions via political and executive inaction, nominal action, and competing policies. To elaborate upon this further it is important to discuss the general principles behind Pakistani environmental policy and the regulatory principles it rests upon, as a whole, especially with reference to the tax policy within Pakistan and its potential impact on social, economic, and consumer demand. There is also a need to discuss hybrid vehicles, alternative fuel vehicles, fuel cell vehicles, and fuel economy within the Pakistani tax and environmental agendas. Also, it appears and it may actually be the case, that current and proposed energy programmes and energy conservation legal policies of Pakistan are in blatant disregard of fundamental environmental and tax policy norms, which make them anything but effective. Truly, even though energy efficiency has risen to the top of the law and policy agenda in Pakistan, it has largely been a comedy of errors. The supporters of the Pigouvian tax measures, which would potentially 'stop' pollution and energy wastage, fail to understand the position in third-world countries, which, is plagued by rampant corruption in the energy sector, including the problem of electricity theft and abuse.

## The 'not-so' Enercon

Regarding Pakistan's current legal environment, in principle it can be agreed that conservation is more efficient than generation. The Pakistani regulatory response to the need to conserve energy was the establishment of the National Energy Conservation Centre (ENERCON), which was established in 1980s under US technical and financial assistance. Practically, the organisation cannot be said to have done the needful despite its well meaning efforts in the face of political pressure for balancing the financial and economic aspect and pressure has emerged over the last decade, and hence the private and public lack of interest even if not apathy towards the subject.

The Enercon Bill 2013 has some interesting upcoming provisions. Under the proposed bill a "Council" is to be established. The Bill states that the Council, or Provincial Government with the concurrence of the Council, may establish any suitable structure or mechanism for enforcement of this Act including energy efficiency standards, labeling, incentives, fines and other related requirements under this Act with effect from the date to be determined by the Council. What is the purpose of the Council under the Bill, one might ask? As per the Bill, "A Council to be known as the Pakistan Energy Conservation Council (PECC)" under the Energy Conservation Bill, 2013 "to provide for the establishment of institutions and enunciation of mechanisms and procedures so as to provide for effective conservation and efficient use of energy".

The Bill depicts that recent legislative efforts have been aimed at reorganizing ENERCON as a more visible organisation with presence in all the provinces and major cities. However, with the change of the current political regime, it is yet to be seen whether ENERCON will live up to its reputation of having at hand a much more strategic business plan with defined annual targets and achievements.

## Conceptual Discussion

The Pigouvian tax introduced in 1920 by A.C. Pigou was based on his treatise, namely "The Economics of Welfare"[1]. In theory this tax would be used to

[1] Pigou, Arthur C. *The Economics of Welfare* , London: Macmillan and Co. 1932, Library of Economics and Liberty [Online] available from http://www.econlib.org/library/NPDBooks/Pigou/pgEW.html; accessed 5 June 2013; Internet.

correct negative externalities like social costs such as crime and pollution, which arise as a result of consumption and production of a certain product. Of late, based on the suggestions in the Mirlees Review and other economic policy makers, the argument is often used to justify environmental taxation in the UK, as being based on the double dividend proposition of the Pigouvian tax.

There is a debate, however, whether environmental tax aimed at encouraging energy conservation, despite its social appeal, can justify on the basis of the 'double dividend' hypothesis. The double dividend hypothesis states that environmental taxes (which may be aimed at energy conservation as well as pollution prevention) 'aid' the environment and hence the society. At the same time, it is also believed that (at least in theory) they also allow other taxes on production and consumption to be reduced, hence bringing about a general relief for the public[2].

Looking at the example of the UK, the concept of environmental taxes has gained more popularity after suggestions from the Mirlees Review[3] that is, that there is a strong case for using taxes, charges and emissions trading schemes (rather than regulation) in the interests of cost efficiency. However, it is not just the Mirlees Review, which has supported the case for environmental taxation.

However, many critics of the Pigouvian tax especially for developing countries are of the opinion that such policies may not be completely conducive to attract foreign investment due to the rising costs of production, fuelled by extensive environmental taxes. Another view is that these measures are merely cosmetic and no solid results have been seen so far which would support the observation made by the supporters of the double dividend theory. Tax incentives and 'permits', which can be bought for careless abuse of energy and/or air pollution, are widely criticized for giving a clear license to pollute industries as well as acting as a tool of tax arbitrage.

While it has been convenient to mimic the Pigouvian tax concept from the West by our not so aware policy makers, the upcoming governments and their policy divisions will need to be aware of the fact that the measures they take now will, in the long term, affect the competitive balance of their economies as well as the future sustainable development of their local businesses.

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[2] Stern, Nicholas. 2006. The Economics of Climate Change. Cambridge: Cambridge University Press.

[3] Don Fullerton Andrew Leicester Stephen Smith, 'Paper written for the Mirrlees Review "Reforming the tax System for the 21st Century" March 2008'

## Much Ado about Nothing: Case of the Pigouvian Tax

In spirit, at least, there is nothing nobler than robbing the rich to give to the poor. The rich are not supposed to be 'evil tax evaders' but also the most likely group of consumers to guzzle public services. The policy makers then decided, 'Hey lets find a way out to punish the rich?" Lets place taxes on home electricity supply and lets give the wealthy industrialists a dose of load shedding . The result? The wealthy industrialist sent his capital abroad, uprooted his investment from here and lay off all the 'poor' employees who worked for him. At his home he installed a special Chinese generator, which runs pretty much everything including air conditioners. The rich man was never punished but the poorer got poor as the country-wide employment, misery and lack of electric supply suffered due to indecisive leaders who could not decide whether the Chinese were offering them a better deal or the Iranians.

Despite the hype given to the Pigouvian tax, modern economists and politicians have failed to understand that Arthur Cecil Pigou did not trust the government to improve human well being by attempting to use good taxes, subsidies, and regulation. Pigou supported Public Choice and rejected the notion that politicians, given constitutional constraints, would be capable of implementing an efficient and effective set of taxes and subsidies. His worst nightmares seem to confirm with the fact that once politicians are given a freehand to devise 'bonafide' tax, they would find themselves much more busy, writing loopholes for favoured interest groups and finding ways to generate evermore revenue[4].

Coming back to the so called rich man and industrialist due to whose tax pampering, dishonest tax declarations and evasions and electricity theft, Pakistan has now been left with third-rate public services. This does not, however, prevent the wealthy from developing inefficient private workarounds. Everyone in Pakistan knows that a generator is a source of noise -pollution and global warming. Every wealthy house pays up to 100,000 PKR or more for a generator, when it would make sense to invest those resources in the electrical grid and the generation of better quality hydel power. However, this is not the only thing we have dealt with in the most dysfunctional context, just like we have failed to address income inequality, climate change and maintain national infrastructure as priorities.

In Pakistan, during the last one decade, there has been a deeper decline of public services accompanied by the rise of private workarounds for the wealthy. The rich can pay for private security, gated communities and private schools, private health clubs and libraries. This mindset has not only been

[4] Samuelson P.A. 1954. "The Pure Theory of Public Expenditure," 36(4) Review of Economics and Statistics 387-389.

visible in North America but also in developing countries like Pakistan, where the feudal rich make do behind high walls topped with shards of glass preferring to throw their garbage on the gate rather than paying the council sweeper for picking the trash.

## Pigou's Misinterpretation and the Double Dividend

At least on paper, the Pakistani policy response has not lagged behind its other world counterparts in its initiatives to respond to these changes as evident from its current law and policy. The perceived concept of Pigouvian regulation itself has a defective basis. This is because there is a clear 'may' in the ability of economic instruments to achieve a given level of environmental protection at lower cost. For example, the tax incentive mechanisms simply provided incentives for polluters to choose the most cost-effective abatement mechanisms. A valid argument is that driven by economic incentives, many polluters may come up with innovative ways of avoiding pollution and hence have their tax liability reduced[5]. A counter argument is that tax evaders are more creative than inventors. Adopting the EU ETS (Emissions Trading Scheme) by allowing the polluters to 'buy' pollution permits, no such ultimate panacea has been created to avoid illegal waste dumping and Carbon Dioxide (C02) emissions. The environmental burden on the livelihoods of the poor, the health of the marine life and the damage to natural human habitats certainly do not have monetary figure, which can be placed upon them. The lacuna in the efficacy of taxation hence becomes much more wide when we actually look at whether the perceived quantification of the costs of pollution abatement is misleading or actually present a true picture[6].

## Conclusion

In terms of future Pakistani Energy Conservation Policy, coming to the mode and manner in which green or environmental taxation is designed, it is worth looking at whether a direct tax will address an ascertained quantification of the amount of pollution being charged for. Ideally then, the double dividend theory would demand that other types of consumption and production taxes supplement the environmental tax. The double dividend theory also envisages, arguably, that the increase in environmental taxes would be supplemented by a decrease in other taxes on food, clothing and educational services. This would be in theory, feasible at a point where distortions in the economy would be

5 Parry, Ian W.H., Margaret Walls, and Winston Harrington. 2007. Automobile Externalities and Policies Journal of Economic Literature, 45(2): 373–399.

6 Nordhaus , William. 2007. Critical Assumptions in the Stern Review on Climate Change. Science 317:201–202.

balanced as a result of the way the emphasis would shift on 'punishing' the polluter. In reality, however, experience has dictated otherwise, as environmental taxes tend to create their own distortions, especially by raising the price of goods, which may or may not be offset by reduced distortions elsewhere in the tax system. This is where the double-dividend theory fails to recognize that if the polluter or energy 'waster' pays, then so do the thousands of people he employs and/or has to fire due to high production costs. Many products and services connected or not directly connected to the taxed product will suffer. Hence such taxes would have a limited revenue potential, certainly not enough to offset with a possible income or capital tax decrease.

For a rational energy policy in the context of declining fossil fuels, limited electricity resources and huge external costs, Pakistan will have to acquire an implementation capability that combines policy shifts with significantly improved implementation capabilities. The Pigouvian tax potentially fails its purpose in accounting for these so-called external costs, whereas given the pollution numbers, the external cost in Pakistan will be far higher than the European and US estimates.■

# IMPACT OF 18TH AMENDMENT ON ENERGY GENERATION

**Advocate Ameena Sohail**

## Introduction

Energy is a vast subject as various sources of energy have been exploited by mankind since antiquity. Restricting ourselves to sources of energy specifically addressed under the Constitution of Pakistan, Oil & Gas and Electricity would be discussed as the critical sectors servicing the energy needs of the masses in Pakistan.

With reference to electricity, the sector has seen varying paths of handling in the sub-continent, mainly consistent with trends prevalent worldwide. The first legislation governing the sector is the Electricity Act, 1910 which recognized electricity as a supply business only and generation of power was part of the supply business exclusively regulated and managed by the provincial governments; continuing in the post-independence era as such, until WAPDA was created as a federal entity in 1958 and was allowed to run the distribution business as well. Under the current constitution of 1973, electricity was placed under the concurrent list of legislation, i.e., both federal and the provincial governments had the authority to legislate on electricity matter and in case of inconsistency between the two, the federal law was to prevail. Further a Council of Common Interests under Article 153 of the Constitution was established to supervise and control functions of institutions dealing with electricity.

The Eighteenth Amendment as one of its key features has abolished the concurrent list and electricity has been shifted to part II of the Federal Legislative List and all matters falling under this list would also be supervised and controlled by the Council of Common Interests, restructured with more robust structure and mandate to regulate items under Federal Legislative List, Part II. Apart from this, the state of the power sector has largely remained unaffected by the 18th Amendment.

The Oil & Gas Sector was exclusively dealt with by the federal government prior to 18th Amendment, apart from sharing of royalty and federal excise duty with provinces. However, the sole ownership of these resources in the name of federal government was now transformed into joint ownership of such assets with provinces. The joint ownership developed confusion among provinces about handling of exploration activities as well.

Constitutional developments under the 18th Amendment has been widely discussed by stakeholders including its significance as a positive step towards recognition of provincial stakes in the federation; however, serious reservations have also been raised with respect to lack of capacity of provinces to deal with enhanced responsibilities under the 18th Amendment. With respect to energy generation, since the main focus of 18th Amendment was enhanced provincial stakes and responsibilities, the economic aspects of the move and the possible negative impact on the development of energy sector were not anticipated. Continued efforts to harmonize newly perceived relations between the provinces and the federation on energy generation and their further development need to be pursued vigorously.

## Power Sector after 18th Amendment

"The federal government is considering ending the constitutional restriction of not allowing provinces and private sector to generate more than 50 MW without federal approval with the objective of enhancing generation capacity." Quoting from an article published last year, the misconception is highlighted to show a common perception about constitutional impairment of provinces to undertake power projects beyond 50 MW and removal of such embargo under 18th Amendment.[1] Annex 1 to this paper highlights constitutional provisions existing prior to 18th Amendment and change therein after this legal development.

The fundamental shift of abrogation of concurrent list also affected electricity but the same was moved to part II of the Federal Legislative List, thereby bringing it into the fold of Council of Common Interests (CCI), as earlier on as well, CCI had the supervision and control of institutions and policies dealing with electric power. However, to make the CCI assertive in discharge of its constitutional responsibilities, some amendments were also introduced in its composition and conduct, as would be discussed below. Provinces under Article 157 had the power and authority to perform the following functions and continue to enjoy the same in the post 18th Constitutional Amendment regime:

*(a)* *to the extent electricity is supplied to that Province from the national grid, required supply to be made in bulk for transmission and distribution, within Province;*
*(b)* *levy tax on consumption of electricity within the Province;*
*(c)* *construct power houses and grid stations and lay transmission lines for use within the Province ; and*
*(d)* *determine the tariff for distribution of electricity within the Province.*

The instant constitutional provision entitles the federal government as well *"to construct or cause to be constructed hydro-electric or thermal power installations or grid stations for the generation of electricity and lay or cause to be laid inter-provincial transmission line."* However, the federal government's entitlement was restricted

[1] "Power generation by provinces, private sector", *Business Recorder* July 16, 2012.

as per proviso to Article 161(1) thereby, *the federal government, prior to taking a decision to construct or cause to be constructed hydro-electric power station in any province, shall consult the provincial government concerned.*

**New-Council of Common Interests**

The Council of Common Interests first established under the 1956 constitution, was retained under the 1973 constitution. Chaired by the prime minister or by a federal minister on his/her behalf and comprised equal membership from the provinces and federal government. The CCI had jurisdiction over subjects under the federal legislative list and electricity, acting as a forum to seek provincial input in the conduct of federal responsibilities. However, the federal government never accorded due importance to this body, hence it remained dysfunctional for most of its existence until the 18th amendment attempted to remove this flaw. The CCI has since been reconstituted; it would have to be chaired by the prime minister and shall include four provincial chief ministers and three federal government nominees as members. The requirement to establish a permanent secretariat with compulsory meeting at least once every quarter are positive developments to invigorate this important constitutional body to foster federalism.[2] The CCI has been entrusted with decision making, monitoring, supervision, and control responsibilities over subjects under the Federal Legislative List Part II, accounting for some 18 subjects including electricity, natural gas and federal regulatory authorities.

CCI has also been provided the status of a conflict resolution forum under Article 157(3). While no significant impact upon electricity sector has occurred after 18th Amendment as the federal government had precedence over provinces in terms of pursuing power projects in all dimensions, however, by strengthening CCI, the affairs have been rebalanced between the federation and the provinces and its "proper working provides an opportunity to build trust and harmony in federal–provincial relations in Pakistan;"[3] an issue gravely faced by mega power projects particularly hydel. A similar situation seems to block development of renewable energy resources that were totally ignored while making these amendments; provinces currently are incapable of advancing their renewable energy projects and the federal facilitating agency, the Alternative Energy Development Board (AEDB) had extreme difficulty in pushing forward wind power projects in Sindh.

[2] Anwar Shah, 'The 18th Constitutional Amendment: Glue or Solvent for Nation Building and Citizenship in Pakistan?" *The Lahore Journal of Economics* 17 : SE (September 2012): pp. 387–424 ; 393

[3] *Ibid, pp. 405*

## Impact of $18^{th}$ Amendment on Oil & Gas Sector

Before the 18th Amendment natural resources, especially mineral oil and natural gas, being part of the Federal Legislative List, were exclusively owned and regulated by the federal government. Under Article 161 of the Constitution net proceeds of the federal duty of excise on natural gas levied at well-head as well as the royalty collected by the federal government, had to be paid to the province in which the well-head is situated. Under Article 158 of the Constitution, the province in which a well-head of natural gas is situated has precedence over other parts of Pakistan in meeting the requirements from the well-head subject to the commitments and obligations of the province producing the gas and other provinces and areas as on the commencing day i.e. 14 August, 1973 or an earlier date in accordance with a notification by the President (Art 265). The $18^{th}$ Amendment maintained its spirit of sharing powers with the federation, however, in case of oil and gas, it has been restricted to share of ownership, hitherto resting with the federal government. Article 172(3), a newly added provision under the $18^{th}$ Amendment, therefore provides,

> *"(3) Subject to the existing commitments and obligations, mineral oil and natural gas within the Province or the territorial waters adjacent thereto shall vest jointly and equally in that Province and the Federal Government."*

The concept of joint ownership of property, has tended to produce different views among the stakeholders and provinces approached the new arrangement as allowing them to share the legislative, regulatory, and policy control on the subjects. The controversy is mainly dedicated to heightened perceptions of the provinces in the backdrop of the spirit behind the $18^{th}$ Amendment. The progressive view among the industry legal experts however does not subscribe to sharing of regulatory, administrative functions etc., and holds the same to be separate functions, distinct from ownership or the right to title.[4]

The other development under the $18^{th}$ Amendment has been the sharing of profits/royalty of gas and hydro-electric power produced from resources located in a province.

> *"161. Natural gas and Hydro-electric power- (1) Notwithstanding the provisions of Article 78,*
>
> *(a) the net proceeds of the Federal duty of excise on natural gas levied at well-head and collected by the Federal Government and of the royalty collected by the Federal Government, shall not form, part of*

[4] M. Arif, "Impact of 18th Constitutional Amendment on Future of Exploration and Production Industry of Pakistan" *OGEL,* 4, no. 6 (December 2011)

*the Federal Consolidated Fund and shall be paid to the Province in which the well-head of natural gas is situated;*

*(b) the net proceeds of the Federal duty of excise on oil levied at well-head and collected by the Federal Government, shall not form part of the Federal Consolidated Fund and shall be paid to the Province in which the well-head of oil is situated."*

The 18th Amendment is also marked by the passage of the 7th National Finance Commission Award announced under President's Order of 2010 whereby in line with sharing of natural resources between provinces and federation, each of the province shall be paid in each financial year a share in the net proceeds of royalty on crude oil in an amount which bears to the total net proceeds in the same proportion as the production of crude oil in the province in that year bears to the total production of crude oil. Similarly payment of net proceeds of development surcharge on natural gas would have to be paid as well. This charge would be worked out on the basis of average rate per MMBTU of the respective province; such average rate being arrived at by nationally clubbing both the royalty on natural gas and development surcharge on gas. The royalty would be distributed in line with Article 161(1) of the Constitution and development surcharge on natural gas would be distributed by making adjustments based on this average rate.[5]

## Conclusions

The 18th Amendment touched upon electricity in a cursory manner. The ownership of natural energy resources with the provinces should have vested with the federation with sharing of dividends by the whole nation.[6] The current energy crisis can only be handled if a unified approach is adopted by the whole country, federation and provinces, together; under situations where provinces have huge liabilities to discharge against federal distribution companies, they need to come forward with utilization of national energy resources for power generation. The power sector reforms though were approved by the CCI in 1992, however, after a passage of more than 20 years, the power sector is in greater shamble than before. Hence, despite skepticism about newer roles, it is believed that unified attempts to manage the current crisis like re-casting of the Strategic Plan of 1992 by CCI is the need of the hour. In addition, a national pledge to remain steadfast to power reforms for

[5] Impact of 18th Constitutional Amendment on Federation – Province Relations, *PILDAT Briefing Paper* no. 39(July 2010):15

[6] Anwar Shah, "The 18th Constitutional Amendment: Glue or Solvent for Nation Building and Citizenship in Pakistan?" *The Lahore Journal of Economics* 17 : SE (September 2012): pp. 387–424 ; 406

an orderly transformation in line with the demands of the modern world. Similarly, harmony and undertaking of roles by both federation and provinces needs to be encouraged for exploitation of vast hydrocarbon resources of the country. The immediate impact of 18th Amendment on oil and gas sector appeared in the form of termination of tendering process for local exploration and production (E&P) of oil and gas resources. A well thought out and equitable mechanism for sharing of statutory receipts emanating from E&P between federation and the provinces is required. With declining foreign direct investment, such turbulence in the handling of E&P sector would increase investors' risk perceptions, thus calling for retention of existing regulatory framework with the legislative, policy and administrative control in the hand of the federal government, subject to participation by the provinces in the decision making process; however, this should not lead to delays in processing etc.

Now that the regulatory functions are under the supervision of the CCI, the unsatisfactory performance of these bodies need to be evaluated by this forum where both federation and provinces coordinate. Energy is an integrated sector and its handling by different bodies and ministries in Pakistan led to aggravate the crisis due to their uncoordinated moves. The 18th Amendment, thus enables us to structure our energy sector in an integrated manner.■

## Appendix I

| | Before Eighteenth Amendment | After Eighteenth Amendment |
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| Article 157 of the Constitution | **Electricity.**-(1) The Federal Government may in any province construct or cause to be constructed hydro-electric or thermal power installations or grid stations for the generation of electricity and lay or cause to be laid inter-Provincial transmission lines.<br>(2) The Government of a Province may-<br>(a) to the extent electricity is supplied to that Province from the national grid, require supply to be made in bulk for transmission and distribution, within the Province;<br>(b) levy tax on consumption of electricity within the Province;<br>(c) construct power houses and grid stations and lay transmission lines for use within the Province; and<br>(d) determine the tariff for distribution of electricity within the Province. | Electricity.-(1) The Federal Government may in any province construct or cause to be constructed hydro-electric or thermal power installations or grid stations for the generation of electricity and lay or cause to be laid inter-Provincial transmission lines [*Provided that the Federal Government, prior to taking a decision to construct or cause to be constructed hydro-electric power station in any province, shall consult the Provincial Government concerned.*]2<br>(2) The Government of a Province may-<br>(a) to the extent electricity is supplied to that Province from the national grid, require supply to be made in bulk for transmission and distribution, within the Province;<br>(b) levy tax on consumption of electricity within the Province;<br>(c) construct power houses and grid stations and lay transmission lines for use within the Province; and<br>(d) determine the tariff for distribution of electricity within the Province.<br>[*(3) In case of any dispute between the Federal Government and a Provincial Government in respect of any matter under this Article, any of the said* |

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| | | *Governments may move the Council of common interested for resolution of the dispute.]* *2<br>*1 For full stop at the end a colon has been substituted and thereafter a Provision has been inserted by section 58 of the Constitution (Eighteenth Amendment) Act, 2010 (Act No. X of 2010)<br>2* Clause (3) has been added by section 58 of the Constitution Eighteenth Amendment) Act, 2010 (Act No. X of 2010) |
| **Federal Legislative List** | Electricity not included and existed under the concurrent legislative list which was abolished under 18th Amendment | Electricity shifted to its part II.<br>PART II<br>1. Railways.<br>2. Mineral oil and natural gas; liquids and substances declared by Federal law to be dangerously inflammable.<br>3. Development of industries, where development under Federal control is declared by Federal law to be expedient in the public interest; institutions, establishments, bodies and corporations administered or managed by the Federal Government immediately before the Commencing day, including the Pakistan Water and Power Development Authority and the Pakistan Industrial Development Corporation; all undertakings, projects and schemes of such institutions, establishments, bodies and corporations, industries, projects and undertakings owned wholly or partially by the Federation or by a corporation set up by the Federation.<br>[4. Electricity. |

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| | | 5. Major ports, that is to say, the declaration and delimitation of such ports, and the constitution and powers of port authorities therein.<br>6. All regulatory authorities established under a Federal law.<br>7. National planning and national economic coordination including planning and coordination of scientific and technological research.<br>8. Supervision and management of public debt.<br>9. Census.<br>10. Extension of the powers and jurisdiction of members of a police force belonging to any Province to any area in another Province, but not so as to enable the police of one Province to exercise powers and jurisdiction in another Province without the consent of the Government of that Province; extension of the powers and jurisdiction of members of a police force belonging to any Province to railway areas outside that Province.<br>11. Legal, medical and other professions.<br>12. Standards in institutions for higher education and research, scientific and technical institutions.<br>13. Inter-provincial matters and co-ordination.]<br>13. Council of Common Interests.<br>14. Fees in respect of any of the matters in this Part but not including fees taken in any court.<br>15. Offences against laws with respect to any of the matters in this Parts.<br>16. Inquiries and statistics for the purposes of any of the matters in this Part. |

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| | | 17. Matters incidental or ancillary to any matter enumerated in this Part. |
| **Concurrent Legislative List** | Concurrent Legislative List<br><br>Concurrent Legislative List and the entries thereto from 1 to 47 omitted by the Constitution (Eighteenth Amendment) Act 10 of 2010.<br>1. Criminal law, including all matters included in the Pakistan Penal Code on the commencing day, but excluding offences against laws with respect to any of the matters specified in the Federal Legislative List and excluding the use of naval, military and air forces in aid of civil power.<br>2. Criminal procedure, including all matters included in the Code of Criminal Procedure, on the commencing day.<br>3. Civil procedure, including the law of limitation and all matters included in the Code of Civil Procedure on the commencing day, the recovery in a Province or the Federal Capital of claims in respect of taxes and other public demands, including arrears of land revenue and sums recoverable as such, arising outside that Province.<br>4. Evidence and oath; recognition of laws, public | Abolished (Effect: Anything falling out of Federal Legislative list was under provincial legislative power) |

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| | acts and records of judicial proceedings.<br>5. Marriage and divorce; infants and minors; adoption.<br>6. Wills, intestacy and succession, save as regards agricultural land.<br>7. Bankruptcy and insolvency, administrators-general and official trustees.<br>8. Arbitration.<br>9. Contracts, including partnership, agency, contracts of carriage, and other special forms of contracts, but not including contracts relating to agricultural land.<br>10. Trusts and trustees.<br>11. Transfer of property other than agriculture land, registration of deeds and documents.<br>12. Actionable wrongs, save in so far as included in laws with respect to any of the matters specified in the Federal Legislative List.<br>13. Removal of prisoners and accused persons from one Province to another Province.<br>14. Preventive detention for reasons connected with the maintenance of public order, or the maintenance of supplies and services essential to the community; persons subjected to such detention. | |

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| | 15. Persons subjected to preventive detention under Federal authority.<br>16. Measures to combat certain offences committed in connection with matters concerning the Federal and Provincial Governments and the establishment of a police force for that purpose.<br>17. Arms, firearms and ammunition.<br>18. Explosives.<br>19. Opium, so far as regards cultivation and manufacture.<br>20. Drugs and medicines.<br>21. Poisons and dangerous drugs.<br>22. Prevention of the extension from one Province to another of infectious or contagious diseases or pests affecting men, animals or plants.<br>23. Mental illness and mental retardation, including places for the reception or treatment of the mentally ill and mentally retarded.<br>24. Environmental pollution and ecology.<br>25. Population planning and social welfare.<br>26. Welfare of labour; conditions of labour, provident funds; employer's liability and workmen's compensation, health insurance including invalidity pensions, old age pensions.<br>27. Trade unions; industrial and labour disputes. | |

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| | 28. The setting up and carrying on of labour exchanges, employment information bureaus and training establishments.<br>29. Boilers.<br>30. Regulation of labour and safety in mines, factories and oil- fields.<br>31. Unemployment insurance.<br>32. Shipping and navigation on inland waterways as regards mechanically propelled vessels, and the rule of the road on such waterways; carriage of passengers and goods on inland waterways.<br>33. Mechanically propelled vehicles.<br>34. Electricity.<br>35. Newspapers, books and printing presses.<br>36. Evacuee property.<br>37. Ancient and historical monuments, archaeological sites and remains.<br>38. Curriculum, syllabus, planning, policy, centers of excellence and standards of education.<br>39. Islamic education.<br>40. Zakat.<br>41. Production, censorship and exhibition of cinematograph films.<br>42. Tourism.<br>43. Legal medical and other professions. | |

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| | 43(A) Auqaf.<br>44. Fees in respect of any of the matters in this List, but not including fees taken in any court.<br>45. Inquiries and statistics for the purpose of any of the matters in this List.<br>46. Offences against laws with respect to any of the matters in this List; jurisdiction and powers of all courts except the Supreme Court, with respect to any of the matters in this List.<br>47. Matters incidental or ancillary to any matter enumerated in this List.<br>Electricity existed under this List | |
| **Provinces** | Electricity was under their shared domain with federal legislature but as long as consistent with Federal Legislation | No Power except all that is provided under Article 157 with in the province. |
| **Electricity Act, 1910** | Usage (Works, Land acquisition, safety) under provincial domain, Electricity Duty on usage of electricity. Electric Inspectors (Provincial Offices of Inspection under NEPRA Act) to check safety aspects and determine disputes between consumers and discos. | Usage and safety standards enforcement needs to be taken care of after losing legislative powers. Office of Electric Inspectors needs to be housed under an appropriate body/independent body of provincial govts. Safe usage of electricity can be dealt with under the jurisdiction of provinces to govern environmental issues as shifted solely to provinces under 18th Amendment. Electricity Duty under constitutional power of Article 157(2)(b) need to be addressed, earlier enforced through Electricity Rules/Finance Act. |

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| **Strategic Plan** | A plan of the federal govt. for restructuring of federal entity WAPDA for eventual privatization passed in 1992 by the Council of Common Interests.<br>Detailed restructuring of the sector being implemented as per PM directive dated 1998. | Reconciliation needed particularly in terms of efforts to enforce uniform tariff with regulation etc. |
| **Council of Common Interests** | Council of Common Interests.– (1) There shall be a Council of Common Interests, in this Chapter referred to as the Council, to be appointed by the President.<br>(2) The Council shall consist of –<br>(a) the Chief Ministers of the Provinces; and<br>(b) three members from the Federal Government to be nominated by the Prime Minister from time to time.]<br>(3) The Prime Minister, if he is a member of the Council, shall be the Chairman of the Council but, if at any time he is not a member, the President may nominate a Federal Minister who is a member of the Council to be its Chairman.<br>(4) The Council shall be responsible to [Majlis-e- | Council of Common Interests.– (1) There shall be a Council of Common Interests, in this Chapter referred to as the Council, to be appointed by the President.<br>[(2) The Council shall consist of –<br>(a) the Prime Minister who shall be the Chairman of the Council;<br>(b) the Chief Ministers of the Provinces; and<br>(c) three members from the Federal Government to be nominated by the Prime Minister from time to time.]<br>(3) Omitted.<br>(4) The Council shall be responsible to Majlis-e-Shoora (Parliament) [and shall submit an Annual Report to both House of Majlis-e-Shoora (Parliament)]. |

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| | Shoora (Parliament)] | |
| **WAPDA Act** | Federal Statute, Amended as per CCI decision to implement Strategic Plan | No effect |
| **NEPRA Act** | Federal Law for regulating the generation, transmission and distribution of electric power as per the decision of the CCI – 1997- Providing for a body (NEPRA) with equal representation from all provinces, as per the legal spirit in pre-18th Amendment era. Section 45 provided an over riding effect to NEPRA Act, rules and regulations made thereunder over all laws inconsistent therewith. Hence as an *eclipse affect* NEPRA continued to develop its rules and regulations necessary to carry out its powers and functions. Electricity Act also came under this effect and slowly and gradually, NEPRA applicable documents covered all aspects of Electricity Act except usage (an explicit domain of provincial govt.) works and acquisition by its licensees (provincial domain again) and criminal aspect of theft of power. Electric Inspectorate was changed into Provincial Offices of Inspection. | Provincial Offices of Inspection to be institutionalized after 18th Amendment. For purposes of executing works, acquisition by NEPRA licencees can be made effective by introducing appropriate amendments in NEPRA Act as per Article 147 & 152 of the Constitution (Power of the Province to entrust functions to the Federation & Acquisition of land for Federal purposes resp.) Similarly, theft of electricity can be covered through Pakistan Penal Code. |

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| **154. Functions and rules of procedure** | 154. Functions and rules of procedure.–<br>(1) The Council shall formulate and regulate policies in relation to matters in Part II of the Federal Legislative List and shall exercise supervision and control over related institutions.<br>(2) The decisions of Council shall be expressed in terms of opinion of the majority.<br>(3) Until Majlis-e-Shoora (Parliament) makes provision by law in this behalf, the Council may make its rules of procedure.<br>(4) Majlis-e-Shoora (Parliament)] in joint sitting may from time to time by resolution issue directions through the Federal Government to the Council.<br>(5) If the Federal Government or a Provincial Government is dissatisfied with a decision of the Council, it may refer the matter to Majlis-e-Shoora (Parliament) in a joint sitting whose decision in this behalf shall be final. | 154. Functions and rules of procedure.–<br>(1) The Council shall formulate and regulate policies in relation to matters in Part II of the Federal Legislative List and shall exercise supervision and control over related institutions.]<br>(2) The Council shall be constituted within thirty days of the Prime Minister taking oath of office.<br>(3) The Council shall have a permanent Secretariat and shall meet at least once in ninety days:<br>Provided that the Prime Minister may convene a meeting on the request of a Province on an urgent matter.]<br>(4) The decisions of the Council shall be expressed in terms of the opinion of the majority.<br>(5) Until Majlis-e-Shoora (Parliament) makes provision by law in this behalf, the Council may make its rules of procedure.<br>(6) Majlis-e-Shoora (Parliament)] in joint sitting may from time to time by resolution issue directions through the Federal Government to the Council.<br>(7) If the Federal Government or a Provincial Government is dissatisfied with a decision of the council, it may refer the matter to Majlis-e-Shoora (Parliament) in a joint sitting whose decision in this behalf shall be final. |

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| **Electricity** | 157. Electricity.– (1) The Federal Government may in any Province construct or cause to be constructed hydro-electric or thermal power installations or grid stations for the generation of electricity and lay or cause to be laid inter-provincial transmission lines:<br>(2) The Government of a Province may-<br>(a) to the extent electricity is supplied to that Province from the national grid, require supply to be made in bulk for transmission and distribution within the Province:<br>(b) levy tax on consumption of electricity within the Province;<br>(c) construct power houses and grid stations and lay transmission lines for use within the Province; and<br>(d) determine the tariff for distribution of electricity within the Province. | 157. Electricity.– (1) The Federal Government may in any Province construct or cause to be constructed hydro-electric or thermal power installations or grid stations for the generation of electricity and lay or cause to be laid inter-provincial transmission lines:<br>[Provided that the Federal Government, prior to taking a decision to construct or cause to be constructed, hydro-electric power stations in any Province, shall consult the Provincial Government concerned.; and]<br>(2) The Government of a Province may-<br>(a) to the extent electricity is supplied to that Province from the national grid, require supply to be made in bulk for transmission and distribution within the Province:<br>(b) levy tax on consumption of electricity within the Province;<br>(c) construct power houses and grid stations and lay transmission lines for use within the Province; and<br>(d) determine the tariff for distribution of electricity within the Province.<br>[(3) In case of any dispute between the Federal Government and a Provincial Government in respect of any matter under this Article, any of the said Governments may move the Council of Common Interests for resolution of the dispute.] |

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| **Natural Gas and Hydro-electric Power** | 161. Natural gas and hydro-electric power.– <br>(1) Notwithstanding the provisions of Article 78 the net proceeds of the Federal duty of excise on natural gas levied at well-head and collected by the Federal Government and of the royalty collected by the Federal Government, shall not form part of the Federal Consolidated Fund and shall be paid to the Province in which the well-head of natural gas is situated; <br>(2) The net profits earned by the Federal Government, or any undertaking established or administered by the Federal Government from the bulk generation of power at a hydro-electric station shall be paid to the Province in which the hydro-electric station is situated. <br>Explanation- For the purposes of this clause "net profits" shall be computed by deducting from the revenues accruing from the bulk supply of power from the bus-bars of a hydro-electric station at a rate to be determined by the Council of Common Interests, the operating expenses of the station, which shall include any sums payable as taxes, duties, interest or return on investment, and depreciations and element of obsolescence, and | 161. Natural gas and hydro-electric power.– <br>[(1) Notwithstanding the <br>provisions of Article 78,- <br>(a) the net proceeds of the Federal duty of excise on natural gas levied at well-head and collected by the Federal Government <br>and of the royalty collected by the Federal Government, shall not form part of the Federal Consolidated Fund and shall be paid to the Province in which the well-head of natural gas is situated; <br>(b) the net proceeds of the Federal duty of excise on oil levied at well-head and collected by the Federal Government, shall not form part of the Federal Consolidated Fund and shall be paid to the Province in which the well-head of oil is situated.] <br>(2) The net profits earned by the Federal Government, or any Undertaking established or administered by the Federal Government from the bulk generation of power at a hydro-electric station shall be paid to the Province in which the hydro-electric station is situated. <br>Explanation- For the purposes of this clause "net profits" shall be computed by deducting from the revenues accruing from the bulk supply of power from the bus-bars of a hydro-electric station at a rate to be determined by the Council of Common Interests, the operating expenses of the station, which shall include any sums payable as taxes, duties, interest or return on investment, and depreciations and element of obsolescence, and over-heads, and provision for reserves. |

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| | over-heads, and provision for reserves. | |
| **Ownerless property** | 172. Ownerless property.– (1) Any property which has no rightful owner shall, if located in a Province, vest in the Government of that Province, and in every other case, in the Federal Government.<br>(2) All lands, minerals and other things of value within the continental shelf or underlying the ocean within the territorial waters of Pakistan shall vest in the Federal Government. | 172. Ownerless property.– (1) Any property which has no rightful owner shall, if located in a Province, vest in the Government of that Province, and in every other case, in the Federal Government.<br>(2) All lands, minerals and other things of value within the continental shelf or underlying the ocean [beyond] the territorial waters of Pakistan shall vest in the Federal Government.<br>[(3) Subject to the existing commitments and obligations, mineral oil and natural gas within the Province or the territorial waters adjacent thereto shall vest jointly and equally in that Province and the Federal Government.] |

# Diplomacy and International Dimension of Energy Management

**Dr. Nazir Hussain**

Pakistan is facing serious energy crisis which is likely to aggravate in the coming years. The under-production, inefficiency, mismanagement and lack of a coherent national energy policy severely undermine Pakistan's ability to cope up with the challenging situation. However, there are a few internal and external options which can be utilised to address its short-term energy needs and formulate long-term energy requirements.

There are four trans-regional pipeline options; Overland Iran-Pakistan (IP) Gas-Pipeline, Overland Turkmenistan, Afghanistan, Pakistan, India (TAPI) Gas-Pipeline, Underwater Qatar-Pakistan Gas-Pipeline, and Imported Liquefied Natural Gas (LNG) through the sea. However, each option is studded with multiple challenges; the US opposition to IP, Afghan security issue with TAPI, expensive cost of Qatar-Pakistan pipeline, and heavy cost of LNG import. However, in order to overcome the immediate energy crisis and put Pakistan onto the road of progress and development, all four options need to be utilised. This requires international cooperation and effective Pakistani diplomacy. Therefore, this paper endeavours to analyse the external options available to Pakistan and a proactive diplomacy to utilize these through regional and international cooperation.

## Pakistan's Energy Scenario

Pakistan's electricity demands were mainly met through hydel production as the country was blessed with abundant water resources and the two major dams built in early 1960s i.e. Terbela and Mangla. Despite massive industrialization and urbanization, the country was self-sufficient in its energy demands. Importantly, in 1999 Pakistan had 1000MW surplus electricity that was being considered to be exported to India. However, the unplanned growth of industry and massive use of gas for commercial and transport purposes led to over-reliance on gas. Subsequently, the electricity generation was also converted to thermal, which increased the production cost of electricity being met through government subsidies. In the absence of a national energy policy, the demand and supply gap continued to increase with no substantial alternatives. Political controversies over building of new dams, massive reliance of industry on gas, un-planned growth of CNG for transport, and substantial theft/line losses led to the massive demand-supply gap.

According to national and international sources, Pakistan's total energy consumption stood at over 63 million metric tons of oil equivalent (MMOE) in 2010-11. Out of which share of gas was 43.9 %, oil 27.9%, electricity 15.6%, coal 11%, and LPG 1.5%. The major consumption source of natural gas witnessed an increase of 7.7% during 2009-10 compared to 2004-05. This created an imbalance energy mix with heavy reliance on gas; 47.5% and oil 30.5% (72% imported). The POL and fuel oil import bill was about US$ 12 billion in 2010-2011. This is projected to rise to US$30 billion by 2015, and US$ 45-50 billion by 2020.[1]

Energy demand over the next 15 years is expected to grow to 122.46 MMTOE by the year 2021-22. That means Pakistan's total primary energy demand is expected to increase from 62.9 MMTOEs in 2008 to 122.46 MMTOE in 2022. Domestic energy resources, which supplied 43 MMTOE in 2007-08 are expected to produce 88 MMTOE by 2021-22. That means 34 MMTOE has to be imported. Even if Pakistan maintains 'business as usual' attitude, it will face a large and growing energy shortfall during the next 15 years.[2]

Due to large transmission and distribution of gas in Pakistan, natural gas will continue to play a major role in Pakistan's energy mix. Demand growth for natural gas is over 6% per annum. The most likely supply/demand scenario shows a demand gap of around 700 MMcf/d in 2010, growing to 1,400 MMcf/d by 2012. Pakistan is highly reliant on gas which constitutes over 34 per cent of the resources used for electricity generation. This high reliance on gas has created a significant gap between supply and demand. There is a natural gas shortage of 1,000 to 1,500 MMcf/d which is further resulting into an electricity shortage of 5000 to 6000 MW in the current scenario. Pakistan is facing a daily shortfall of over 400mcf of gas, which is projected to increase to 4bcf by 2025.[3]

This has resulted in massive electricity and gas load shedding which has not just hampered the everyday life of Pakistani citizens but has also severely affected economic growth and political stability. The US Energy Information Administration states that in 2007 Pakistan's natural gas reserves were around 28,000 billion cubic feet could last for twenty years.[4] However, with the reliance on gas skyrocketing, many experts believe that the country's reserves will be exhausted much sooner. A new estimate suggests that the indigenous

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1 *Economic Survey 2010-11,* Islamabad: Govt. of Pakistan, 2011.

2 Munawar B. Ahmed, "Perspectives on Pakistan's Energy Crisis" presentation given at a National Conference on 'Electric Power Deficit' at the Institute of Electrical & Electronics Engineers, Pakistan (IEEEP) at Islamabad in October 2011.

3 'Integrated Energy Plan 2009-2022' Report of the Energy Expert Group, Islamabad: Economic Advisory Council, Ministry of Finance, Govt. of Pakistan, March 2009.

4 The US Energy Information Administration 2010, available at www.eia.org

gas reserves are expected to deplete by 2020 and high reliance on imported gas is projected in the near future.[5]

## Available Options and Challenges

In order to meet the massive demand of energy, a coherent national energy policy is required that should cover effective management, short to long term planning, tapping of additional local energy sources, building of new dams and fast-track working on regional pipelines. In the outside energy sources, IP gas pipeline, TAPI gas pipeline, Pak-Qatar gas pipeline project and import of LNG are considered to be available options for Pakistan.

**Two Proposed Pipelines in South Asia**


Map I • B 2139 heritage.org

## Iran-Pakistan Gas Pipeline

Though the idea of supplying Iranian gas to South Asia was first floated in 1989, the Iran-Pakistan-India (IPI) pipeline agreement was formally signed in 2008. In the 2008 pipeline plan agreed by the three countries, IPI was proposed to start from Asaluyeh, South Pars, stretching over 1,100 km in Iran itself before entering Pakistan and travelling through Khuzdar, with one section of it going to Karachi on the Arabian Sea coast, and the main section travelling to Multan. From Multan, the pipeline was to travel to Delhi where it would end. IPI was to initially have a capacity to deliver roughly 22 billion cubic metres per year which was to evolve to a maximum of 55 billion cubic metres. Iran would initially transfer 30 mcm (750mcf) of gas per day to Pakistan but would increase to 60mcm per day. It would be for 25 years and the supply would begin by December 2014.[6]

[5]' Integrated Energy Plan 2009-2022' Report of the Energy Expert Group, Islamabad: Economic Advisory Council, Ministry of Finance, Govt. of Pakistan, March 2009.

[6] See Noor-ul-Haq, 'Iran-Pakistan Peace Pipeline' *IPRI Factfile,* July 2010.

However, in March 2010, when the Iranian and Pakistani authorities met to sign a final agreement in Ankara, India backed out, presumably under the US pressure and also its own distrust on Pakistan. Hence from IPI it has become Iran-Pakistan (IP) pipeline. Furthermore, the cost for pipeline initially calculated at US$ 4 billion in 1995, is now around US$ 7.6 billion. Under the 'Sovereign Agreement' the pipeline should be operational in 2014 and Pakistan would be required to pay a penalty equal to the cost of 750 MMcf/d of gas if it fails to receive gas by the agreed date. Moreover, Islamabad has agreed to extend the guarantees to Tehran that it will ensure unhindered gas supply to any third party, if it wishes to become part of the IP gas pipeline project at a later stage.[7]

Iran, crippled by the sanctions in place and fearing further sanctions, is desperate for the IP pipeline to be completed. As Iranian oil exports are expected to decrease across the globe it is looking at the IP as an economic lifeline to sustain its economic survival. During India's involvement it had even suggested that the pipeline be extended up to Bangladesh and further to China. Pakistan's primary benefit from the Iran-Pakistan pipeline is to utilize gas it very desperately needs for domestic and industrial use and power generation. The construction of pipeline will also create job opportunities in backward areas of Balochistan and Sindh. Iran is also interested to build an oil refinery at Gwadar at a cost of US$ 4 billion with a capacity of 400,000 bpd.[8] Other than the economic benefits for Pakistan, the most significant benefits, however, can be achieved if the IP becomes IPC i.e. the Iran-Pakistan-China pipeline.

Pakistan, however, is facing certain problems that it needs to address. The US has already threatened Pakistan with sanctions, which was also evident as some Pakistani firms refused to be part of the financial consultancy for the project. Moreover, there exists Baloch animosity over any Pakistani mega project which does not involve the province. However, in June 2006, Balochistan Assembly passed a resolution seeking royalty for the province, Baloch representation in the IP talks, free gas for adjacent population and 100 % job share.[9]

The South Pars/North Dome field is a natural gas condensate field located in the Persian Gulf. It is the world's largest gas field, shared between Iran and Qatar. According to the International Energy Agency, the field holds an estimated 50.97 trillion cubic meters (1800 trillion cubic feet) of in situ gas and some 50 billion barrels of condensates. This gas field covers an area of 9700 square km, of which 3700 square km (South Pars) is in Iranian territorial

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[7] Ibid.

[8] Khaleeq Kiani, 'Iran to setup US$ 4 bn oil refinery in Gwadar' *Dawn,* February 21, 2013.

[9] Sanaullah Baloch, 'The Baloch Perspective,' *News International,* March 20, 2013.

waters and 6000 square km (North Dome) is in Qatari territorial waters.[10] Therefore, the proposed pipeline project would allow Pakistan to generate additional 4000MW of electricity at cheaper rate. It will also restore the 2,232MW of idle thermal power generation capacity with the diversion of about 406 MMcf/d, leaving 344 MMcf/d for industrial and domestic use. Importantly, Pakistan would pay US$ 3 billion a year to Iran but it would reduce its oil imports by US$ 5.3 billion, resulting in a net reduction in oil imports by around US$ 2.3 billion.[11]

## Trans-Asia/TAPI Gas Pipeline

The Trans-Asia or Turkmenistan, Afghanistan, Pakistan, India Gas Pipeline project was signed between the respective governments in 2002 and 2006 to transport the Turkmenistan gas to the South Asian region via Afghanistan. However, the project dates back to mid-1990s, when the US oil giant UNOCAL conceived a plan to tap the Central Asian energy through South West Asia. An Argentinian Oil giant; the BRIDAS was also working on the same lines and put plans to the Afghan warlords and Pakistani government to lay the proposed trans-Asia gas pipeline. The commercial competition between the UNOCAL and BRIDAS resulted into an open conflict between the two and ultimately ending the project as a result of the rise of Taliban and subsequently the 9/11 episode and war on terror.[12]

Nonetheless, the trans-Asia pipeline project was rejuvenated by the signing of agreements between Turkmenistan, Afghanistan and Pakistan in May 2002 and December 2002 at Ashgabat. Later, the Indian government also joined the project in 2006, thus formalizing the Turkmenistan, Afghanistan, Pakistan and India (TAPI) Gas Pipeline Project. Importantly, the Asian Development Bank (ADB) provided US$ 100 million for the feasibility of the proposed project.[13]

The TAPI is 1,680 km pipeline, emanating from Turkmenistan's Dulatabad (4th largest in the world with 16 trillion cubic meters) gas field, would cover 145 km in Turkmenistan, 735 km in Afghanistan, 800 km in Pakistan and enter into India. The projected US$ 7.6 billion pipeline would run through Dulatabad, Herat, Kandhar, Quetta, Multan to Fazilka and would

[10] Daniel Canty, 'Field Focus: Iran's South Pars Development' *Arabian Oil and Gas,* May 29, 2011, available at www.arabianoilandgas.com

[11] Farooq Tirmizi, 'Analysis: Iran-Pakistan pipeline a mutually convenient political stunt,' *Express Tribune,* March 13, 2013.

[12] See for details, Lutz Kleveman, *The New Great Game: Blood and Oil in Central Asia*, (New York: Grove Press), 2003, and Ahmed Rashid, *Taliban: Militant Islam, Oil and Fundamentalism in Central Asia,* (New York: I.B. Tauris), 2009.

[13] John Foster, 'Afghanistan, the TAPI Pipeline and Energy Geopolitics' *Journal of Energy Security,* March 2010.

supply 90 MMCMD, out of which 38 MMCMD each would be utilized by Pakistan and India and remaining 14 MMCMD by Afghanistan.[14] The project was to be initiated in 2013 with 2017-18 as completion/operational date. However, in March 2012, Afghan government stated that it is only interested in transit fee and not in gas supplies.[15]

The proposed TAPI project is expected to generate 5-6,000 MW of electricity for energy-starved Pakistan, besides earning transit fee from India. The project would not only substantially reduce Pakistan's energy demands but could also become an important economic dynamic for bridging Indo-Pakistan rivalry in South West Asia, especially in Afghanistan. Moreover, by opening the TAPI route, Turkmenistan can become an important Eurasian natural gas hub and opening potential revenue stream. Afghanistan would get an estimated US$ 300 million transit fee annually and additionally it would be a source of employment and economic activity, a much needed source of economic stability for Afghanistan. Pakistan would meet its growing energy demands besides earning huge transit revenue from gas supplies to India.[16]

Despite TAPI's economic potential and commercial viability, the project faces a number of challenges. Unlike the Iran-Pakistan Gas Pipeline, the US is in favour of the project and India is a willing partner. However, it is the Russian Federation that is opposed to the project mainly because it would like to transport the Turkmenistan gas to Europe through its own territory thus keeping a check on the Central Asian energy resources, besides benefiting economically.[17] Another important bottleneck is the instability and insecurity in Afghanistan, which is likely to aggravate after 2014, in the post-withdrawal period. Moreover, the project is still being considered as a 'pipedream' as the project has not yet been started.

## Gulf-South Asia/Pak-Qatar Gas Pipeline

The idea to import gas through an offshore pipeline from Qatar was initiated in 1990s, when the Crescent Petroleum International, a Sharja-based company, proposed the Gulf-South Asia (GUSA) gas pipeline and was interested to finance it too. However, the project was delayed due to various reasons and ultimately, in July 2000, the two governments signed a MOU to operationalize the gas pipeline project. The Crescent Petroleum has carried out a detailed

[14] Tridvesh Sing Maini and Manish Vaid, 'Roadblocks remain to TAPI pipeline construction' *Oil and Gas Journal,* March 4, 2013.

[15] Zafar Bhutta, 'Energy needs: Russia may be awarded IP contract by April' *Express Tribune,* Islamabad, March 29, 2012.

[16] Tridvesh Sing Maini and Manish Vaid, 'Roadblocks remain to TAPI pipeline construction' *Oil and Gas Journal,* March 4, 2013.

[17] Nikita Mendkovich, "The TAPI pipeline and Russia's Gas Policy," *New Eastern Outlook*, November 2010.

survey route of the pipeline with a cost of US$ 4 million. The engineering design of the proposed project is performed by the Brown & Root Company of the US.[18]

The GUSA proposed pipeline is 1,186 km with an estimated cost of US$ 1.88 billion that would supply 1,600 MMSCF/D to Pakistan. The pipeline would start from Qatari gas field and would pass through Diba-UAE, where an intermediate compressor station would be built and ultimately reaching Pakistan at Jiwani, near Gwadar.[19]

Importantly, the proposed pipeline is blessed with the US approval as its company is technically involved, besides the Qatari company ready to finance the project. However, the proposed project is costly due to its underwater route. It is estimated that an offshore pipeline has twice the cost of an overland pipeline. Therefore, the project is still on the paper, and no substantial progress is being witnessed.

## Liquefied Natural Gas (LNG)

Yet another option being considered is to import LNG from Qatar to Pakistan with potential to include China and India at later stage. In 2005, the governments of Qatar and Pakistan agreed to cooperate in Gas Pipeline Project and LNG import with Qatari technical assistance and investment. A projected private deal of US$ 25 billion LNG import form Qatar was struck off by the Supreme Court of Pakistan after which the government decided to buy LNG on government-to-government basis. In 2012, the two governments signed a MOU for the import of LNG. Pakistan showed its keen interest to import 500 million cubic feet of LNG per day that can produce 2,500 MW of electricity.[20] The deal was stuck up due to pricing of the LNG as Qatar demanded US$ 18 per Million British Thermal Unit (MBTU), however after the IP gas pipeline deal, the Qatari government agreed to reduce the price to US$ 13-14 MBTU.[21] Pakistan was contemplating to construct the technical facilities at Port Qasim near Karachi but no progress has been seen since 2012.

However, natural gas transported through overland or undersea pipeline in its natural state or as LNG in oil tankers is a costly affair. For LNG transportation, the capital outlay would include an expenditure of US$ 2 billion for a liquefaction plant, over US$ 200 million for each LNG tanker and over

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[18] Noor-ul-Haq, 'Gas Pipeline Projects in South Asia' *IPRI Factfile,* August 2005.

[19] 'Musharraf will discuss gas pipeline with Qatar' *Daily Times,* August 9, 2005.

[20] 'Pakistan, Qatar reach agreement for importing 500 million cfpd of LNG' *Express Tribune,* February 7, 2012.

[21] 'Qatar willing to sell 2 million tonnes LNG below $18/MMBTU' *Daily Times,* March 13, 2013.

US$ 500 million for re-gasification plant.[22] Pakistan would be unable to meet this cost at its own until Qatari government or international investors join in.

## The Proposed Pipeline Projects

| Project | Cost | Intl Support | Challenge | Status |
|---|---|---|---|---|
| IP | US$ 7.6 b | No | US | 75% Complete |
| TAPI | US$ 7-10 b | Yes | Afghan Security | On Paper |
| GUSA | US$ 1.88 b | Yes | Cost Factor | On Paper |
| LNG | NA | Yes | Cost Factor | On Paper |

## International Cooperation and Diplomacy

Out of the four external options available to Pakistan, only the IP gas pipeline project is without the regional/international cooperation. In the remaining three options, financial support, investment opportunities and international cooperation are available. Therefore, Pakistan has bright chances to fast track the available options by involving other regional/international stackholders but that requires a proactive diplomacy.

In the case of IP project, initially India was also involved and China and Bangladesh were also being considered as potential consumers to join in. It should be noted that with increasing interest from China, Pakistan has the potential and the opportunity to become a transit corridor of energy for China through the deep-water seaport, Gwadar. The port of Gwadar built by China, is proposed to be connected to a pipeline that would go up north through the Karakoram Highway (KKH) to China's Uighur autonomous region of Xinjiang. Even before the pipeline is constructed the transportation network from Gwadar to KKH is established enough to transport energy supplies to Xinjiang. Gwadar is also a way for China to reduce its dependence on the Malacca Straits, which it terms as becoming increasingly dangerous.[23] Moreover, Iran is already exporting gas to other regional consumers, which are not under the US sanctions. It exports about 6-9 BCMA to Turkey via a 2,500 KM pipeline connecting the two countries since 1996. Iran also exports 1 BCMA gas to Armenia, and in turn imports electricity. Iran and Armenia are in negotiations to gradually increase the volume to 2.3 BCMA. Also Iran has designated a 'clean' private company, Tadbir Energy Company, which is not

[22] International Energy Agency, *World Energy Investment Outlook: 2003 Insight,* Paris, International Energy Agency, 2003.

[23] Zahid Anwar, 'Gawadar Deep Sea Port's Emergence as Regional Trade and Transportation Hub: Prospects and Problems' *Journal of Political Studies,* vol.1, Issue 2/vol.17, Issue 2, Winter 2010.

under the US sanctions.[24] Therefore, Pakistan has the bright opportunity to build its case for the IP completion. As the US has plans of withdrawing from Afghanistan in 2014, it needs the support and assistance of Pakistan. Pakistan should capitalize this scenario and convince the US to support the project. This poses a great challenge to Pakistan's effective diplomacy which needs to be proactive to put Pakistan back on the path of progress and prosperity by overcoming its energy requirements.

## Conclusion

It is ironic that ideas to have trans-regional energy pipelines were initiated in early 1990s but no concrete effort was made to realize these. Now, that Pakistan is starving due to energy shortfall regional pipelines are being given consideration after wasting two decades.

However, in order to meet its growing energy demands, Pakistan has many options but it is argued that a land-based pipeline would be much cheaper than any other available option. Therefore, the first and foremost priority should be to work on the overland pipelines like IP and TAPI, and later to also include GUSA and LNG. It is important to mention that the IP is 75% completed and is set to be operationalized by December 2014.

By operationalizing these regional pipelines, Pakistan can serve as an Energy Corridor in the region as China and India are likely to join the projects in future. The import of gas form Iran has a strategic importance for the region. Once the US pressure is eased, India facing energy crunch may change its mind and re-join the project. This would put the two arch-rivals in an economic interdependence that would be beneficial for both the countries. Pakistan can also become a conduit for bridging the Gulf energy to China, gaining significant economic benefits to Pakistan. As Iran has announced plans to build a 400,000 barrel-per-day oil refinery at Gwadar, ensuring energy supplies to China, even if the Straits of Hormuz gets closed. Therefore, in the medium to long term policy projection, Pakistan should consider to utilize all options available incorporating the concerns of all stackholders and involving the regional and trans-regional investors.■

[24] See Noor-ul-Haq, 'Iran-Pakistan Peace Pipeline' *IPRI Factfile,* July 2010.

# ROLE OF UNIVERSITIES AND THINK TANKS IN ENERGY CONSERVATION IN PAKISTAN

**Muhammad Mustansar Billah Hussain**

## Introduction

From antiquity to industrial age and now at the threshold of a smart age, the role of energy has been pivotal in human life and its transformative evolutions. With the increased usage of energy, fast expanding global populations, dwindling energy resources of the day, conservation has become an important factor in energy security equation, globally. Energy conservation is basically reducing energy consumption through different means including judicious use of energy, efficiency enhancement, and curtailing the need for energy.

Pakistan is undergoing severe energy shortages for couple of years, which have affected social, economic and political life in the country. There have been drives to tackle this menace, mostly though increasing electricity generation capacity in the country. However, Pakistan's power sector problem is greater than mere generation capacity. Pakistan's energy supply mix,[1] inability to provide adequate fuels for thermal power plants, corruption in the power sector, and inefficient use of energy also contribute to the problem. Solution to these problems lies in different concerted efforts made over a long period of time, which requires financial capacity as well as sustained political will. Energy conservation, however, provides the country with an option to reduce power shortages and reduce expenditure for energy fuel purchasing. This money could be invested in making energy use particularly electricity usage more efficient though replacement of older systems with new efficient ones.

This paper considers important question that why energy conservation is important for Pakistan? In order to make conservation meaningful, the paper also looks into consumption trends in Pakistan and discusses conservation potential in different sectors of consumption. Then, it addresses the main question that what role could Pakistani universities and think tanks play in conservation of energy.

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[1] According to *Pakistan Energy Yearbook 2012*, out of total 64,727 thousand tonnes of oil equivalent primary energy supply, natural gas' share was 32,033 thousand tonnes of oil equivalent and crude oil/petroleum products/LPG's share was 20,280 thousand tonnes of oil equivalent.

## Importance of Energy Conservation for Pakistan

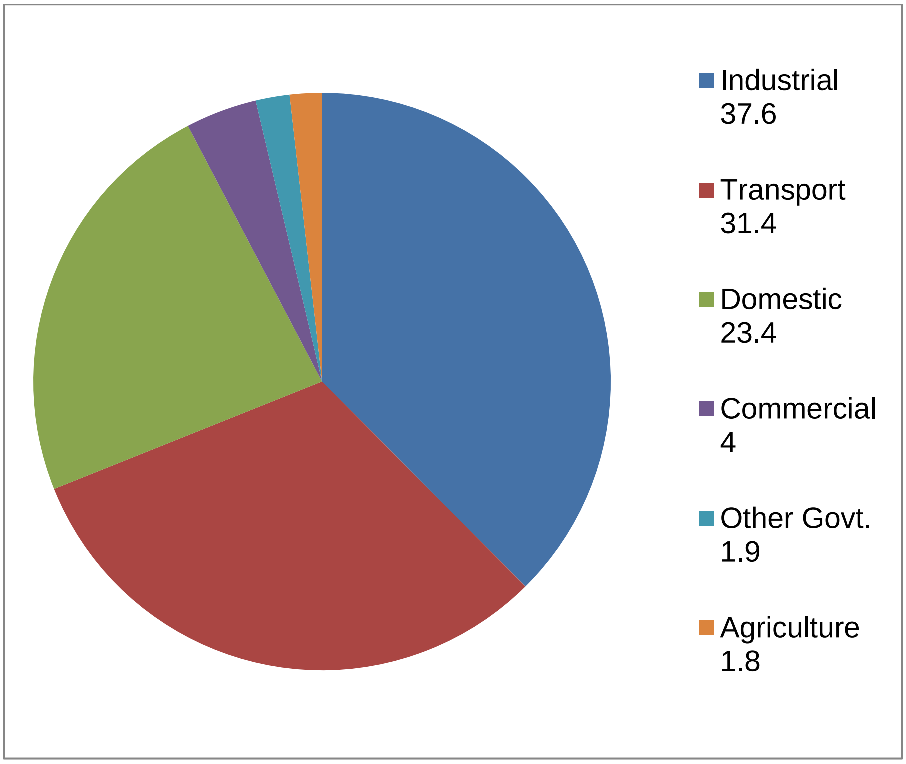
Because energy is a global and fungible commodity, the need to conserve it is also global. However, in the same context, this need cannot be overstated. If a country has fossil fuel dominated energy supply mix, low reserve/production ratio of its indigenous fossil fuels, rising energy demand which is expected to grow exponentially due to increasing population, low capital to invest in energy generation projects, bureaucratic inertia determinately slowing the progress in alternative energy spectrum; the immediate low cost and definite energy can come from conservation. Thus conservation in itself becomes a source of energy. Pakistan's energy supply mix is dominated by thermal power that is generated by furnace oil and gas. It is very expensive as country spends a huge sum on importing oil. Country's indigenous gas reserves are also low, hence there is planning for importing gas from Iran and Turkmenistan. Therefore, energy conservation is very essential for Pakistan.

## Consumption of Energy in Pakistan

*Pakistan Energy Yearbook 2012* notes that 40.026 million tonnes of oil equivelant (toe) primary energy was consumed in Pakistan during FY 2011-2012.[2] Industrial sector was the biggest consumer of energy with 37.6 percent share, which was followed by transport's 31.4 percent, domestic sector's 23.4 percent, commercial sector's 4 percent, other government's 1.9 percent and agriculture's 1.8 percent share. Figure I shows sector wise energy consumption in Pakistan. However, these shares in consumption exclude the share of fuel consumed in thermal power plants to generate electricity.

[2] *Pakistan Energy Yearbook 2012* (Islamabad: Ministry of Petroleum & Natural Resources, Hydrocarbon Development Institute of Pakistan, March 2013), p. 3

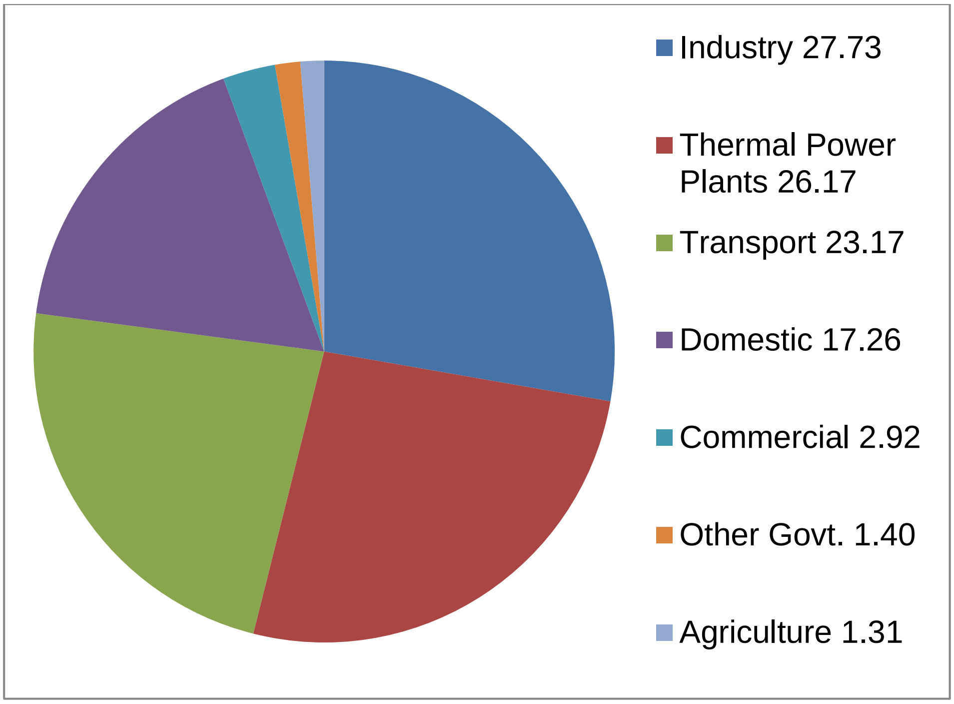
**Fig: I**
**Sector-wise Energy Consumption in Pakistan - 2011-12 (% in TOE) (Excluding Fuels consumed in Thermal Power Generation)**




Source: *Pakistan Energy Yearbook 2012* (Islamabad: Ministry of Petroleum & Natural Resources, Hydrocarbon Development Institute of Pakistan, March 2013), p. 6.

If fuels supplied in thermal power generation are also included in sector-wise energy consumption, thermal power plants become the second largest primary energy consuming sector in Pakistan. In that case, reflected in figure II, industrial sector consumes 27.73%, thermal power generation 26.17%, transport 23.17%, domestic 17.26%, commercial sector 2.92%, other government 1.40%, and agriculture 1.31% of total primary energy consumption in the country.

**Fig: II**
**Sector-wise Energy Consumption - 2011-12 (% - in TOE)**
**(Including Fuels consumed in Thermal Power Generation)**




Source: Compiled from data available in *Pakistan Energy Yearbook 2012* (Islamabad: Ministry of Petroleum & Natural Resources, Hydrocarbon Development Institute of Pakistan, March 2013), pp. 6-8

## Energy Conservation Potential in Pakistan

There is a lot of potential for energy conservation in all sectors of energy consumption in Pakistan. According to ENERCON,[3] which is a public sector think tank for conservation of energy, on average 25 percent of energy could be saved in Pakistan. It is estimated that Pakistan can save up to US$ 5 billion per annum through energy conservation.[4] Table I details sector-wise energy conservation potential in Pakistan.

[3] National Energy Conservation Center. For details see http://www.enercon.gov.pk/

[4] http://www.enercon.gov.pk/index.php?option=com_content&view=article&id=28&Itemid=27

**Table 1**
**Sector-wise Energy Conservation Potential in Pakistan**

| Sector | Conservation Potential |
|---|---|
| Industry | 25% |
| Transport | 20% |
| Agriculture | 20% |
| Buildings | 30% |
| **Average** | **25%** |

**Source:** http://www.enercon.gov.pk/index.php?option=com_content&view=article&id=28&Itemid=27

## What Role Pakistani Universities and Think Tanks Could Play?

Pakistani universities could be classified into four major types, all of which could contribute in energy conservation through their on-campus activities, laboratory research and outreach campaigns in related fields of their expertise. These four types of universities are: Sciences, Engineering & Technological Universities; Agricultural Universities; IT and Administrative Sciences Universities; and Social Sciences Universities. In order to evaluate what these universities could do for conservation of energy, their potential role would be discussed one by one.

### *Engineering Universities*

Engineering universities can contribute importantly in energy conservation in many ways. By designing and promoting efficient buildings while bringing the costs to lower end in order to make them affordable for local consumers, engineering universities could help in energy conservation. Globally buildings consume 35% of energy of which 75% goes to space and water heating.[5] It is noted that generally, most of Pakistani buildings are without insulation, which

[5] International Energy Agency, *CO2 Emissions from Fuel Combustion 1971-2004* (Paris: IEA, 2006), quoted in Shaukat Hameed Khan, "Technology Status and Costs of Emerging Alternative Sources" in Robert M. Hathaway & Michael Kugelman eds. *Powering Pakistan: Meeting Pakistan's Energy Needs in the 21st Century* (New York: Oxford University Press, 2009), p. 57

raises the heating and cooling cost. Gas and electricity consumption could be significantly reduced in buildings and domestic sector if proper insulation material is used to protect against heating and cooling losses. By developing efficient building insulation material, and peculiar specifications for different climate regions in the country, engineering universities could help in energy conservation.

Engineering universities could also contribute in energy conservation to a considerable extent by improving boiler efficiency in industry. As noted above, industry is biggest consumer of energy in Pakistan, and boilers are major energy consumers within industrial sector; enhancing boiler efficiency in industry would significantly contribute in energy conservation. *New York Times* recently reported that 18 Bangladeshi textile factories took certain small steps including upgrading boilers, dyeing and rinsing machines, and insulating steam pipes and fixing leaks, which enabled those factories to conserve 16 million cubic meter of gas and 10 million kilowatt-hour of electricity per annum.[6]

Engineering universities could help government in promotion of energy-efficient appliances by effective campaigns about the dividends of conservation that energy efficient appliances yield. Another area where engineering universities could help in conservation of energy is by promoting use of solar geysers in order to conserve gas or electricity that is otherwise used for heating water. It has been noted by experts that 30 percent of the natural gas domestically consumed in Pakistan could be conserved through active solar heating.[7] Engineering universities could contribute in adoption of solar water heating at large scale by devising low cost units with local materials in partnership with local manufacturers.

Pakistan faces huge transmission-distribution losses in electricity sector. Engineering universities could also help the country in devising ways to reduce such losses. These losses in some other countries such as Germany, Japan and South Korea are very low, and our technological and engineering universities could study distribution systems in those countries and come up with practical solutions befitting to Pakistan's economic and fiscal environment to successfully tackling the issue. Figure III shows comparative transmission-distribution losses in percent for year 2011.

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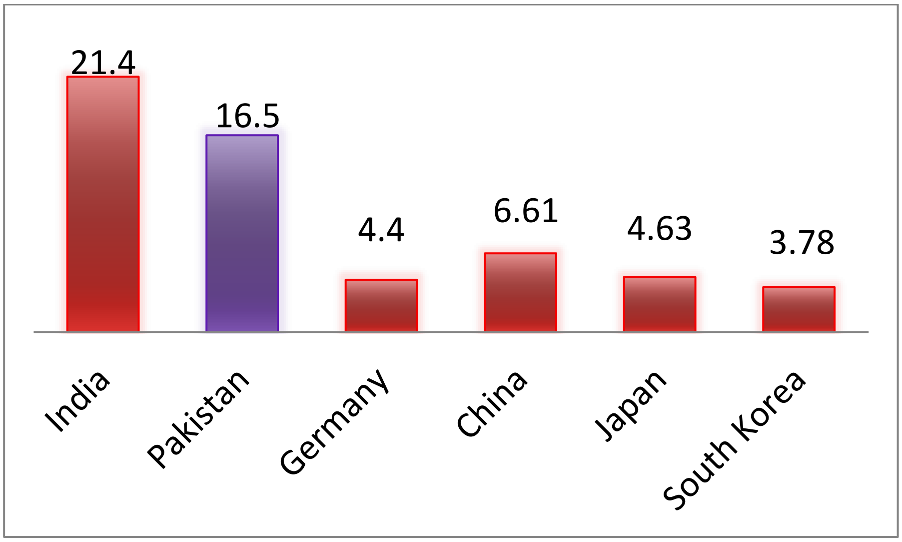
[6] "Conservation Pays Off for Bangladeshi Factories", *New York Times*, March 21, 2013, http://www.nytimes.com/2013/03/22/business/energy-environment/conservation-pays-off-for-bangladeshi-factories.html?pagewanted=all&_r=0

[7] Shaukat Hameed Khan, "Technology Status and Costs of Emerging Alternative Sources" in Robert M. Hathaway & Michael Kugelman eds. *Powering Pakistan: Meeting Pakistan's Energy Needs in the 21st Century* (New York: Oxford University Press, 2009), p. 58

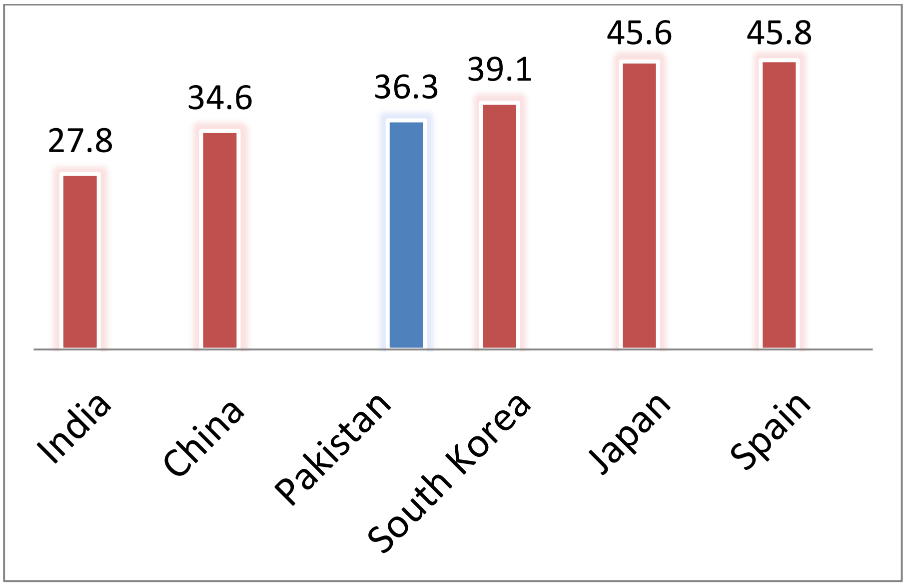
**Fig: III**
**Comparative Transmission-distribution Losses (2011 – in %)**




Source: "Energy Efficiency Indicators" by *World Energy Council*, www.worldenergy.org/data/efficiency-indicators

Engineering and technological universities could help in further improving the efficiency of thermal power plants working in Pakistan. Figure IV shows comparative thermal power plants efficiency according to World Energy Council. Pakistani thermal power plants' efficiency is better than those in India and China. However, it is important to note that in Pakistan, furnace oil and gas are the major fuels used in thermal power plants, whereas Chinese and Indian thermal power plants are mostly fuelled by coal. The fuel type is an important determinant in efficiency. Nonetheless a comparison of Pakistani thermal power plants efficiency with most efficient plants in Spain or South Korea reveals that there is huge potential to further improve the efficiency of Pakistani thermal plants and engineers could contribute in this regard.

**Fig: IV**
**Comparative Efficiency of Thermal Power Plants in % (2011)**




Source: "Energy Efficiency Indicators" by *World Energy Council*, www.worldenergy.org/data/efficiency-indicators

*Agriculture Universities*

Pakistan is an agricultural country blessed with world's largest contagious gravity flow irrigation system. However this irrigation system remains unable to provide enough water to irrigate even in the province named Punjab; the land of five rivers. Out of 56 million acre feet (MAF) water that is Punjab's share in river waters, 11 MAF is lost in canals, whereas another 10 MAF is lost in water courses. Due to flood irrigation practices another 14 MAF is lost in the fields. This aggregate loss of 35 MAF is compensated by injecting 33 MAF water from underground extraction through tube wells.[8] These tube wells are powered by high speed diesel or electricity, which makes a significant portion of energy consumed by agricultural sector in Pakistan. Agricultural universities could contribute in energy conservation in agricultural sector by minimizing the use of tube wells, which could be obtained through twin tracks: a)

[8] *Punjab Irrigated-Agriculture Productivity Improvement Project (PIPIP) 2011-12~2016-17*, Directorate General Agriculture (Water Management) Punjab, Oct. 2011, p. 9. Available at http://www.ofwm.org.pk/downloads/pipip/PC-1-PIPIP.pdf

minimizing the water requirement for agricultural sector by promoting drip and sprinkle irrigation systems over flood irrigation, and b) by helping irrigation departments in minimizing the loss of water in canals and water courses through upgrading them in order to reducing the need of pumped water for irrigation. This would not only reduce the amount of electricity and diesel oil to pump water from underground, it would also help in mitigating stress on country's water resources and the swift declining water table in areas where agriculture largely depends on underground water.

*IT and Administrative Sciences Universities*

As noted above, the world is at the threshold of a smart age. Revolutionary developments in information technology and communications has made it possible to prevent waste of energy in all activities of our social, transportation, domestic as well as industrial output. Advanced countries are taking full advantage of such developments. IT and administrative universities in Pakistan have a critical role in transformative developments. These universities could help in designing simple software that can contribute in energy conservation at large business ventures, huge industrial setups as well as at the small local level setups such as regulating traffic signals. These universities could also develop software that can provide daily, weekly and monthly audits of the use of energy in all sectors of energy consumption.

*Social Sciences Universities*

Social sciences universities have a promising role to play in energy conservation. It is the promotion of technologies and means of conservation as well as developing a sense of responsible use of energy that could help in great way in economizing and rational use of energy. Unfortunately, despite long hours of load shedding, a culture of sensible use of energy is still lacking in Pakistan. Social science universities and their departments such as anthropology, economics, Pakistan studies, mass communication etc. could help in achieving a replica of "setsuden spirit" through highlighting the importance of energy conservation. Setsuden (electricity conservation) was a national movement in Japan to prevent blackouts in the aftermath of Fukushima meltdown in 2011. In surveys among Japanese electricity consumers, 90% respondents indicated their willingness to participate in setsuden. Under setsuden, big power users cut their peak consumption by 15%; industry, businesses and households turned lights off, and set thermostat above 80 degree Fahrenheit; people began to wear comfortable clothes in summer instead of suits and ties; people began using stairs instead of elevators; a culture of putting off lights and working in the glow of computers was promoted; and turning off air conditioning at subways and departmental stores.[9]

*Leading by Example*

Universities also need to lead conservation efforts by setting example. Pakistani universities could initiate on-campus programmes to promote energy conservation in order to set example and promote dividends of energy conservation through making public the energy consumption statistics before and after launching their conservation drive. Boston University through its *sustainability@boston* reduced 9 percent of its energy use since 2005 despite 13 percent campus growth during this period through: LED lighting retrofits; occupancy sensors; daylight-responsive lighting controls; de-lamping; and boiler efficiency upgrade.[10]

Similarly, Massachusetts Institute of Technology (MIT) launched its Energy Initiative in 2006. The initiative "includes research, education, campus energy management and outreach program".[11] During 2007~2012 MIT saved energy in thermal and electrical projects worth over $4.5 million cumulative annual savings.[12] "In FY 2012, MIT successfully reduced over 5.6 million kwh in electricity use".[13] It achieved conservation through investments in lighting, central utility plant upgrades, new construction systems, demand ventilation, variable speed drives, air change rate reductions, chiller upgrades and residential hall refrigerator replacements. It fitted its campus with 100,000 sensors to monitor the functioning of building automation systems across campus to evaluate building-wise consumption of electricity, heating and cooling requirements. It also tracked occupancy through Wi-Fi network connectivity.[14]

*Energy Related Activities in Universities*

Pakistani universities are slowly starting to realize the challenge that emanates from energy shortages, and the role conservation could play in ameliorating energy security. There have been some initiatives that include Energy 2012 International Symposium organized by CECOS University of IT and

[9] For details about setsuden see: http://www.nytimes.com/2011/09/26/opinion/in-japan-the-summer-of-setsuden.html?_r=0; and http://ajw.asahi.com/article/0311disaster/recovery/AJ2011101013078

[10] http://www.bu.edu/sustainability/what-were-doing/energy/

[11] http://mitei.mit.edu/about

[12] http://mitei.mit.edu/campus-energy/progress/efficiency-conservation

[13] http://mitei.mit.edu/campus-energy/progress/efficiency-conservation

[14] "Reducing Wasted Energy in Commercial Buildings", http://mitei.mit.edu/news/reducing-wasted-energy-commercial-buildings

Emerging Sciences, Peshawar in October 2012.[15] The symposium discussed energy efficient buildings, and smart grid etc. National University of Sciences and Technology's (NUST) inauguration of Center for Energy Systems (CES) in January 2012 was also a good step.[16] The Center held energy management training programme in collaboration with German International Cooperation and APTMA in May 2013 that included auditing boiler efficiency, waste heat recovery, application of simple software tools in energy management systems, evaluating electrical equipment efficiency, and power generation efficiency audit.[17] Moreover, CES offers MS in Energy Systems Engineering which in its curricula includes a course on Energy Management in Buildings. Likewise, Mehran University of Engineering and Technology, Jamshoro, offers PhD in Energy Systems Engineering.[18] However, there is more that should be done by universities. Broader activities for conservation of energy should be pursued by universities more energetically in order to make conservation a national priority. In schools of management, there should be a compulsory course on energy conservation. Social sciences disciplines should launch outreach campaigns for interactive awareness for conservation. A leading by example role played by universities is a must for success of such initiatives. In technological universities, disciplines for energy resources engineering, management and conservation should be established. Governments should allow even public sector universities to make partnership with leading international energy companies for funding such disciplines.

## Think Tanks' Role

Think tanks could play important role in conservation of energy through their research, publications and conferences. Think tanks specializing on energy security should also be launched outside the public sector. In the public sector, ENERCON is very active in its campaigns recently; however, there is a need to highlight this subject of national importance by both governmental as well as non-governmental institutions. Think tanks focusing on energy can highlight the importance of conservation of energy to a wider audience through dissemination of their research and publications. They could also influence policy makers to give more emphasis on conservation aspect of energy security. To this end, think tanks could undertake studies to gauge energy conservation impact of launching public transport systems in mega

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[15] http://www.cecos.edu.pk/ienergy/home.html
[16] http://www.nust.edu.pk/INSTITUTIONS/Centers/CES/AboutUs/Pages/Welcome-to-CES.aspx
[17] http://www.nust.edu.pk/INSTITUTIONS/Centers/CES/Events/Pages/EMTR.aspx
[18] http://www.muet.edu.pk/news/admissions-open-phd-degree-programs-july-2013-session

cities. Thereby through their statistic based research they could convincingly appeal to the governments to adopt measures that need capital investment but offer larger economic and energy conservation dividends in the long run.

By organizing workshops and symposia with the objective to train people from industry, media and general public on the conservation aspects, think tanks could contribute in launching a national drive for energy conservation.[19] Through their collaboration with similar institutions abroad, think tanks could also help in introducing new ideas and technologies in conservation. Think tanks can promote energy conservation through their studies and research on comprehensive effect evaluation of conserving energy in various industries or sectors of consumption.

## Conclusion

Pakistani universities and think tanks can play an important role in energy conservation by showcasing new technological ideas for industry, electricity production and distribution, transportation, agriculture and domestic sectors. Through such endeavors these institutes could help in mitigating energy crisis in immediate term. Moreover, people are at the centre stage regarding energy generation, consumption and balance between supply and demand. Universities and think tanks' contribution in inculcating conservation culture through outreach campaigns in society would have its dividends in energy security and much beyond■

[19] There are plenty of ideas about energy conservation. Our think tanks need to adopt these ideas and make them practical for Pakistani environment. International Energy Agency has put forward 25 ideas for energy efficiency which are available at http://www.iea.org/topics/energyefficiency/25brightideas/25%20bright%20ideas_iea.pdf

# CHAPTER IV

# PRIVATE POWER GENERATION & INFRASTRUCTURE

**N.A. Zuberi**

## Background

Pakistan's economy has historically been marred by power shortages, which has remained one of the chronic problems hampering socio-economic growth of our country. The phenomenon of load shedding was first experienced by the nation in the early nineteen eighties and since then the country has been facing acute power outages from time to time.

Back in the eighties, the electricity demand for Pakistan was progressively increasing at an estimated rate of 7-8 percent per annum but the required capacity additions in the national grid could not be matched with the same pace. This situation called for immediate intervention by the Government of Pakistan through adoption of policy measures aimed at massive resource mobilization for investment in the power/energy sector.

## First Shot

In 1985, Government of Pakistan developed a long-term strategy for attracting multinational investment for construction and operation of electric power generation facilities. The objective of the energy strategy was to implement a plan that cultivates an atmosphere conductive to high-level electricity generation growth without straining the governmental resources. In November 1985, the private sector was invited to build, own and operate (BOO) the energy generation projects for concessional period beyond 20 year. In November 1987, the GOP announced the policy of financing of private sector projects. The key features of that policy were establishment of the 'Private Sector Energy Fund (PSEDF) for financing the private sector power projects. PSEDF was financed by GOP through US Agency for International Development (USAID) grant and loans from the World Bank and Japan Export Import (JEXIM) Bank, Governments of Italy and France, Nordic Investment Bank, and UK (ODA). The fund was to be managed by the National Development Finance Corporation (NDFC) on behalf of the Government. The purpose of this arrangement was to provide security and comfort to commercial lenders to encourage them to finance the projects. A Private Power Cell (PPC) in the Ministry of Water & Power was also created.

## HUBCO – the Forerunner

In response to the general invitation of 1985, Xenel Industries Limited (XENEL) of Saudi Arabia and Hawker Siddeley Power Engineering Limited (HSPE) of UK each separately submitted proposals for establishment of two 600 MW stations (2 x 300 MW for Xenel and 4 x150 MW for HSPE). However, in order to avail economies of scale in terms of the supply of fuel and the interconnection with WAPDA's transmission system, Xenel and Hawker Siddeley, submitted in December 1987 a revised joint proposal to the GOP for a 1200 MW (4 x 300) steam oil fired power.

On April 27, 1988, two identical 'Letters of Intent' were issued simultaneously, one in the name of M/s Xenel and the other in the name of M/s Hawker Siddeley. Since there was no proper feasibility study, tariff mechanism, or standardized agreements, the project saw lots of ups and downs and ultimately got commissioned after eleven (11) years in 1997 by Hub Power Company Limited (HUBCO) that was incorporated in Pakistan on August 01, 1991 to replace the Hub River Power Company (HRPG) incorporated by the earlier sponsors.

## Task Force on Energy 1993

In October 1993 a twelve (12) member Task Force on Energy was constituted and entrusted[1] with the task of i) drawing up an outline of new Energy Policy, ii) formulation of strategy for elimination of load shedding , iii) recommending proposals for mobilization of resources for Energy Sector, iv) recommending proposals for promoting private sector investment (foreign and domestic) and v) making recommendations for enhancing indigenous oil and gas production.

The Task Force in its report inter alia noted and recommended, "Resource mobilization on such a massive scale in face of fierce international competition for attracting foreign direct investment, and a rather limited domestic capital market, will not come about, *unless major policy reforms and structural changes are undertaken to make the investment environment attractive for foreign and domestic investors.*"[2]

Inter alia, the Task Force in its report not only suggested the set of measures[3] which ultimately became the core of 1994 Power Policy, but also suggested constitution of a Private Power Board[4] so as to facilitate one window operations.

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1 "Report of Prime Minister's Task Force on Energy", January 1994, 2 of Annexure 1.1

2 Ibid, 20

3 Ibid, 21 -24

4 That Board was actualized in the form of Private Power & Infrastructure Board, usually known as PPIB

## Power Policy 1994

The gist of the policy recommendations given by the Task Force was to provide an upfront transparent and attractive working platform at which international and domestic investors and their lenders can come forward and develop private sector power projects without going into protracted negotiations and parleys. Hence in addition to the very attractive fiscal and financial incentives, concessions and protections, the hall marks of Power Policy were i) Standardization of Agreements (i.e. implementation agreement (IA), power purchase agreement (PPA), fuel supply agreement (FSA)), and Bulk Power Tariff.

The incentives, the agreements and the Bulk Power Tariff – all three – were worked out on the basis of balancing of the 'Risks' involved in a private power generation project and apportionment of those 'Risks' to the parties who are best positioned to mitigate those risks. Whereas the private sector investors were expected to absorb the risk of power project conceiving, designing, arrangement of funds, construction, fuel procurement as well as operations and maintenance for the term of the project, the governments protected the investors from market risk (i.e. selling their commodity to only one buyer), currency fluctuation risk, foreign exchange availability risk, risk of hikes in fuel prices, natural calamities, change in law, expropriation, political instability and encroachment, and above all payment default of power purchaser. Such balancing act of Risks was protected through the agreements enforceable through law.

The Power Policy 1994 was a mega success. Brief synopsis of 1994 Power Policy is given below:

| | No. | Gross Capacity (MW) |
|---|---|---|
| **Applications Received** | 127 | 26,000 |
| **Letters of Interest** | 82 | 19,662 |
| **Letters of Support** | 34 | 9,062 |
| **Financial Close Achieved** | 19 | 3,454 |
| **Projects Commissioned** | 14 | 3,021 |

### Independent Power Producers (IPPs) Commissioned Pursuant to Policy 1994

| Sr. No. | Name of Project | Fuel | Capacity | Investment |
|---|---|---|---|---|

| | | | (MW) | (M US$) |
|---|---|---|---|---|
| 1 | Gul Ahmed Energy Ltd., Karachi | Oil | 136 | 138.00 |
| 2 | Kohinoor Energy Ltd., Lahore | Oil | 131 | 138.68 |
| 3 | Tapal Energy Ltd., Karachi | Oil | 126 | 129.70 |
| 4 | AES Lalpir Ltd., Multan | Oil | 362 | 344.00 |
| 5 | AES Pak Gen, Multan | Oil | 365 | 364.30 |
| 6 | Southern Electric Co., Lahore | Oil | 136 | 141.71 |
| 7 | Habibullah Coastal, Quetta | Gas | 140 | 155.52 |
| 8 | Fauji Kabirwala Co., Multan | Gas | 157 | 170.00 |
| 9 | Saba Power Company, Lahore | Oil | 125 | 152.39 |
| 10 | Rousch Power, Multan | Gas | 450 | 540.32 |
| 11 | Japan Power Generation, Lahore | Oil | 135 | 123.24 |
| 12 | Uch Power Ltd., Uch | Gas | 586 | 690.50 |
| 13 | Altern Energy Ltd, Attock | Gas | 29 | 9.16 |
| 14 | TNB Liberty Power Ltd., Dharki | Gas | 235 | 381.17 |
| | | **Total (MW)** | **3,113** | **3,479** |

## Creation of PPIB

As per the recommendations of Task Force, Private Power & Infrastructure Board (PPIB) was created in August 1994 through an administrative order with the mandate to:

- Promote private investments in power sector;
- Provide One-Window facility on behalf of Government of Pakistan (GoP), its Ministries / Departments;
- Execute IA and provide guarantees on behalf of GoP;
- Monitor and assist IPPs in executing PPA, FSA, Gas Supply Agreement (GSA), Water Use Licence (WUL) with relevant GoP agencies;

- Provide technical, financial and legal support to Ministry of Water and Power, Provinces/AJ & K.

Power Sector experts, investors and their lenders, multi-donor institutions and relevant agencies have acknowledged that besides the attractive incentives, it was the PPIB and its expertise and acumen of PPIB professionals which resulted in mega success of Power Policy 1994. Since its inception in 1994, PPIB has managed to attract an investment of around US $ 9.7 Billion in the power sector of Pakistan from leading international and domestic investors and lenders. As of today PPIB has successfully inducted 29 IPPs (utilizing gas, Residual Fuel Oil (RFO), High Speed Diesel (HSD) as fuel) including 84 MW New Bong Escape Hydel Power Project.

The cumulative power generation capacity of these IPPs is 8,657 MW which constitutes around 42 per cent of total installed capacity of the country.

## Private Power and Infrastructure Board Act 2012

In light of the greatly expanded role of PPIB it was proposed that PPIB be re-established under a new statute, reiterating its existing functions and expounding new role.

Giving PPIB a statutory status was required not only to improve its overall functioning, but also to provide it a legal support for carrying out its functions while implementing the power policies of the government. Accordingly, the process for making PPIB a legal entity was initiated after due processing through the Cabinet, CCI, National Assembly and Senate. Subsequently the 'Private Power and Infrastructure Board Act, 2012' was passed by the Parliament; received assent of the President on March 2,2012 and published in the Gazette of Pakistan on March 6, 2012.

## Functions of PPIB

Under the Act, PPIB exercise all powers which enable it to effectively perform its functions as specified below:

- Recommend and facilitate development of power policies;
- Consult the concerned Provincial Government, prior to taking a decision to construct or cause to be constructed a hydroelectric power station in any Province and to take decisions on matters pertaining to power projects set up by private sector or through public private partnership and other issues pertaining thereto;
- Coordinate with the Provincial Governments, local governments, Government of Azad Jammu and Kashmir (AJ and K) and regulatory bodies in implementation of the power policies, if so required;

- Coordinate and facilitate the sponsors in obtaining consents and licences from various agencies of the Federal Government, Provincial Governments, local governments and Government of AJ and K;
- Work in close coordination with power sector entities and play its due role in implementing power projects in the private sector or through public private partnership as per power system requirements;
- function as a one-stop organization on behalf of the Federal Government and its Ministries, Departments and agencies in relation to private power companies, their sponsors, lenders and whenever necessary or appropriate, other interested parties;
- Draft, negotiate and enter into security package documents or agreements and guarantee the contractual obligations of entities under the power policies;
- Execute, administer and monitor contracts;
- Prescribe and receive fees and charges for processing applications and deposit and disburse or utilize the same, if required;
- Obtain from sponsors or private power companies, as the case may be, security instruments and encash or return them, as deemed appropriate;
- Act as agent for development, facilitation and implementation of power policies and related infrastructure in the Gilgit-Baltistan areas and AJ and K;
- Prescribe, receive, deposit, utilize or refund fees and charges, as deemed appropriate;
- Open and operate bank accounts in local and foreign currencies as permissible under the laws of Pakistan;
- Commence, conduct, continue and terminate litigation, arbitration or alternate dispute resolution mechanisms at whatever levels may be necessary or appropriate and hire and pay for the services of lawyers and other experts therefore;
- Appoint technical, professional and other advisers, agents and consultants, including accountants, bankers, engineers, lawyers, valuers and other persons;

- Hire professional and supporting staff and, from time to time, determine the emoluments and terms of their employment, provided always that at no stage shall such emoluments be reduced from such as are agreed in the contracts with such persons; and

- Perform any other function or exercise any other power as may be incidental or consequential for the performance of any of its functions or the exercise of any of its powers or as may be entrusted by the Federal Government to meet the objects of this Act.

After its creation PPIB has processed many policies and facilitated numerous investment proposals from the private sector as under:

**(a)** Power Generation Policy 1994 (besides 1292 MW HUBCO project which was processed prior to 1994 Power Policy);
**(b)** Hydel Policy 1995;
**(c)** Transmission Policy 1995;
**(d)** Power Generation Policy 2002;
**(e)** Developing (to an advanced degree) a policy of 'Private Freight Train Operations';
**(f)** National Policy for Power Co-Generation by Sugar Industry - Jan 2008;
**(g)** Guidelines for Setting Up Private Power Project under Short Term Capacity Addition Initiative — August 2010.

## 1995 Hydel Policy

The 1995 Hydel Policy was announced by the government to promote and encourage the private sector in hydel power generation. PPIB's facilitation under 1995 Hydel Power Policy is as given below:

| | No. | Gross Capacity (MW) |
|---|---|---|
| **Letters of Interest**[5] | 41 | 1,385 |
| **Letters of Support** | 13 | 444 |
| **Project Under Development** | 1 | 132 |

## Commissioned Hydel IPPs

| Sr. No. | Name of Project | Capacity (MW) | Investment (M US$) |
|---|---|---|---|

[5] In the 1995 Hydel Policy the issuance of LOIs and LOSs was the responsibility of the respective province and afterward the project was to be handled by PPIB.

| | | | |
|---|---|---|---|
| 1 | New Bong Escape Hydro Power Project | 84 | 215 |

## Infrastructure Policies

The infrastructure policies i.e. transmission and private freight operator policies, could not yield any concrete project but the work done by PPIB in this area has created a a fund of knowledge which is available for future ventures in private sector.

## Power Policy 2002

With a view to addressing the future power requirements of the country, the GoP announced 'Policy for Power Generation Projects 2002' (the "Power Policy 2002"). The Policy 2002 has been amended from time to time to make it more investor friendly. Due to attractive incentives / concessions offered by this policy, private investors gave a tremendous response. A synopsis of PPIB's facilitation under Power Policy 2002 is as given below:

| | **No.** | **Gross Capacity (MW)** |
|---|---|---|
| **Letters of Interest** | 33 | 9,998 |
| **No. of ICBs Processed** | 04 | 4,000 |
| **Letters of Support** | 19 | 3,788 |
| **Financial Close Achieved** | 13 | 2,677 |
| **Projects in Operation** | 12 | 2,530 |
| **Projects Under Development** | 20 | 8,969 |

## Commissioned IPPs Pursuant to Policy 2002

As a result twelve (12) IPPs of 2,530 MW power generation capacity have been commissioned so far having investment worth US$ 2.7 Billion: details are given below:

| Sr. No. | Name of Project | Capacity (MW) | Investment (M US$) |
|---|---|---|---|
| 1 | AttockGen Power Project | 165 | 176.62 |
| 2 | Sheikhupura (Atlas) Power Project | 225 | 227.00 |
| 3 | Engro Power Project | 227 | 188.54 |
| 4 | Sahiwal (Saif) Power Project | 229 | 246.87 |
| 5 | Orient Power Project | 229 | 190.17 |
| 6 | Nishat Power Project | 200 | 234.99 |
| 7 | Nishat Chunian Power Project | 200 | 237.41 |
| 8 | Muridke (Sapphire) Power Project | 225 | 244.88 |
| 9 | Liberty Power Tech Project | 200 | 241.06 |
| 10 | HUBCO-Narowal Project | 220 | 288.00 |
| 11 | Foundation (Daharki) Power Project | 185 | 217.00 |
| 12 | Bhikki (Halmore) Power Project | 225 | 261.00 |
| **Total (MW)** | | **2,530** | **2,753.54** |

## National Policy for Power Co-Generation by Sugar Industry

In order to utilize the potential of sugar mills to utilize the waste of sugar cane i.e. bagasse to produce power generation the GoP approved the "National Policy for Power Co-Generation by Sugar Industry" (the "Co-Gen Policy") on 13th November 2007 to be administered by PPIB. Pursuant to the Co-Gen Policy, seven sugar mills have been registered with PPIB and are pursuing their projects having cumulative capacity of more than 550 MW.

## Short Term Capacity Addition Initiative

In order to remove the deficit of around 5,000 MW, the ECC has approved the Short Term Capacity Addition Initiative under which technically and financially sound business parties are being invited for establishment of IPPs on BOO basis within the jurisdiction of NTDC. Under this initiative, the interested parties are free to offer one or multiple projects of any capacity (above 50 MW) based on any technology and fuel in consultation with the Power Purchaser/PPIB.

## Future Targets of PPIB for Private Power & Infrastructure

In future PPIB's main focus will remain on the 'Key' words of Cheaper Electricity, which is possible by developing hydro and coal resources. Both of them need a lot of support from provincial agencies. PPIB have always been supporting them and wil continue to do so. Its efforts for development of hydro and coal resources are highlighted as given below:

## Initiative to Create Development Fund

In countries and sectors with high Perceived Risks, the governments feel obliged to provide additional support in bringing Foreign Direct Investment (FDI). Whereas the normal; support may be in the shape of lucrative but balanced policy Incentives for private sector investors, one of the tested tool for providing the additional support may be to put in place a Development Fund which may be used for (i) putting equity in EPC[6] + F[7] Projects i.e. projects where EPC contractors arrange loan in shape of Suppliers' Credit to be refunded from operations of the Project, and (ii) Subordinated Loan for the Projects. The concept of development fund in energy projects has a successful history in Pakistan. The Private Sector Energy Development Fund (PSEDF) created with the help of World Bank and administrated through Private Energy Division (PED) under the National Development Finance Corporation (NDFC) proved as a harbinger of the era of IPPs. The 1st PSEDF which was participated by World Bank (US$ 150 million), Japan

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[6] EPC stands for Engineering, Procurement, and Construction.
[7] F stands for Financing i.e. arranging loans in shape of suppliers' credit.

Export Import Bank (US$ 150 million), Government of France (US$ 28.79 million), Government of Italy (US$ 49.44 million), Mixed Credit (US$ 11.65 million) resulted in commissioning of 1292 MW HUBCO project. The 2nd PSEDF participated by World Bank (US$ 250 million), Japan Export Import Bank (US$ 250 million), Bank of Canada (US$ 80 million), and Government of France (US$ 9.589 million) helped develop the success story of Policy 1994. Since in current scenario availability of financing has become comparatively difficult, PPIB is currently actively pursuing the concerned to create an Energy Fund which may help develop new hydro as well as coal projects.

## Simplified Framework for Fast Track Implementation of Hydro Power Projects

The draft Hydel Framework for fast track implementation of hydro power projects was earlier prepared by PPIB in consultation with the relevant stakeholders. However, PPIB Board, while considering the Hydel Framework in its 90th meeting held on 6th January 2012, decided that "*The Proposed Framework for Fast Track Development of Hydropower Projects be further studied and modified in consultation with the stakeholders to bring clarity*". Accordingly, PPIB, in consultation with the relevant stakeholder, made necessary modifications in the aforesaid framework to make it more simplified so that it now provides a clear cut, simple and easy to understand set of procedures so that investors would feel comfortable and secured in making investments in the hydropower sector of Pakistan.

## Hydropower Projects in Public-Private Partnership Mode

The Feasibility Studies of two hydropower projects located in Kohistan Valley, Khyber Pakhtunkhwa namely 665 MW Lower Palas Valley Hydropower Project and 496 MW Lower Spat Gah Hydropower Project were earlier completed by WAPDA in public sector in 2010. WAPDA in August 2010 decided to implement these projects in Public Private Partnership (PPP) Mode. Accordingly, WAPDA invited Expression of Interest (EOI) in July 2011 for development of the Project in PPP Mode under the provisions of "*Policy for Power Generation Projects 2002*".

In response, proposals were received from private sector firms and after due evaluation two separate Korean Consortiums were selected for each of these projects. Subsequently, these projects have been transferred to PPIB for further processing under the Power Policy 2002. As per updated status, WAPDA, Government of Khyber Pakhtunkhwa (GoKP) and each of the respective Korean Consortiums (public and private sponsors) have signed an MOU on 24th December 2012 and subsequently will sign a Joint Development Agreement (JDA) respectively as per specified timelines in MOU (within one year). Thereafter, PPIB will continue the processing of these projects as per the provisions of Power Policy 2002.

## Development of Upfront Tariff for Coal based Power Projects

With the aim to minimize the procedural processes, save time of tariff approval/reviews and facilitate investors in carrying out their own due diligence regarding financial viability/acceptability of the tariff, PPIB initiated the process of facilitating NEPRA in the preparation of Upfront Tariff on various technologies. In this regard detailed working on Upfront Tariff for 50 MW, 200 MW, 600 MW and 1000 MW coal based power plants was provided to NEPRA. The detailed working on Upfront Tariff consisted of different tariffs based on local coal and imported coal fueled power projects with local as well as foreign financing options.

The proposed Upfront Tariff working was also sent to NEPRA for further processing.

## Support to Thar Coal

PPIB's prime focus during last few years remained on the development of Thar Coal based power projects. PPIB has extended its fullest support to Thar Coal and Energy Board (TCEB) – which is mandated to be the focal agency for development of Thar Coal. The GoP has approved following set of incentives for development of Thar Coal:

- Thar Coalfield be declared as Special Economic Zone, and the projects of development of Thar (also including coal mining and power generation) be declared as Projects of National Security';
- 20 per cent ($ based) IRR to firms which achieve Financial Close before December 31, 2015 for Mining & Power Projects based on indigenous coal and additional half a percentage IRR i.e. 20.5 per cent IRR for firms which achieve Financial Close by or before December 31, 2014;
- Zero per cent customs duties on import of coal mining equipment and machinery including vehicles for site use;
- Exemption on withholding tax to shareholders on dividend for initial 30 years;
- Exemption on withholding tax on procurement of goods and services during project construction and operations;
- Exemption for 30 years on other levies including special excise duty, federal excise duty, WPPF and WWF;

- In addition to the aforesaid incentives, Coal Based Power Projects and Coal Mining Projects in Sindh shall have the same incentives, concessions, protections and security package as that available to IPPs developed pursuant to Power Generation Policy 2002 (as amended from time to time).

## Conversion of Existing IPPs to Cheaper Fuels

The last one decade witnessed exorbitant increase in the prices of furnace oil and gas which are the primary fuels of almost all IPPs operating in Pakistan. The price of furnace oil showed 527 per cent increase (Rs. 11,569/M.Ton to Rs. 72,537/M.Ton) whereas 240 per cent rise in gas price (Rs. 182/MMBTU to Rs. 620/MMBTU) was recorded during period 2001-2012. Similarly 53 per cent devaluation of Pak Rupee against US Dollar (Rs. 64 to Rs. 98) was also noted during the same period. This led to higher cost of electricity generation which could not be matched with appropriate tariff adjustments and became one of the major contributors in accumulation of huge circular debt. The affordability and availability of electricity for domestic as well as industrial consumers remained a chronic problem which adversely affected the socio-economic growth of the country.

In that bleak situation PPIB proactively acted and analyzed various options to counter the impacts of skyrocketing price of furnace oil and depleting gas reserves. PPIB formulated a 'Concept Paper' exploring the possibilities of converting existing IPPs to cheaper fuels like coal. PPIB has also drafted Guidelines for interested IPPs to help them convert their plants to cheaper fuels. After approval of the guidelines, IPPs would be able to convert their plants to cheaper fuels.

## PPIB Vision 2020 — Ultra Mega Power Parks Based on Local and Imported Coal

Pakistan's power generation requirement would be more than 30000 MW[8] whereas the maximum capability during June 2012-13 is estimated around 15000 MW[9]. This means that Pakistan will need more than 14000 MW additional power generation capacity. Achieving such huge target would not be possible with ordinary measures. Therefore there is a need to draw a sketch for two mega power parks for development of Power & Infrastructure on a bigger canvas.

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[8] Source: General Manager Planning Power National Transmission & Despatch Company (NTDC) Ltd

[9] Ibid

*Imported Coal Based Power Park*

The port infrastructure of the country is inadequate to import vast quantities of coal required for large scale power generation. Therefore a dedicated jetty or a coal terminal would be required for bulk import of coal for the power projects. To reduce transportation cost and minimize the environmental hazards during coal transport any imported coal based project would thus be located as near the coast as possible keeping in view the other factors such as least cost power evacuation etc. A feasibility study conducted by WAPDA in 1991 for a 3600 MW imported coal project concluded that the area near Gadani ship breaking yard, Balochistan is suitable for an imported coal project of around 4000 MW. There is ample land available at that location and has very low & sparse population density. The environmental impact of the imported coal project at this location would be minimal.

Based on that feasibility study an Ultra Mega Power Park of at least 3600MW (in phases) having its own dedicated jetty is proposed. The coal jetty would be constructed/operated by an entity formed under Public Private Partnership (PPP) between the private sector and concerned public sector organizations such as Port Bin Qasim (PQA) and Karachi Port Trust (KPT).

For import of coal and supply thereof to power projects, another entity would be formed under PPP mode comprising of private sector and public sector entities. This entity may operate on the pattern similar to that of Lakhra Coal Development Company (LCDC), which is a Joint Venture of Pakistan Mineral Development Corporation (PMDC), Government of Sindh and WAPDA, for coal mining from Lakhra coal field and selling it to Lakhra Power Plant.

The land for the Power Park would be acquired and developed by a third entity jointly formed by PEPCO, Government of Sindh and Government of Balochistan to facilitate the power projects. Plots of land would be sub leased to private investors for development of power projects. The development of Power Park would include construction of common switchyard for power evacuation from all the power projects, a common ash disposal pond, water supply, effluent treatment/discharge, housing facilities and road infrastructure with adequate security arrangements.

The road infrastructure development would include not only constructing roads within the Power Park but also developing a road for accessing Karachi port from the Power Park. The security arrangements would require adequate security of the Power Park as well as pickets/patrolling of law enforcing agencies of the road from Karachi to the Power Park.

The size of each IPP in the Power Park would be 600 MW. The technology of the projects would invariably be supercritical and comprise of one steam turbine of approximately 600 MW. Since the IPPs would use the leased land and common facilities the mode of IPP would be Built, Own, Operate and Transfer (BOOT) to government after the concession period of 30 years.

Strict compliance with Pakistan's environmental laws will be observed and all projects would include effluent treatment and environmental impact mitigation measures. Ash is the bulkiest effluent of power generation from coal and requires substantial arrangements for its adequate disposal. A common ash pond would be developed and operated ensuring adequate and environment friendly ash disposal. ■

**Appendix I**

## Indigenous Coal Based Power Park

Like imported coal based Power Park, a local coal based Power Park can be developed at any one block of Thar. Similar to the jetty, the coal mine would be developed in Public Private Partnership. A precedent of public private partnership already exists in the shape of Sindh Engro Coal Mining Company (SECMC) which is the Joint Venture between the Government of Sindh and M/s Engro Energy Pvt. ltd. for coal mining at Thar Block-II.

Keeping in view the previously conducted feasibility studies at Thar, suitable site of this Power Park would be the area near mine mouth. However, this is barren land with very poor road infrastructure and no power evacuation facility. Converting this area into a Power Park would require infrastructure development i.e. construction of common switchyard for power evacuation from all the power projects, a common ash disposal pond, housing facilities, cooling water supply & discharge, effluent treatment/discharge and road infrastructure with adequate security arrangements. These issues would be dealt in the same pattern as already discussed under imported coal Power Park.

The land for the Power Park would be acquired by Government of Sindh to facilitate the power projects. Plots of land would then be sub leased to private investors for development of power projects.

Like imported coal based Power Park the size of each IPP would be 600 MW. The technology of the projects would invariably be supercritical and comprise of one steam turbine of approximately 600 MW. Strict compliance with Pakistan's environmental laws will be observed and all projects would include effluent treatment and environmental impact mitigation measures. Ash is the bulkiest effluent of power generation from coal and requires substantial arrangements for its adequate disposal. A common ash pond would be developed and operated ensuring adequate and environment friendly ash disposal.

**Appendix-II**

## Private Sector as a Catalyst in Improving Economy of the Country

HUBCO, the fourteen IPPs developed under Power Generation Policy 1994, the twelve IPPs developed pursuant to 2002 Power Policy, and the first Hydel IPP under 1995 Hydel Policy have resulted in investment worth billions of dollars.

This huge investment with its multiplier effect has tremendously benefited the country's economy. An indirect contribution is the creation of many employment opportunities during construction as well as operations phases.

The banking sector which is worst hit around the world is thriving and benefiting very well in Pakistan from the IPP business. Other beneficiaries are the Construction and Service Industry.

The IPPs have also contributed in the social welfare in their respective areas by establishing schools, hospitals, community centers, providing clean drinking water facilities etc. IPPs have further participated in improvement of environment through plantation of trees.

**Appendix-III**

## Proposed
## Scope & Responsibilities of Stakeholders in Ultra Mega Power Park Based on Imported Coal

| Sr. | Scope | Responsibility | Mode | Proposed Stakeholders |
|---|---|---|---|---|
| 1 | Construction, Operations and Maintenance of Jetty near Gadani Ship Breaking Yard (adjacent to Kayo Island) and construction of coal storage area in phases sufficient for handling coal up to 10.0 million tons/annum (sufficient for 4000 MW) | Coal Port Company, a new Special Purpose Vehicle to be created (New SPV) | Public or Preferably PPP | KPT, Port Qasim and Gawadar Port Authorities, Baluchistan Govt. and Private Sector |
| 2 | Import and Supply of Coal | Coal Supplier Company, a new Special Purpose Vehicle to be created (New SPV) | Public or Preferably PPP | PEPCO, PNSC, and private sector |
| 3 | (i) Procurement and development of land for Power Park,<br>(ii) Construction of internal and external roads and bridges to shorten road distance from Karachi side up to the site,<br>(iii) Fencing of Power Park, security pickets and watch towers,<br>(iv) 6 secured sites for | Infrastructure Development Company, a new Special Purpose Vehicle to be created (New SPV) | Public or Preferably PPP | GoP(through MoW&P), GoB, PEPCO (also GOS where territorial jurisdiction so warrants) and private sector |

| | | | | |
|---|---|---|---|---|
| | 600 MW IPPs,<br>(v) Development of site for common switchyard,<br>(vi) Development of common ash pond,<br>(vii) Disposal of ash as well as domestic and industrial waste, and<br>(viii) Secured multi-story rented residential quarters (many activities phase wise) | | | |
| 4 | (i) Provision of electricity during construction and subsequently residential area as well as jetty and Power Park<br>(ii) Construction of Common Switchyard and Transmission | PEPCO (already existing) | Public | PEPCO (World Bank and other donors) |
| 5 | Six IPPs of 600 MW size each in phases | IPPs (New) | Private Thru bidding or unsolicited first come first basis) | PPIB |
| 6 | Power Park Development Authority | Power Park Regulatory Authority (New) | Governing Board under Prime Minister | GoP/GoB/GoS |

**Appendix-IV**

## Proposed
## Scope & Responsibilities of Stakeholders in Ultra Mega Power Park Based on Indigenous Coal

| **Sr.** | **Scope** | | **Mode** | **Proposed Stakeholders** |
|---|---|---|---|---|
| 1 | Development and Operations of open pit mine having ultimate coal production capacity of up to 20.0Million tons/annum (sufficient for 3600-5000 MW) | Coal Mining Company, a new Special Purpose Vehicle to be created (New SPV) | Public or Preferably PPP | GOP(through MoW&P)/Mo PNR, Govt. of Sindh (GOS) and Private Sector |
| 2 | (i) Procurement and development of land for Power Park,<br>(ii) Construction of internal and external rail/road infrastructure,<br>(iii) Arrangement of common cooling water and waste disposal etc.<br>(iv) 6-8 secured sites for 600 MW IPPs,<br>(v) Development of site for common switchyard,<br>(v) Development of common ash pond,<br>(vii) Disposal of ash as well as domestic and industrial waste, and<br>(viii) Secured multi-story rented residential quarters (many activities phase | Infrastructure Development Company, a new Special Purpose Vehicle to be created (New SPV) | Public or Preferably PPP | PEPCO, GOS/GOP(through MoW&P) and private sector |

| | | | | |
|---|---|---|---|---|
| | wise) | | | |
| 3 | (i) Provision of electricity during construction and subsequently residential area as well as Power Park (ii) Construction of Common Switchyard and Transmission | PEPCO (already existing) | Public | PEPCO (World Bank and other donors) |
| 4 | Six to eight IPPs of 600 MW size each in phases | IPPs (New) | Private thru bidding or unsolicited first come first basis) | PPIB |
| 5 | Power Park Development Authority | Power Park Regulatory Authority (New) | Governing Board under Prime Minister | GoP/GoS |

# GRIDS & Infrastructures: CWS Combustion Technologies

**Salman Qaisrani**

## Application of Coal Water Slurry Technology in Power Generation

## Introduction

*Pakistani Coal Supply*

Despite mounting concerns over regulatory supply and quality risks, Pakistani coal sector remains under lime light as an attractive option. With strong growth potential, improved bargaining power, broader market scope, consolidation opportunity and favourable industry dynamics all offer a compelling investment option. Pakistan will remain one of the world's largest coal reserve country of indicated coal reserves of 185,000 Million Metric Tons. About 80% of Pakistani coal reserves fall under low/medium rank coal, such as lignite and sub-bituminous coal. However, coal has one or two disadvantages; among those are its mineral content, especially the sulfur bearing component, and the problems in handling and storing of coal, such as dust and the need for expensive mechanical handling and reclamation systems.

1. By contrast, liquid fuels are naturally low in mineral content, can be freed of their sulfur compounds, and are easily handled and stored.
2. On the other hand, coal is abundant, widespread, and fairly cheap to produce; while oil reserves are much smaller and are concentrated in politically unstable areas, and the commodity can become very expensive indeed, regardless of production costs.

*Increasing Utilization for Medium-Low Coal*

Utilization of coal as primary feedstock for power generators in the future will still remain a high priority; as indicated based on the continuous development of coal processing technology. While remaining reserves of high rank coal (6.100 7.100 Kcal) continue to decrease, future use of Pakistani largest coal reserves which 80% belongs in medium/low category (4000 - 5500 Kcal and <4000 Kcal), will surely experience. Significant growth in terms of consumption. This trend has started to show, as indicated by effort performed by some countries to modify and retrofitting power plant configuration for this purpose.

## Description of CWS

*What is CWS?*

Coal Water Slurry (referred to as CWS) is an environment friendly coal based liquid-Fuel that can be used to replace petroleum. It is prepared through particular technical process from 65% 70% coal, 29% 34% water, and minor (1%) quantities of chemical additives. Hence, CWS is slurry of powdered coal and water, which maintains a stable state over a long period when a small amount of additive is provided properly.
Standard Specifications
Density65~70%
Viscosity~1000CP
Sized<50 m
Ash<7%
SS<0.5%

*Advantages of CWS*

1. Good Combustion Efficiency: the combustion efficiency of CWS is 96% - 99%, boiler efficiency is about 90%, which reach the level of oil.
2. Good Effect on Environmental Protection: the combustion temperature of CWS is approximately 1200 to 1300 degree C and emissions of SO2 and Nox are low
3. Advantages on Technology: CWS can be transported and burned like oil, nonflammable liquid and its manufacturing temperature is low, so it is safe.
4. Less Investment: The investment in transportation is about 1/3 of railway and 2/5 of electrical wire, and to be compared with retrofitted to coal, the cost of oil fire boiler retrofitted to CWS fuel is 1/3 ~1/2 of coal fire boiler, the retrofit time is just 1/3 that of coal fire boiler.

*Coal Water Slurry as New Energy Source*

For CWS Combustion Process, the atomized CWS burns in the furnace in four stages of
Combustion:
1- Moisture evaporation
2- Releasing volatile materials and ignition
3-Fix carbon combustion
3- Coke burn-out
Ignition temperature: 425 deg C 550 deg C 100 dig C lower than pulverized coal Combustion temperature: about 1350 deg C100 deg C 200 deg C lower than fuel Oil Burner and Nozzle for CWS Steady Combustion a special burner and nozzle must be used. The nozzle must be made from high abrasive and

corrosion resistance material.

*CWS Technology Development and Its Benefits*

i. **Using coal to replace oil reduces fuel cost of users:**
   a. For retrofitting: 1.8 to 2.2 Ton of CWS can replace 1.0 Ton of heavy fuel oil, depending on the heating value.
   b. Investment pay-out of retrofitting is about 5 months. Investment cost to build

   New CWS boiler is about the same with new oil fired boiler, but the operating cost is significantly lower on the CWS boiler.

ii. **To realize clean use of coal, use energy source economically and rationally, improve environmental protection**
   a. The raw coal, for CWS is cleaned coal low in ash and sulfur content.
   b. CWS burning temperature is 100 to 200 deg C lower than oil or pulverized coal, it can effectively reduce NOx and SO2 and can easily meet national and local environmental protection standard.
   c. Additional de-sulfurized can be provided if further reduction of sulfur dioxide is required.

iii. **Energy saving effect is remarkable**
   a. CWS has high combustion efficiency (above 95%-99%).
   b. CWS combustion is easy to control and its waste is low.

iv. **Providing new manner in coal transportation: CWS can be transported through Pipelines and stored in storage tanks:**
   a. Less construction investment in railway and highways and rolling stocks
   b. Less land indemnification for right of ways
   c. Less environmental pollution
   d. Easier in handling and operation
   e. Low running costs and high reliability

v. **Burning CWS replacing loose coal and improves regional environment.**

   CWS can be manufactured in the mine mouth to supply several power plants by using ships and pipelines. It's just like distribution system from oil refinery to power plants.

vi. **Replacing diesel oil through special processing.**

   CWS can be produced to improve its quality to replace diesel oil.

*Favourable Economic Effects*

It is difficult to compare the relative costs of using a CWS against traditional coal or oil firing because the price of the CWS itself varies according to the coal price, the location of the plant, and/or the plant capacity etc. The economic advantage compared to pulverized coal is, however, indicated by significant reduction in handling cost by simplifying facilities required for loading and unloading activities.

In general, 2 tons of coal water slurry (costs ± US$ 200) can replace 1 ton of heavy oil (costs US$ 780), a significant saving of production cost. Users can save tremendous fuel cost for per ton of fuel oil (heavy oil). Coal water slurry can replace heavy oil fuel and brings tremendous economic benefits as an oil substitute fuel.

## Current End Users of the Product and its Market Potential

At present, there are more than 20 processing plants, producing coal water slurry with the total production capacity of more than 4 million tons in China; there are more than 5,000 oil burning boilers, available to be converted to CWS fuel, with the annual oil burning amount of over 39 million tons and the demand of coal water slurry about 78 million tons, if the ratio of calorific value of oil to CWS is 2 to 1 Meanwhile, with the increase of petroleum price and strengthening of environmental protection, more and more coal burning boilers and petroleum burning boilers will be reformed to coal water slurry burning boilers. So, this product is in large demand and its marketplace is wide as well. Coal-liquid mixtures are most likely to be used in boilers that were designed for coal but have changed over to oil, or in oil boilers that can burn coal-liquid mixtures without serious loss of output (de-rating). Other suggested uses have been in diesel engines, for blast-furnace injection, in process heating, and in rotary kilns.

## Application in China

**LIST CWS APPLICATION IN CHINA**

*(New and Retrofitted)*

| User | Boiler Capacity | Type | Year in Operation |
|---|---|---|---|
| Zhejiang University | 1 x 1.5MW boiler | New | 1983 |
| Beijing First Papermaking Factory | 1 x 20t/h oil boiler | Retrofit | 1985.10 |
| Beijing First Papermaking Factory | 1 x 60t/h oil boiler | Retrofit | 1989.11 |
| Beijing First Papermaking Factory | 2 x 35t/h | New | 1991 |
| Shengli Oil Field Elbow Plant | 1 x 3MW hot water boiler | Retrofit | 1994.04 |
| Shengli Oil Field First Building Co. | 1 x 7MW hot water boiler | Retrofit | 1994 |
| Henan Oil Plant in Residential Area | 1 x 4t/h Chain-grate boiler | Retrofit | 1995 |
| Shandong Bayi Coal Mine | 1 x 4t/h<br>1 x 10t/h chain grate boiler | Retrofit | 1998,2001 |
| Shandong Baiyanghe Power Plant | 3 x 220t/h oil boiler | Retrofit | 1992-1999 |
| Shengli Oil Field Power Plant | 1 x 10t/h oil boiler | Retrofit | 2000.10 |
| Shengli Oil Field Shengnan Residential Area | 1 x 14MW hot water boiler | Retrofit | 2000.12 |
| Jilin Oil Field | 1 x 1.75MW hot water stove | Retrofit | 2000.12 |
| Guangdong Maoming Power Plant | 2 x 220t/h oil boiler | Retrofit | 2000-2001 |
| Qingdao Haizhong Co. | 6 x 1-10t/h | New | 2000.8 - 2001.04 |
| Fujian Coal Transportation and Sale Corp | 1 x Pottery Drying Stove | Retrofit | 2000.09 |
| Shantou Wanfeng Thermal Power | 1 x 220t/h oil boiler | Retrofit | 2001.06 – 2006.03 |
| Datong Huihai Corp | 1 x 4t/h | Retrofit | 2001.02 |
| Shengli Oil Field | 18 x 7MW & 14 MW hot water boiler | New | 2001.11 |
| Huainan Coal Mine | 1 x 10/th | New | 2002.09 |
| Xinwen Coal Mine | 2 x 4/th Grate Fired Furnace | Retrofit | 2002 |
| Liaohe Oil Field | 1 x 20t/h Heat Furnace | Retrofit | 2002 |
| Daqing Residential Building | 1 x 7MW hot water boiler | Retrofit | 2002 |
| Suzhou Lintong Chemical Co | 1 x 4t/h | Retrofit | 2002 |
| Jiangsu Huaibei Chemical Factory | 1 x 20t/h Grate Fired Furnace | Retrofit | 2003.04 |
| Shanghai Xianeng Co | 3 x 10t/h | New | 2003-2004 |
| Shenyang Paraffin Plant | 1 x 75t/h Fluidized Bed | Retrofit | 2003.06 |
| Jilin Petrochemical oil Refining Factory | 2 x 65t/h oil boiler | Retrofit | 2003.09 |
| Shandong Qilu Petrochemical Factory | 2 x 65t/h oil boiler | Retrofit | 2003.10 |
| Jilin Petrochemical Ethene Factory | 1 x 75t/h | New | 2003.10 |
| Maoming Power Plant | 2 x 410t/f oil boiler | Retrofit | 2003.04 – 2005.09 |
| [illegible] | [illegible] | New | 2003.04 |
| Qingdao Kaiyuan Group | 2 x 130t/h | New | 2004 |
| Shandong Zaozhuang Mine | 1 x 130t/h | New | 2004.10 |
| Nahai Longguang Group | 1 x 670t/h | New | 2005.09 |
| Zhuhai Leather Plant | 2 x 8Mcal Heat Furnace | New | 2005.09 |
| Dongguan Fuan Textile Plant | 1 x 150t/h | New | 2007 |
| Guangdong Nanhai Changhai Power Plant | 1 x 670t/h | New | 2008 |
| Shenyang Paraffin Plant | 1 x 75t/h Fluidized Bed | Retrofit | 2008 |

## Coal Specification Limitation

Based on the available experience, the type of coal which is in accordance with the properties and is well suited is bituminous & Lignite type coal with following limits of various specification.

| S/No. | Coal Parametres | CWS Boiler |
|---|---|---|
| 1 | Heating Value Range (K Cal/Kg) | >3500 |
| | Class II CWS, GB Standard | >4300 |
| 2 | Moisture Content Range (%) | <40 |
| | Class II CWS, GB Standard | <35 |
| 3 | Ash Content Range (%) | No Requirement |
| | Class II CWS, GB Standard | <8% |
| 4 | Volatile Matter Range (%) | >15 |
| 5 | Fixed Carbon Range (%) | No Requirement |
| 6 | Sulfur Content Range (%) | No Requirement |
| | Class II CWS, GB Standard | <0.65% |

The comparison of Pakistani Coal specification with the limits of Coal as allowed for usage in CWS combustion technology shows that local Pakistani Coal is an ideal for usage in CWS Combustion Technology.

| Sr . No | Properties | Local Coal Limits | CWS Allowable Limits |
|---|---|---|---|
| 1 | High Moisture Content | 16.1-47.2 | < 40 |
| 2 | High Volatile Matter | 26.5-40.95 | > 15 |
| 3 | High Sulfur Content | 1.1-9.5 | No requirement |
| 4 | Low Heating Values | 5,219 -12,338 | > 3500 |
| 5 | High Ash Content | 9.35-37.5 | No requirement |
| 6 | Fixed Carbon | 10.96-43.46 | No requirement |

### CWS Parent Source: 5 Classes

1-Washed coal
2-Coal washing sludge
3- Black Liquid from Paper making
4- Chemical waste water, Petroleum Coke

### Boiler Function Media: 6 Classes

1-Steam,
2- Hot water
3-Heat-transfering oil
4-Alkali Cooking
5-Steam Pouring into the oil-field
6- Ceramic drying

### Coal Particle Size

The key parameter which must be observed in this phase is to determine the particle size of the coal and the coal concentration in the CWS that will be used. For CWS, the size of coal particles to be used should be smaller size distribution than the pulverized coal for fuel, which is about 40-50 micrometer. That is done, in order to obtain good flow characteristics and to prevent coagulation especially at the nozzle area.

## Coal Concentration in CWS

The next parametre is to determine the coal concentration to be us as CWS. The limitation of coal concentration is the fluidity of CWS which is measured in viscosity unit (dimension). The higher the coal concentration in CWS, the higher the viscosity which means the fluidity will be owner. On the other hand, the lower the coal concentration in CWS then the calorific value of CWS will be smaller and this means the heat release will be smaller. At this point in time the good coal concentration in the CWS is in the neighborhood of 70%, which at this concentration the CWS fluidity is still within acceptable limit. Other than aforementioned coal properties, another property required is to stabilize the coal particles in the CWS; this is necessary because of the basic difference properties between coal as solid material and water as liquid, of which if the two are mixed, the coal tends to precipitate in the water. To prevent precipitation, a surfactant agent as additive is required, in order to generate coal dispersed stabilization in the water. This stable state can be maintained by mixing additive of natural gum type of material or usually polysaccharide is used in the mixture of coal & water The CWS manufacturing process is described as follows.

## CWS Process Piping

i. To maintain the linear velocity in the range of 0.6 – 2.4 m/sec
ii. For easy cleaning, in the event of plugging caused by drying of CWS, the use flange joint or T-type joint is preferred. Within the piping system, there must be assurance that no spaces causing the flow to become stagnant or there may be leakages causing the water of the CWS flowing out or drying up the CWS
iii. The losses of flow resulted by friction at the flow channel due to high fuel viscosity can be calculated using Darcy's equation. This equation can be modified for non-Newtonian or can also be performed by making over capacity from the pump design. Other aspect that also usually performed is by using variable speed pumps.
iv. The piping system to the combustion chamber system must be equipped with water purging facilities, specifically to be used during shutdown condition. Other items that must be observed in the piping system are valves. In principle, the valves to be used must be sufficiently resistant against CWS erosion, minimize plugging of the flow, and the valve easily be adjusted for the flow. Usually, valves with many curves at the body should be avoided for CWS application. Valves that can be used at the CWS piping.

*There are Two Alternatives for the Fuel Change Over*

i. To retrofit existing boilers with new CWS burner system and modify the combustion chamber.

ii. To replace the boilers and the burner system with new ones specially designed for CWS fuel Favorable differential economics of replacing the boilers over retrofitting the boilers warrant replacing the old age boiler with new boiler, specifically design for CWS fuel. The caloric value of the coal for the CWS is calculated for optimum boiler size and burner design to fit existing space.

iii. Replacing the boiler, the life expectancy of the plant can be extended by approximately 30 years.

*Coal Water Slurry Technology is Preferred over Coal Gasification & Coal Pulverization*

- High combustion efficiency
- Low in pollution discharge
- With good fluidity
- Stable during storage
- Can be transported like liquid using pipeline network.
- Reduce combustion temperature about 3 to 5%, the temperature drop has taken place as a result of heat utilized to vaporize water.
- Improve environment.
- CWS has high combustion efficiency (generally above 95 to 98%)
- Low in wastage (Sealed storage and transportation) and easy to control
- Energy saving effect is remarkable.
- The combustion efficiency increases by more than 10% which can save energy by more than 20%.
- The coal particle size for CWS is finer than the particle size of coal in the pulverized coal boiler.
- The SOX and NOX emission is within clean technology limits.
- Lower dust particle pollution and gas emission.

Due to volatility and high moisture content the available resources of local indigenous coal are only meant for CWS combustion technology.

*Cost Comparison with other Fuels*

Following table gives a general idea of cost per KWh from different fuels for Power Generation.

| Sr.No | Description | Cost per KWh (Rs) |
|---|---|---|
| 1 | Natural Gas | 4 -9 |
| 2 | Furnace Oil | 21-24 |
| 3 | Diesel | 22-26 |
| 4 | CWS | 6-9 |

The per unit (KWh) energy cost of CWS is almost at par to Natural Gas, i.e. Rs 6-8 per Kwh. The Cost comparison is as following.

- 65-75 % cheaper than Furnace Oil.
- 70-75 % cheaper than Diesel Oil.
- 5-10 % expensive than Natural Gas.

The Per Ton equivalent cost of CWS is Rs. 26254/- (approx.) as compared to Furnace Oil cost of Rs.70560/-

**Combustion/Overall Boiler Efficiencies & Specification Comparison of different Coal Technologies**

| S. No. | Description of Fuel | Fuel Combustion Efficiency (%) | Overall Boiler Efficiency (%) |
|---|---|---|---|
| 1 | Coal Water Slurry (CWS) | 96 – 99+ | 90+ |
| 2 | Fluidized Circulating Bed (FCB) | 95 | 84 |
| 3 | Pulverize Coal (PC) | 98 | 84 |
| 4 | Coal Gasification | 88- 90 | 87 |

| Items | CFB Boiler | PC Boiler | CWS boiler |
|---|---|---|---|
| Surrounding environment | The surrounding environment is relatively dirty because of coal storage and coveying system. | The surrounding environment is relatively dirty because of coal storage and coveying system. | The surrounding environment is clean ( the fuel is conveyed by tank trucks and pipes.) |
| Safety | Low(the fuel may self ignite.) | Low(the fuel may self ignite.) | High(the fuel will not self ignite) |
| Stability | Relatively poor(the stability of the boiler depends on the stability of the crushing system) | Poor(The stability of the boiler depends on the stability of the pulverizing system) | Good (the CWS preparing system is separated from the boiler system so that the two systems are of mutual non-interference.) |
| Others | The boiler furnace is big and tall, which means the initial investment will be very large. The auxiliary power consumption runs up to 7%. The furnace will be severely worn, which may in turn affect the operating stability and the annual operating hours. | The coal quality change may greatly influence the operation of the boiler | 300-350°C ) Relatively high hot air temperature required (300-350°C) |

| Items | CFB Boiler | PC Boiler | CWS boiler |
|---|---|---|---|
| Heating Value of Fuel （kj/kg） | 18392 | 20900 | 18560 |
| %）Combustion Efficiency | >95 | >98 | >99 |
| Calculated Thermal Efficiency（%） | 86 （As per ASMEPTC4.1，based on HCV) | 86.5 | 87 |
| t/h）Fuel Consumption | 71.5 | 62.2 | 69.2 |
| Investment | Higher(with big & tall furnace, coal yard and crushing system required) | Higher(coal yard and pulverizing system required) | Lower |
| Emission | NOxCoarse dust particle, low emission of Nox | SO2、NOx High emission of dust, SO2 and Nox. | Nox Relatively low emission of Nox |
| Occupied area | Large (coal yard and crushing system required) | Large (coal yard and pulverizing system required) | Small (the fuel is stored in tanks and conveyed by pumps) |
| Load regulating performance | Poor load regulating performance | Poor load regulating performance | The boiler load can be controlled by the transducer of CWS pump smoothly. |
| Operation | Relatively complex(in terms of the operation of the crushing system) | Complex( caused by the pulverization system) | Simple( it can be controlled automatically) |

*Ideal Fuel for utilizing Local Indigenous Coal*

The local coal has high moisture content ranging from 16% to 47% and volatile matter ranging from 19% to 39%. These two specifications makes the utilization of local coal not possible in other coal technologies such as pulverization but contrary to these specifications are best utilized in Coal

Water Technology as water is an integral part of Coal Water. Moreover it makes coal explosion proof.

*Conversion of Existing Furnace fired Power Plants*

The present Furnace/Gas Fired Steam Power Plants can be converted to Coal Water Technology by minor retrofitting of existing boiler at minimum capital cost on fast track basis.
Coal Water can be burned in an oil/natural gas-designed boiler with a little retrofitting work in a short period.
In the industrial and commercial markets, fire tube boilers represent the major portion, about 70 percent, of small oil and gas fired boilers are fire tube and rest are water tube. Annually, these boilers consume 10% of the total energy used in combined industrial and commercial market sectors. Thus, replacing the premium fuels now used in these markets with CWS would accomplish a significant reduction in oil and gas consumption.

*Important Steps in Conversion of Water Tube Boiler on CWS Fuel*

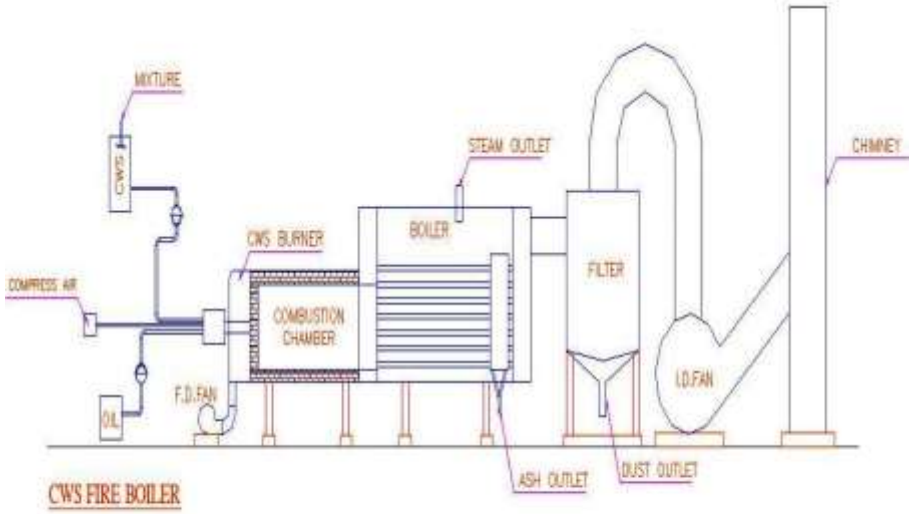
- The existing burner will be modified along with the new CWS nozzle with compressed air system. Whereas, the existing furnace oil firing system will remain as it is.
- The F.D fan/supply air fan/ I.D fan will be additional installed to maintain the requirement of CWS.
- In furnace area, we have to generate ash discharge system.
- At boiler exhaust after economizer a cyclone will be installed along with filter for dust control.
- Boiler must have economizer and per-heater to improve the efficiency in CWS firing system.
- De-sulfurization system will be installed in the boiler stack.
- The existing furnace oil tank will be modified with agitators/mixers.
- The existing furnace oil piping can be modified and installed for CWS supplied system.

New compressed air system will be installed to supply compressed air to the CWS burning system

*Important Steps in Conversion of Fire Tube Boiler on CWS Fuel*

- Install Pre combustion chamber.
- Install New CWS/Oil Fire Burner on pre combustion chamber.

- Install All CWS Burner Accessories include CWS Tank with agitator, pumps, Compressed Air Lines, Oil Tanks for pilot burner and burner control system.
- Modifying boilers for collection of Ash.
- Install back filters at exhaust for collect dust in flue gases.
- In case of High Sulfur: desulfurization plant will be installed to treat the flue gases.
- ID Fans will be installed at inlet of chamber.




Water-tube boilers dominate large industrial and utility application and, as the name implies, are designed differently than fire tube boilers. In water tube boilers the combustion gases flow outside and around tubes filled with water, which is heated to produce steam. In fire tube boilers, however, heat is transferred from hot combustion gases flowing inside tubes to water contained in the shell that surrounds the tubes. Because the shell of the fire-tube boiler must withstand the pressure of the steam produced, high pressure and large boiler sizes (i.e. large shell diametres) would require extremely thick shell walls. Thus fire tube boilers have smaller capacities than water-tube boilers.

The FO/NG fired water tube boiler can be converted into CWS combustion technology by replacing the burner of existing boiler to CWS fired burner. These burners are also available in dual firing. A pre heating system of the furnace should be setup to attain the required temperature because CWS does not attain the specific temperature quickly. A diesel firing must be done at first then after temperature is attained, CWS is fired.

Besides the burner, high pressure ceramic's nozzle is also needed for CWS combustion. These nozzles maintain the velocity and rate of CWS firing.

The nozzles are specially design for CWS combustion purpose and are patient by Zhejiang University.

*Low Pressure boilers Steam Cost Comparison*

Coal Water Slurry fired Fire Tube process Boilers are ideal for usage in Process industry. It is not only environment friendly and can be stored within the premises of highly sensitive industries towards pollution and the existing fire tube boilers on Natural Gas & Furnace Oil can be retrofitted to CWS combustion technology on financially viable terms on fast track basis. The end product that is the process steam is cost effective as compared to other combustion fuels. A comparison is stated below.

| **Furnace Oil** | | |
|---|---|---|
| Furnace Oil required per ton steam | 68 | Kg/Ton |
| Cost of Furnace Oil | 78 | Rs/Kg |
| Cost of steam Per Ton | **5304** | Rs |

| **Natural Gas** | | |
|---|---|---|
| Gas required per ton steam | 80 | m3/Ton |
| Cost of Gas | 17.5 | Rs/m3 |
| Cost of steam Per Ton | **1400** | Rs |

| **Rice Husk** | | |
|---|---|---|
| Heat Required | 665096 | Kcal |
| Rice Husk Required(3000KCal/Kg) | 215 | Kg |
| Rice Husk Cost | 8 | Rs |
| Steam Cost Per Ton | **1716** | Rs |

| **Wood 665096 Kcal** Heat Required | | |
|---|---|---|
| Wood Required(2500KCal/Kg) | 266 | Kg |
| Wood Cost | 8 | Rs |
| Steam Cost Per Ton | **2128** | Rs |
| **CWS** | | |
| Heat Required | 665096 | Kcal |

| | | |
|---|---|---|
| Coal Required (5000KCal/Kg) | 133 | Kg |
| CWS Required | 190 | Kg |
| Cost of CWS | 8.51 | Rs/Kg |
| Cost per Ton of Steam | **1619** | **Rs** |

*Application of CWS Technology in Industries: 7 classes*

i. Electricity Power
ii. Petroleum Chemical
iii. Coal
iv. Metallurgy
v. Glass
vi. Ceramic
vii. Chemical

*Boiler Application: 3 Classes*

i. Power stations
ii. Industrial boilers
iii. kilns

*Furnaces Retrofitted to CWS Fuel: 6 Classes*

i. Four-corner
ii. T-fired boiler
iii. Fluidized bed boiler
iv. U-type boiler
v. D-type boiler
vi. H-fired boiler

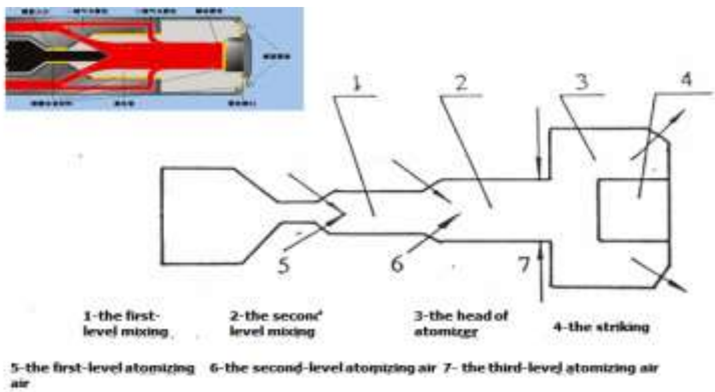
## Environmental Parametres of CWS Technology

*Environmental Advantages*

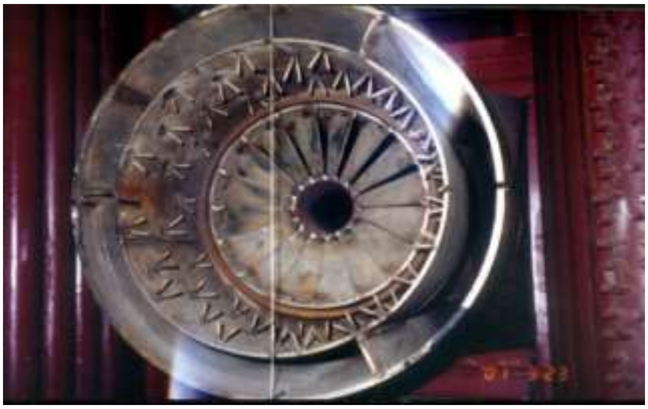
Coal Water Slurry (referred to CWS") is a coal based liquid-fuel, environment friendly, it is a proven clean fuel technology for power generation. Coal Water Slurry is an energy source with lower pollution which will contribute to improve environmental protection; it is easier in handling with convenience in storage, transportation and combustion, just like Heavy Oil, overcoming the disadvantages of solid coal. It has high combustion efficiency and low in pollution discharge. By applying transportation through pipeline, the pollution caused by coal dust particles can be reduced. On the other hand, CWS combustion will reduce combustion temperature about 3 to 5%. The temperature drop has taken place as a result of the heat utilized to vaporize the water. The decrease of the combustion temperature will reduce the formation of NOx gas. In the process at high temperature, where water and coal in the CWS could react producing CO and H2 which will accelerate combustion process. By using energy source economically and rationally; this improves environmental impact. In order to produce Coal Water Slurry, the coal needs to be pulverized and then mixed with water to cause the production of coal slurry with low sulfur content which will satisfy the air pollution regulations. CWS has high combustion efficiency (generally above 95% - 98%). CWS combustion is low in wastage (sealed storage and transportation) and easy to control. The energy-saving effect is remarkable. By using CWS as fuel, the combustion efficiency increase by more than 10%, which can save energy by more than 20%. The Coal Water Slurry (CWS) is made by mixing pulverized coal with water and small amount of chemicals; the coal as CWS is then transportable by pipeline. Conversion of coal to CWS is technically and logistically attractive because it opens the possibility to exploit coals mines remote from rail and highway system, economically and sold as Coal Water Slurry. This suggest lower transportation costs than by using conventional transportation methods, from area lacking rail and road facilities, which will reduce heavy vehicles traffic for coal transportation, significantly, and ultimately reduce the road maintenance. The coal particle size for CWS is finer than the particle size of coal in the pulverized coal boiler. This is connected with the CWS stability and improvement of combustion efficiency. In order to achieve product stability and its flow properties meeting the fuel specification, additive as surfactant is added into the CWS product. The quantity is in the range of 1–4% of the total CWS. Flash emissions depend on the fuel ash content in the slurry. Chemical characteristics of CWS ash are generally found to be similar to those of the parent pulverized coal in large boilers where carbon conversion is high. However, the bulk density of CWS ash is lower and, other conditions being equal; its deposition in the furnace is drastically reduced which will improve environment conditions. Compatible calorific value with the caloric value of the fuel to be replaced, For new power plants, coal with GCV of 4200 to 6100 kcal/kg can be used as CWS raw materials. Stable during the combustion, it must be reactive that can reduce the saturation effect resulted by the mixing with water during the combustion.

The key parametre which must be observed in this phase is to determine the particle size of the coal and the coal concentration in the CWS that will be used. For CWS, the size of coal particles to be used should be smaller size distribution than the pulverized coal for fuel, which is about 40-50 micrometre. That is done, in order to obtain good flow characteristics and to prevent coagulation especially at the nozzle area. The next parametre is to determine the coal concentration to be us as CWS. The limitation of coal concentration is the fluidity of CWS which is measured in viscosity unit (dimension). The higher the coal concentration in CWS, the higher the viscosity which means the fluidity will be owner. On the other hand, the lower the coal concentration in CWS then the calorific value of CWS will be smaller and this means the heat release will be smaller. At this point in time the good coal concentration in the CWS is in the neighbourhood of 70%, which at this concentration the CWS fluidity is still within acceptable limit. Other than aforementioned coal properties, another property required is to stabilize the coal particles in the CWS; this is necessary because of the basic difference properties between coal as solid material and water as liquid, of which if the two are mixed, the coal tends to precipitate in the water. To prevent precipitation, a surfactant agent as additive is required, in order to generate coal dispersed stabilization in the water. This stable state can be maintained by mixing additive of natural gum type of material or usually polysaccharide is used in the mixture of coal.

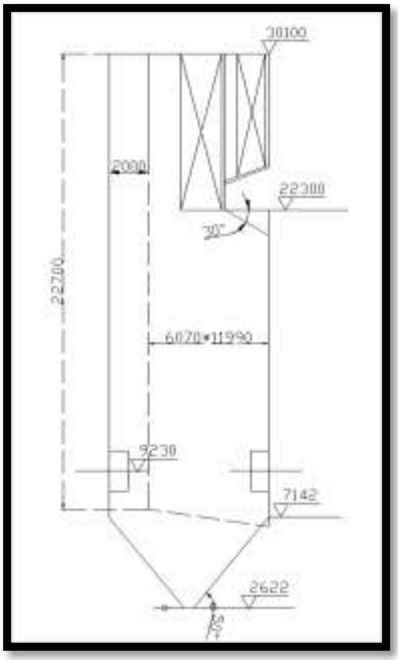
**CWS Combustion Technique (As to how the environmental advantages are achieved)** The combustion process is as follow:




CWS is a boiler burner fuel. The burner has specially designed high pressure ceramic nozzles. The nozzles ensure the steady ignition and high efficiency combustion. The nozzles make the efficiency of CWS Boiler equal to coal powder boilers, so as to ensure the economic competition ability of CWS. As the length of CWS torch increases, and the flame emissivity changes it keeps the temperature of flue gases at the exit of furnace low enough and makes wide load adjustment. The major function of high pressured ceramic nozzles is to atomize CWS with high viscosity well.

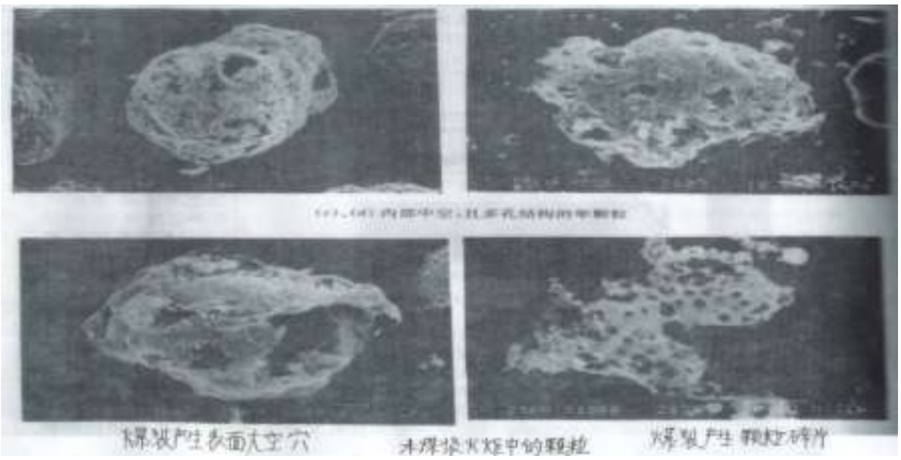


The difference between CWS and natural gas in terms of combustion characteristics determines that the volume heat release rate as required by the CWS Boiler is different from that of natural gas boiler. Therefore, the furnace needs to be retrofitted in case of Conversion from natural gas or furnace oil to CWS combustion technology and consequently the heating surface area of furnace has to be increased. For new CWS fired Boilers the volume heat release rate as required by CWS is taken into consideration during the design and execution phase. The boiler load after retrofit will remain the same as the original boiler.



When CWS is fired, the furnace temperature reduces from 3% to 5% because of the presence of water in CWS, thus the flame temperature in CWS combustion is lower by 100~150℃ than that in pulverized coal combustion. Thus, the pollutants emissions of fly ash, SOx and NOx are low in CWS combustion. The 50 micron particles of Coal in CWS catches fire at a temperature lower by 100~150℃ than that in pulverized coal, thus higher heating value is obtained at lower temperature which is the major cause of less pollutants emission.

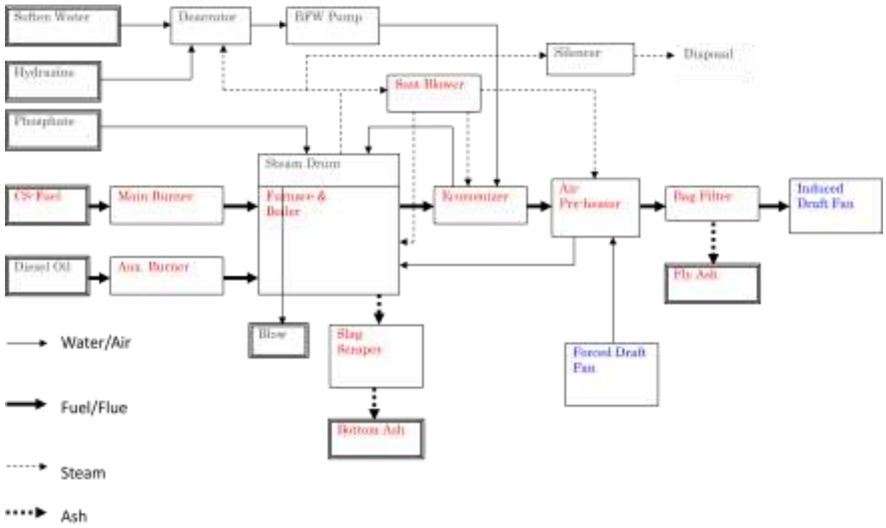
CWS has high combustion efficiency of 99%, in the process at high temperature, where water and coal in the CWS could react, producing CO and H2 which will accelerate combustion process. The Oxygen in primary and secondary air through pumps engulfs the 50 micron particle of coal and burns the inbuilt moisture of the coal as well, thus the coal of high moisture content can be used. The high combustion efficiency leaves less un burn material hence less physical and flu gas pollution.



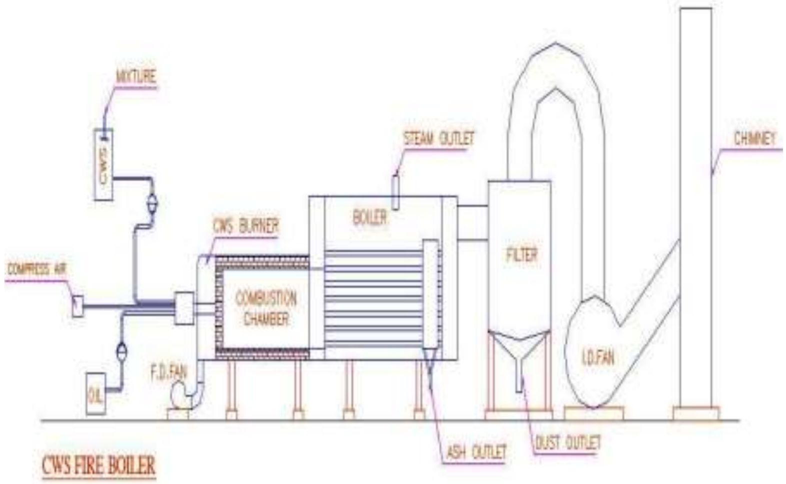

*CWS after the Evaporation Process*

At the exit point of the boiler dust filter will be installed. The type of dust collector to be installed will be determined in accordance with the dust emission standards issued by local environmental protection authorities. Normally ESP will be adopted if the dust emission standard is 200mg/Nm3 or above, while filter type dust collector will be required if the emission has to be controlled below 50mg/Nm3.

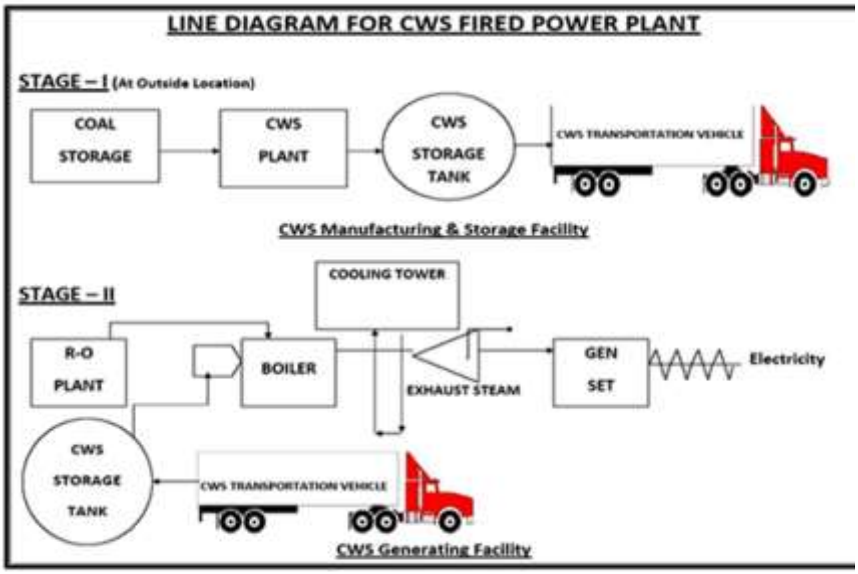
Due to liquid state of CWS, while firing it, prevents the furnace from slugging. Designed speed of flue gas at the tail heating surface is higher, when retrofitted to CWS boilers to prevent the abrasion by ash, and to prolong the life-span the boiler. The removal of ash in Water tube Boiler will be conducted at the bottom part of the boiler. The bottom heating surface after retrofit will still be membrane walls. The main retrofitting method is to change the original flat bottom membrane into hopper structure so that the tubes of bottom side will not be weakened.




For fire-tube boiler an ash collecting duct is induced in the tubes as shown in the figure, Install Back Filters at exhaust for collect dust in flue gases. In case of high sulfur; desulfurization plant will be installing to treat the flue gases.

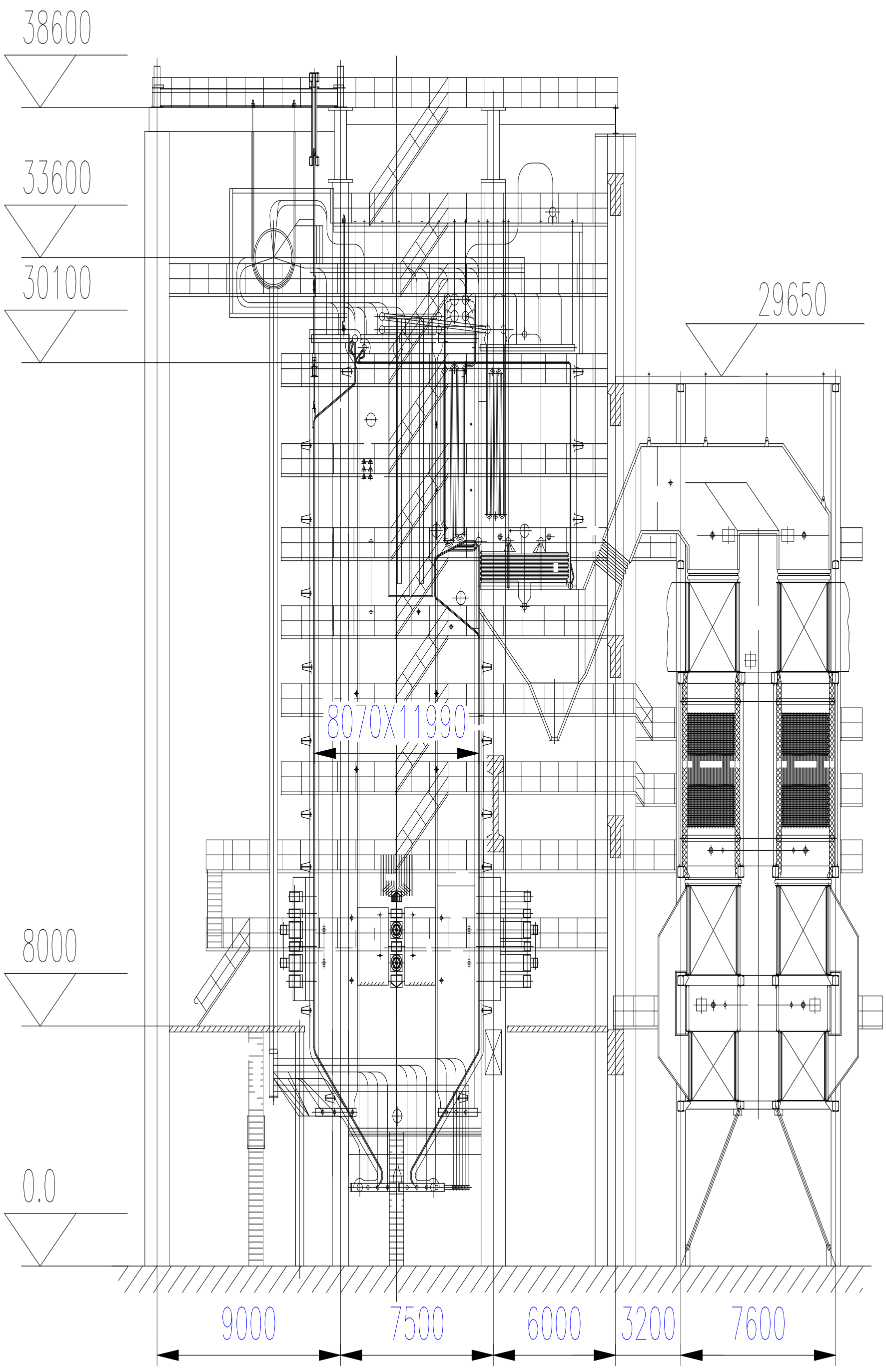



CWS as an advanced clean coal technology is an ideal oil-replaced fuel because it can be conveniently and cleanly stored, transported atomized and burned like oil. CWS can be transported in a large amount of 5~10Mt/a through a long distance of 500~1000km.



## Real Time Scenario for Environmental & Emission Parametres

### 1- Nanhai Power Plant, Guangdong, China



| **Measure items** | **Units** | **100% Load** | **80% Load** | **70% Load** |
|---|---|---|---|---|
| SH Steam flow | T/h | 408.5 | 336 | 287 |
| SH Steam pressure | MPa | 9.56 | 9.25 | 9.57 |
| SH Steam temperature | ℃ | 536 | 537 | 536 |
| Feed water temperature | ℃ | 227.5 | 231 | 227 |
| Water flow in de super heater | T/h | 16.9 | 19.5 | 17.3 |
| CWS consumption | m3/h | 51.2 | 41.9 | 37 |
| Flue gas temp. at boiler outlet | ℃ | 144.9 | 144.6 | 138.8 |
| Heat loss of the flue gas | % | 7.55 | 8.21 | 8.42 |
| Carbon content in fly ash | % | 2.58 | 2.2 | 2.7 |
| Carbon content in bottom ash | % | 2.17 | 1.76 | 0.14 |
| Heat loss of the unburned carbon | % | 0.27 | 0.32 | 0.26 |
| Heat loss due to the diffusion through walls | % | 0.59 | 0.72 | 0.85 |
| Combustion efficiency | % | 99.73 | 99.68 | 99.74 |
| Boiler efficiency ($\eta$) | % | 91.53 | 90.7 | 90.43 |

2- **Four 220t/h (50 MW) oil-fired boilers are retrofitted to 100% CWS fuel. The SH steam load reaches 100% in Maoming power plant and 85% in Shantou power plant.**

| **Measure items** | **Symbol** | **Units** | | | | |
|---|---|---|---|---|---|---|
| | | | 40% | 50% | 60% | 80% |
| SH steam flow | D | t/h | 88 | 106 | 132 | 176 |
| Flue gas temp. | $t_{py}$ | ℃ | 133.0 | 134.7 | 131.5 | 145 |
| Heat loss of the flue gas | $q_2$ | % | 6.762 | 7.271 | 6.762 | 6.734 |
| Carbon content in bottom ash | $C_{hz}$ | % | 2.4 | 2.4 | 2.15 | 1.92 |
| Carbon content in fly ash | $C_{fh}$ | % | 3.27 | 2.15 | 2.052 | 3.65 |
| Heat loss of the unburned carbon | $q_4$ | % | 0.344 | 0.226 | 0.220 | 0.382 |
| Heat loss of the unburned gas | $q_3$ | % | 0.052 | 0.033 | 0.050 | 0.039 |
| Heat loss due to the diffusion through walls | $q_5$ | % | 1.64 | 1.36 | 1.09 | 0.82 |
| Boiler efficiency | $q_1$ | % | 92.23 | 91.11 | 91.88 | 92.03 |
| Combustion efficiency | $q_r$ | % | 99.60 | 99.74 | 99.73 | 99.58 |

Based on the above actual environmental parameters of CWS combustion technology and research, the comparison with local international NEQ standards is

| S No | Parameters | CWS Operational Data (mg/Nm3) | NEQS Revised Standards (mg/Nm3) Pakistan | NEQS Revised Standards (mg/Nm3) International |
|---|---|---|---|---|
| 1 | NOX | 450 | 1200 | 940 |
| 2 | SOX | Less than 600 | 1700 | 1300 |
| 3 | Dust | Less than 100 | 500 | 400 |

## Conclusion

- Coal Water Slurry (CWS) is an ideal source of energy both at Generation & Grids.
- Less infrastructure cost
- Coal Water Slurry (CWS) is a new type of liquid fuel, environment friendly fuel that can replace petroleum as fuel in the energy conversion and process industries.
- Coal Water Slurry (CWS) can be made using low quality coal with high moisture content & volatile matter, most suitable for local indigenous coal.
- CWS has oil like appearance, can be handled like liquid, burns like oil and coal, the cost is just slightly higher than coal. It resembles Heavy Fuel Oil with good fluidity; therefore, stable during storage and can be transported conveniently like liquid, through pipes and by pumps.
- The capital investment costs is very low relative to coal gasification and liquefaction processes, which can be more than US$6.5 billion for a 100,000 BPSD complex, as compared to US$150 million for CWS of the same size.
- It has high combustion efficiency and low in pollution discharge.
- The successful introduction of CWS technology into the industries, in China, to replace heavy fuel oil has a very significant impact in the utilization of low rank coal, for new 100 Thermal Power Plants. The simultaneous and parallel development of advanced coal cleaning technologies as in the case of CWS could allow Pakistan to make a

fast transition, economically, away from our limited resource of oil and natural gas to our most abundant resource of coal. Coal based CWS will be the fuel of this century and beyond.■

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# ENERGY CONSERVATION THROUGH REDESIGNING OF BUILDINGS

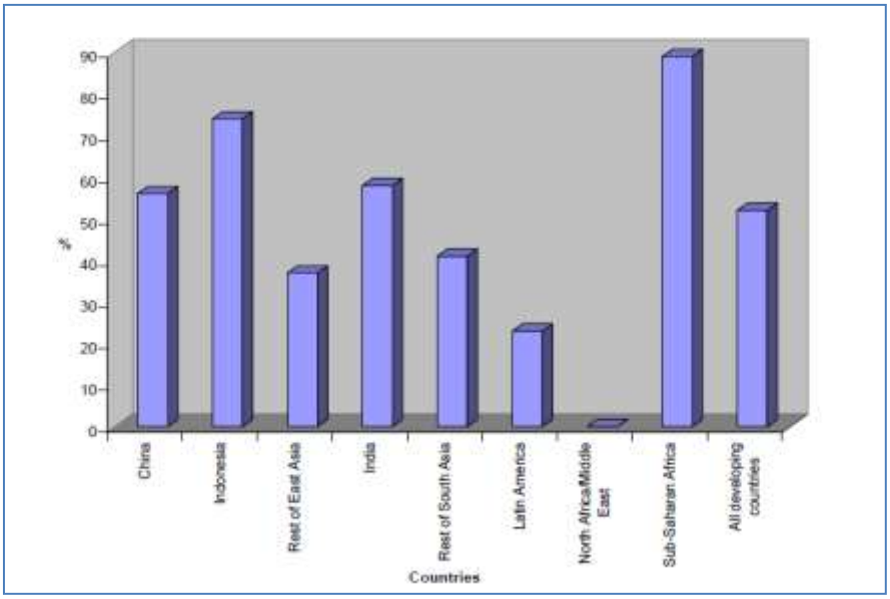
**Dr. Ashfaq Ahmed Sheikh**

## Preamble

Access to energy is fundamental to fulfilling basic social needs, driving economic growth and fuelling human development. This is because energy services have an effect on productivity, health, education, safe water and communication services. With the passage of time, the growing needs for sustenance and improved living standards have been asserting the demand to explore and acquire more energy resources. Significant changes occurred in the past 50 to 60 years, as advances in productivity and evolution of technology enabled higher living standards and better lifestyles for the people (Exxon, M., 2013). The population of the world will rise by more than 25 per cent from year 2010 to 2040, reaching nearly 9 billion. All these developments coupled with changes in the nature and scope of regulations, are all transforming the energy landscape. On average, the poorest 2.5 billion people in the world use only 0.2 TOE (tonnes oil equivalent) per capita annually while the billion richest people use 5 TOE per capita per year, which is 25 times more. In 2011, per capita energy consumption in the United States of America (USA) was 7.28 TOE as compared to 0.45 TOE in India and 0.487 TOE in Pakistan (USA Energy Efficiency Report, 2012). However, per capita electricity consumption for USA is about 1.0 TOE whereas in India and Pakistan it is 0.064 TOE and 0.035 TOE respectively.

The household sector accounts for 15 to 25 per cent of primary energy use in developed countries whereas this share is relatively higher in developing countries (Oleg D. and Ralph C., 1999). The estimates show that 2.6 billion people still lack access to modern cooking fuels even though electricity generation has grown much over the last two decades. Figure 1 shows the per cent of population still using biomass for cooking and heating in developing countries (Modi et al., 2005). Although the household sector does not have major share in total energy consumption it plays a central role in demand and supply perspective. The household consumption per capita varies by region and reflects dramatic differences where a variety of factors are involved. The climatic conditions in which we live, our incomes, and the efficiency of our homes and appliances, all play pivotal role in our household energy consumption. According to the US Energy Information Administration (EIA), homes built since 1990 are on average 27 per cent larger than homes built in earlier decades. Between 2010 and 2040, residential demand in the OECD countries (Organization of Economic Cooperation and Development) will decrease, whereas in the Non-OECD countries it will go up by about 35 per cent (Exxon M., 2013). Heating and cooling are the main energy usage in buildings. The use of air conditioners is estimated to triple before 2030. Most of this energy is wasted due to inadequate insulation.

**Fig: 1**
**Per cent of Population using Biomass for Cooking and Heating in Developing Countries**




Despite low per capita energy and electrify usage, Pakistan is facing acute shortage where load shedding at household level ranges from 6 to 18 hours and industrial sector is facing complete or partial closure from 2 to 3 days per week. Besides, developing new power sources, minimizing line losses and circular debt issues, the energy conservation and efficiency in supplies and consumption are equally important for the industry as well as for the household sector.

Energy consumption in houses is highly dependent upon their design besides energy use habits. Building design with less energy consumption is not just the outcome of applying one or more isolated approaches or technologies but it is an integrated process that requires optimal combination of building layout, architectural design, materials, appliances and implementation (Department of Energy USA, 2001). According to an analytical study, a building design with good energy saving provisions may cost extra 15 – 20 per cent whereas it can save 30 per cent or more in energy costs than on a conventional building design.

Since energy development and management are regulated by the government sector, therefore the sustainability of energy resources, requires safe and energy efficient building design, especially in light of the recent strengthening of regulation and standards such as ISO 50001, an international standard for energy management issued in June 2011. It is absolutely imperative that we improve energy efficiency in buildings by incorporating international best practices appropriate to our environment, coupled with traditional materials, technologies and craftsmanship developed indigenously over a very long time.

## International Standards for Energy Efficient Buildings

The minimum benchmarks and standards formulate the basis for designing an energy efficient building. The criteria and benchmarks may vary from one region to another and based on the desired level of perfection or regulatory requirements. However, the fundamental principle is to design buildings to save energy or minimize energy utilization.

### *International Energy Conservation Code (IECC)*

Internationally, the designers and architects recognize the need for a modern up-to-date energy conservation code for dressing the design of an energy efficient building envelope and installation of energy efficient equipment, lighting and power systems with emphasis on performance. The International Energy Conservation Code, as a dynamic document, was developed to meet these needs through model code regulations that will result in the optimal utilization of fossil fuels and non-depletable resources in all communities large and small (International Code Council, 2013). This comprehensive energy conservation code establishes minimum regulations for energy efficient buildings using prescriptive and performance-based provisions. It is founded on broad-based principles that make possible the use of new materials and new energy efficient designs.

### *Leadership in Energy and Environmental Design (LEED)*

LEED (Leadership in Energy and Environmental Design) is a voluntary, consensus-based, market-driven programme that provides third-party verification of green buildings (LEEDS, 2013). LEED consists of a suite of rating systems for the design, construction and operation of high performance green buildings, homes and neighborhoods. Developed by the US Green Building Council (USGBC), LEED is intended to provide building owners and operators a concise framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions. Since its inception in 1993, the US Green Building Council has grown to encompass more than 7,000 projects in the United States and 30 countries, covering over 1.501 billion square feet of development area. The hallmark of LEED is that it is an open and transparent process where the technical criteria proposed by USGBC members are publicly reviewed for approval by the almost 20,000 member organizations that currently constitute the USGBC.

LEED certified buildings are intended to use resources more efficiently when compared to conventional buildings simply built to code. LEED certified buildings often provide healthier work and living environments, which contributes to higher productivity and improved employee health and comfort. The USGBC has compiled a long list of benefits of implementing a LEED strategy, which ranges from improving air and water quality to reducing solid waste, benefiting owners, occupiers, and society as a whole.

*Energy Star*

ENERGY STAR is a national programme from the US Environmental Protection Agency and the US Department of Energy. The programme includes a system that rates furnaces, water heaters, major appliances, and electronics such as televisions and computers based on energy savings and carbon emissions. ENERGY STAR'S website (www.energystar.gov) includes the ratings as well as suggestions for energy efficient home improvements and buying an energy efficient new home.

*Building Code of Pakistan-Energy Provisions 2011*

Although there are some standards for load connectivity and design layout being followed loosely in Pakistan but energy efficiency and conservation in building design is yet a far cry. The recent development of Building Code of Pakistan-Energy Provisions 2011 is a significant step towards energy efficient building design. The Code, as its Phase-I, is applicable to buildings and building clusters that have a total connected load of 100 kilo Watts or greater, or a contract demand of 125 kVA or greater, or a conditioned area of 900 $m^2$ or greater, or unconditioned buildings of covered area of 1,200 $m^2$ or more. The scope of the Energy Provisions is applicable to provide minimum energy-efficient requirements for the design and construction of new buildings and their systems; new portions of existing buildings and their systems, if the conditioned area or connected load exceeds the above prescription.; new systems and new equipment in existing buildings; and increase in the electricity load beyond the set limits.

These Energy Provisions are compatible with relevant standards of ASHRAE, ANSI, ARI, ASTM etc. The only exception is Section-4 Building Envelope, which has been developed keeping in view Energy Codes of regional countries and the local environment. The Code extends over nine different sections to cover the regulatory and building design aspects while maintaining minimum energy-efficient requirement.

| | |
|---|---|
| Section – 1 | Purpose |
| Section – 2 | Scope |
| Section – 3 | Administration and Enforcement |
| Section – 4 | Building Envelope |
| Section – 5 | Heating, Ventilating and Air Conditioning |
| Section – 6 | Service Water Heating |
| Section – 7 | Lighting |
| Section – 8 | Electrical Power |
| Section – 9 | Definitions, Abbreviations and Acronyms |

The Code is not applicable to the buildings that do not use either electricity or fossil fuel, government notified historically significant and heritage buildings, and equipment and portions of building systems that use energy only for manufacturing processes. The purpose of Energy Provisions-2011 is to provide minimum requirements for energy-efficient design and construction of buildings. This would help developing a culture for energy saving in construction of buildings and thereby saving on energy bills. The future development of Energy Provisions-2011 shall encompass low-end users and buildings, if deemed necessary upto 10KW and/or of appropriate covered area.

For the effective implementation of the energy provisions, besides extensive training programmes, there would be trained certified Energy Managers and energy Auditors jointly by Pakistan Engineering Council and ENERCON.

## Best Practices For Energy Efficient Building Design

Energy efficiency in buildings is not only possible due to energy efficient design but it is also dependent upon the management and operational practices to conserve energy and enhance overall system efficiency. The design and management considerations are more or less similar for the designing of new as well as the existing buildings.

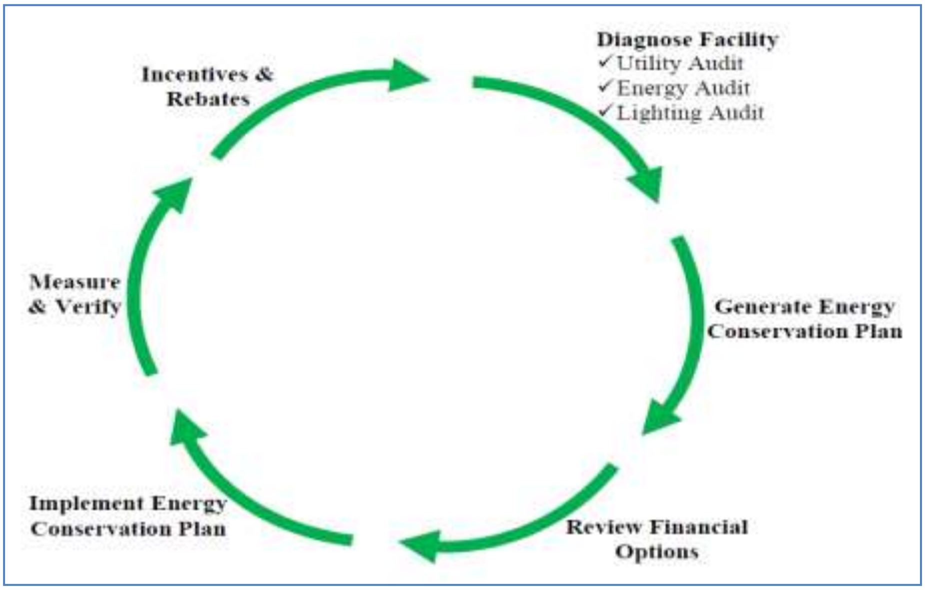
*Energy Conservation through Management*

In an energy efficient house, it is possible to reduce annual energy bills by up to 40 per cent as compared to an average built house. Under the present and future energy situations, home owners should consider developing an energy conservation plan for their homes, which is not only environmentally friendly but also economically sound.. It is possible even in the existing homes to adopt energy saving approaches, as one is given below;

- Identify the areas in the home where energy is being lost or inefficiently used;
- Prioritize the areas according to how much energy is being lost or inefficiently used; and
- Step by step correct the problems according to the limits of your energy saving budget.

The following process is being widely followed in developed countries incorporating performance based redesigning of buildings with focus on energy conservation and efficiency, which is very much in line with the above approach starting from diagnostic analysis of facility, developing energy conservation plan in the light of financial options, implementation of plan, then measuring and verifying the changes/ system efficiency towards savings and rebates.

**Fig: 2**
**Result-oriented Energy Efficiency Process**



As a case study, the management measures taken by Pakistan Engineering Council in 2009, starting from energy audit of its headquarters building at Islamabad and replacing energy efficient lighting (LEDs and energy savers), helped saving upto ten times of the existing lighting load and thereby saving on the energy bills.

*Energy-efficient Building Design Considerations*

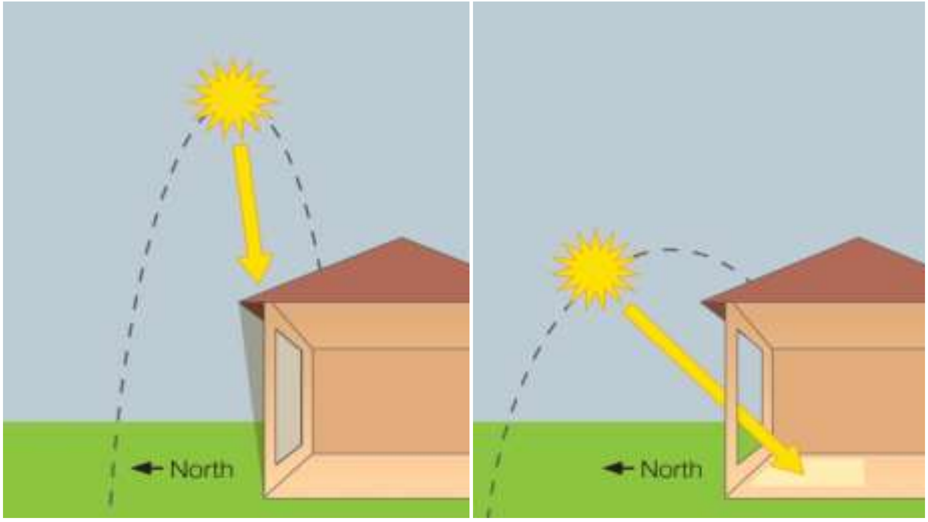
The design of an energy-efficient building may range from a sophisticated multistoried mall to a double story residential house. Bringing existing homes up to energy high performance will be a major challenge in the years to come. The homes can be brought to various levels of efficiency, ranging from a simple weatherization to an extensive remodelling where deep energy savings and rebates are available. For a home to be energy efficient it needs to have all the right elements of design including the following considerations.

*Building Orientation, Form and Layout*

The theoretical direct solar radiation incident on differently oriented surfaces should be analysed in building design especially with energy saving consideration. The home should be orientated and located on a block to maximise the amount of sunlight it receives. When selecting a block of land consider: the size, orientation and slope of the block to maximise sunlight entry; tree coverage and height to avoid too much shading; and height and proximity of surrounding buildings to avoid overshadowing. The ideal orientation for the building is therefore identified by checking the chosen building form (single storey, long and narrow building etc.) and for suitable orientation, the exact heat and/or cold load is determined. The ideal location considers daytime living areas facing north and the long axis of the house running east to west.

Daytime living areas should be located on the north side with large north facing windows to capture the winter sun. Bedrooms and utility areas should be located on the south side (Figure 3). If the design allows it, bedrooms and other rooms can also face north. Variations on house orientation can occur if the house cannot be located facing north, upto 30 degrees east or 20 degrees west of true north. In these cases, extra shading may need to be considered for summer. Large windows on the north side of the house let the sunshine in during winter because of the low angle of the sun. Eaves prevent sunshine entering the house in summer because of the high angle of the sun.

**Fig: 3**
**Building Orientation for Summers and Winters**




**Summer sun:** The sun is higher as it moves across the sky in summer

**Winter sun:** On winter days the sun is low in the sky as it moves from east to west

*Lighting*

Preference should be given to design a building where no artificial lights would be needed in the daytime. This is more complex than it sounds because artificial lighting is required even in buildings where window areas for adequate day lighting have been provided. It has been experienced that many people prefer to switch on artificial lights after blocking out all natural light by curtains, particularly in summer.

The culprit for this seemingly irrational behaviour is glare from window areas, large or small. Glare is not a function of brightness or size of light source but of contrast. Car headlights cause acute glare on a dark road, much less on a properly lit road and are barely perceptible during daytime. Office spaces, day-lit from one side (Figure 4) will always suffer from glare problems because of the contrast between the window and the window wall. In the absence of supplementary artificial lighting, such spaces will bear a 'gloomy' character. The problem can be rectified by lighting a workspace from two opposite or adjacent walls (Figure 5). Unless specially designed, skylights can also cause glare.

**Fig: 4**
**Glare Due to Day Lighting from One Side**

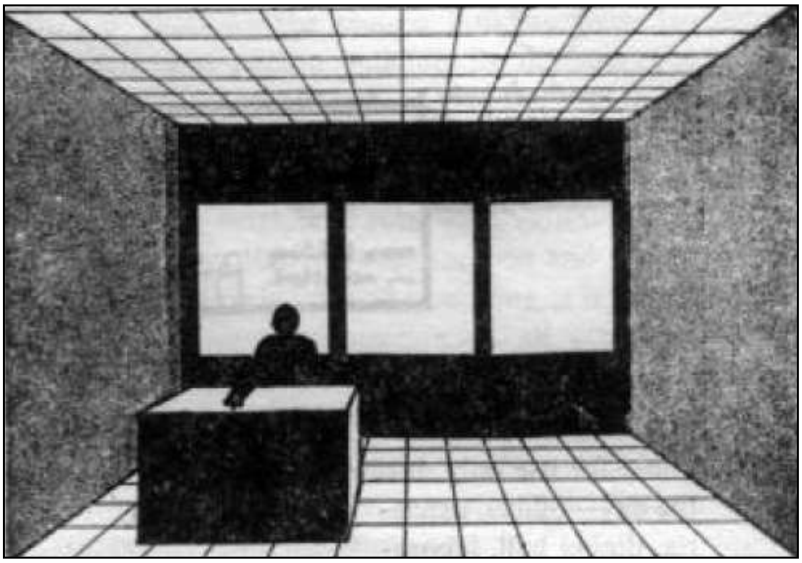
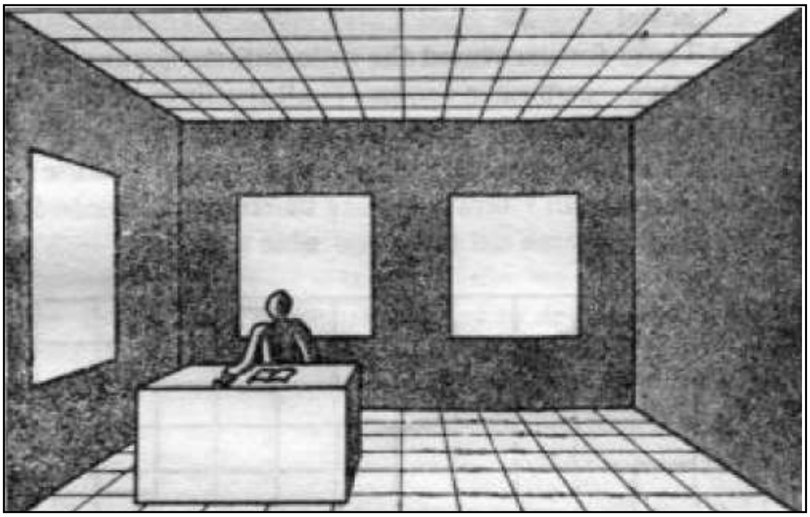


**Fig: 5**
**Improved lighting with Windows on Two Walls**



*Space Cooling and Thermal Comfort*

Thermal comfort for human beings depends upon air temperature, mean radiant temperature, relative humidity and air velocity. Machines, however, are affected mainly by the air temperature and in exceptional circumstances by the mean radiant temperature or relative humidity. The design of the buildings for people is therefore somewhat different from that for machines. Ceiling fans (for example) will affect the comfort level of people but not of machines. Because people can move about from one space to another and can put on additional clothing or take it off. The comfortable working conditions for machines which are stationary are usually more demanding than for people. Therefore, the design of built up areas should be considered according to the time of use as follows.

| S.No. | Space | Comfort Criteria |
|---|---|---|
| 1 | Those for use only during the day (offices, cafeteria, dining hall, laboratories, etc.) | night-time temperatures do not matter |
| 2 | Those for use only at Night (bedrooms) | day-time temperatures do not matter |
| 3 | Those for use round the Clock (computer rooms) | comfortable range needed all the time |
| 4 | Those for intermittent use only (auditorium, lecture rooms etc.) | not very rigid comfort requirements, as use can be restricted to comfortable periods |

*Ventilation*

Structural ventilation of buildings at night helps to cool down the building and the building mass so cooled warms up slowly the next day. During daytime, when the outdoor air temperature is high it is best to minimize ventilation. Natural ventilation of day-use spaces (offices and laboratories) in summer is therefore of no use whatsoever. Improper ventilation is generally the reason for the poorer thermal performance of office buildings as compared to houses. Offices tend to be ventilated during the daytime and closed up at night for security. To make use of the cooling effect of night ventilation, it is necessary to organize ventilation apertures so that they could be left open at night without fear of thieves or of wind blowing away papers etc. Special precautions are necessary to prevent birds or animals from entering the building.

*Air-Conditioning*

The computer areas require greater cooling than is possible with natural cooling methods. The ideal situation would be one in which computers could be tropicalised to work at higher temperatures, or if computers could have built-in air-conditioners to cool only the critical heat generating parts. In the absence of such computers, it is necessary to provide cooling of the entire computer work area.

Normal air-conditioning consumes a great deal of energy and to prevent this avoidable energy expense, solar air-conditioning could be installed, which is becoming popular. Electricity is required only for blowers and pumps. Such a system is ideally suited for spaces which are in use only during the daytime as very little energy storage is then needed. The solar collectors normally occupy an area one to one and a half times the floor area to be cooled. For twenty-four hour operation of the cooling plant, the solar collector area will be twice as much and even then a stand-by energy source is required for cloudy (but hot) days. The installation costs of such a system become uneconomical and the reliability is also poor.

*Building Material and Construction Techniques*

Massive construction results in a lower daytime temperature inside the building, but may become uncomfortable at night when the heat absorbed in the structure finally reaches the inside space. Light weight construction results in high daytime temperatures but cools down quickly in the evening when it will be more comfortable than the massive structure. Buildings for predominant daytime use should, therefore, be of massive construction whereas areas such as hostel bedrooms, used mainly at night, should be built from light weight materials.

Spaces for round the clock use present special problems and some form of cooling other than mere arrangement of thermal mass is needed to make them comfortable. Spaces for casual use need no special consideration, as it is possible to restrict their use to the comfortable periods of the day.

All of these buildings, however, should be designed to prevent over-heating of internal spaces. In warm climates, the most important factor that causes over-heating of a building is solar radiation. Absorption and inward transmission of solar radiation can be reduced by choosing an appropriate building form and shading devices. Further heat removal from the building can be affected by natural or induced ventilation, evaporation of water and use of heat sinks.

*Insulation against Heat and Cold*

Insulating your home is the most important measure for making your home energy efficient. Windows and other glazed surfaces in an average insulated home can account for more heat gain or loss than any other aspect of the building fabric. Choosing the right size windows and the right glazing material can significantly improve the efficiency of your home.

Ideally all north facing windows should be full length to allow the heat from the winter sun in. East and west facing sides should have a minimum area of glass or none at all. Sunlight shining directly on north, east and west facing windows produces the same amount of heat per square meter as a one bar radiator. As a general guide, the total window area should be less than 25% of the total floor area of the house. A guide to the percentage of window area to wall area for each direction is:

- North facing 60 per cent
- South facing 30 per cent
- East facing 15 per cent
- West facing 0 – 7 per cent

*Use of Alternate Energy*

The renewable energy resources may also be used in contrast to conventional energy resources. Solar energy may be used for electricity generation, water heating and cooling purposes. These resources are not only environment friendly but also promote use of energy more efficiently. As the energy resources are becoming scarce worldwide, the incorporation of renewable energy resources is becoming a mandatory part of energy efficient design as also being imposed by the housing regulatory and development authorities.

## Concluding Remarks

The availability of energy is becoming scarce in the wake of growing needs for various human requirements. At the same time, there are changing trends of energy usage from developed to developing countries in the context of energy efficiency and conservation. The energy use at household level although accounts for 25 per cent of total primary energy but its efficient use may help both the consumers as well as the energy producers to maintain the balance between demand and supply.

A carefully designed home taking consideration of its orientation, layout, daylight entry, and ventilation, coupled with careful selection of building material and construction techniques, may help save energy significantly without adding extra cost but facilitates living comfort and saving on energy cost.■

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# Pakistan's Energy Choices

**Dr. Shaukat Hameed Khan**

## Introduction

Pakistan is in the middle of a major socio-economic crisis because of the non-availability of electricity on a sustained and affordable basis. Electricity in Pakistan is neither available nor affordable. The crisis is basically caused by major supply side constraints, as well as suppression of demand. Inefficiency in generation, transmission and distribution system is exacerbated by thefts, leading to higher prices for those who pay their bills. The clear example of this state of affairs is reflected in the so called 'circular debt' which crossed Rs 872 billion in 2012. Tariff differential subsidies, and mismanagement and confusion caused by the 'unbundling' of the earlier monolith, WAPDA, have all contributed to the present crisis.

Several options are available to Pakistan in its quest for energy autarky. *First*, Pakistan needs massive investment in power generation and associated infrastructure; the implementation plans must be aligned within global energy dynamics which determine primary energy supply and price. *Second*, Pakistan is not only an inefficient producer of electricity, it is also a very inefficient *user* of energy in terms of productivity. *Third*, there is need to understand the key driver of technological innovation, which serves to increase the global energy *envelope* and hence affects energy prices. These are already impacting the development of shale gas reserves across the globe. *Fourth*, 'new renewables' such as solar and wind are not expected to provide major relief, and need to be viewed only as a 'supplement', since these are not available 24/7 and are expensive anyway. *Lastly*, while regional energy grids can be attractive, Pakistan has failed to leverage this option in an effective manner because of political constraints and inadequate preparation as regards gas pipelines, while plans for electricity imports have wrongly assumed that spare electricity is economically available and assured from Central Asia or India.

This article examines some options amidst current data which alone will enable the right decisions to be made. It is suggested that there is a unique opportunity for our industry to capitalise on the huge bill Pakistan has to pay for overcoming the energy crisis.

## Background

Modern economies are built upon access to cheap, *carbon-based* energy sources. These have determined affordability, availability, and security in the past, and all projections point to this state continuing for the foreseeable future. Global demand is expected to double by 2050 as compared with 2000 levels, and 90% of growth in energy demand is driven by emerging economies as more people moving out of poverty, demanding more energy and gaining access to it.

Pakistan's energy demand is part of Asia's growing appetite brought about by a rising middle class, which is demanding greater access to food, transportation and mobility, housing and services. An increasing number is looking for their first TV set, refrigerator, computer or automobile. Demand in Pakistan has increased four-fold in the last 25 years; it is expected to increase eight-fold by 2030[1], and by a factor of 20 by 2050. The ratio of growth rate of demand of primary energy: Gross Domestic Product (GDP) growth rate has hovered around 1.0 for the past many years, but has crossed ~ 1.3 since 2008[2]. With the backlog of the last several years, electricity demand is now growing at over 9 percent per annum, with a requirement of nearly 160,000 MW by 2030. This would include a minimum 'spare / standby' of around 10,000-12,000 MW as to cater for maintenance, breakdowns, or natural

[1] Energy Security Plan, 2005; and Vision 2030.

[2] The CAGR (GDP) is ~ 5.6% during 1970...2005 (Various Pak. Econ. Surv. Reports, 2005-12).

disasters. It may be noted that global warming and climate change have not been factored into the Energy Security Plan 2005.

Because of past negligence, the energy and electricity scenario in Pakistan is likely to remain fragile for the next several years.

## International Dimensions of Energy

An energy deficient country like Pakistan which imports two-thirds of its primary energy cannot ignore international trends, A major rethink is now underway globally, based on resurgence in oil and gas production in countries such as the US and Iraq, spread of unconventional gas production, retreat from nuclear power in several countries, and increases in 'new renewables' (solar and wind). All projections point to the domination of fossil fuels for the foreseeable future. Between 1973 and 2012, share of hydrocarbons[3] (coal, oil and gas) in primary energy fell from ~86% to ~71%, while their share in electricity production declined from 75% to 68%, which shows its predominance of fossil fuels in the energy sector. This is well illustrated in Fig 1, which serves as a snapshot[4] of the industrial economies of the last 200 years. It is worth noting that while primary supplies grew by a factor of 2.1 during the period, electricity generation grew by 3.5, pointing to an 'electrification' of global economies and societies.

The discourse in Pakistan tends to revolve around the use of high priced oil for power production. While this is true since 2006, the relative cost of equal heating value from oil or natural gas remained nearly one[5] for many years going back to the eighties (Fig 2).

It was reasonable to use oil then; it is logical to move away from it now towards more efficient coal or gas based systems.

**Fig 1: Changing Energy Mix, Since 1800 (Smil, 2010)**

[3] Key World Energy Statistics, IEA, 2012

[4] V. Smil*; "Energy Transitions,* 1800-1960"; & EXXON: 2012**;"** *The Outlook for Energy: A View to 2040"*

[5] EIA, World Energy Outlook, 2012

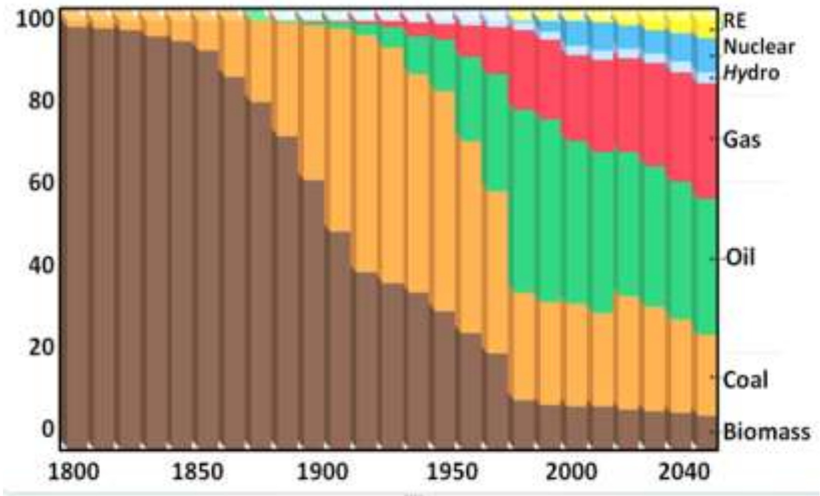
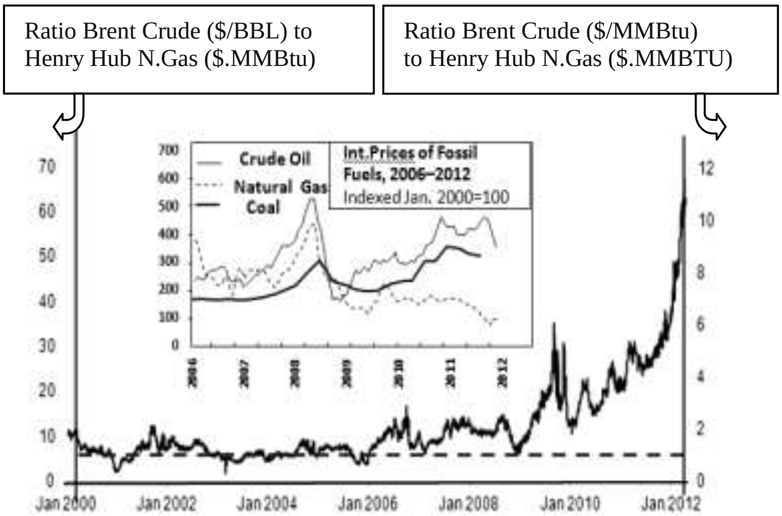



**Fig 2: Relative Cost of Oil and Gas**




Gas prices are falling worldwide because of major rise in production in the US; in fact this has led to displacement of coal by gas in the US, which allows coal for export into the EU, which in turn displaces expensive Russian gas.

This highlights the volatile nature of international energy prices and supplies, which are marked by an increased role of technology in exploiting potential new reserves.

## Pakistan's Energy Options

Pakistan possesses several options to meet its energy goals for autarky and affordability. Security of supplies will come through a more intelligent diversification of primary energy sources, whether local or imported. This diversification is also a hedge against price volatility.

*Managing the Supply Side*

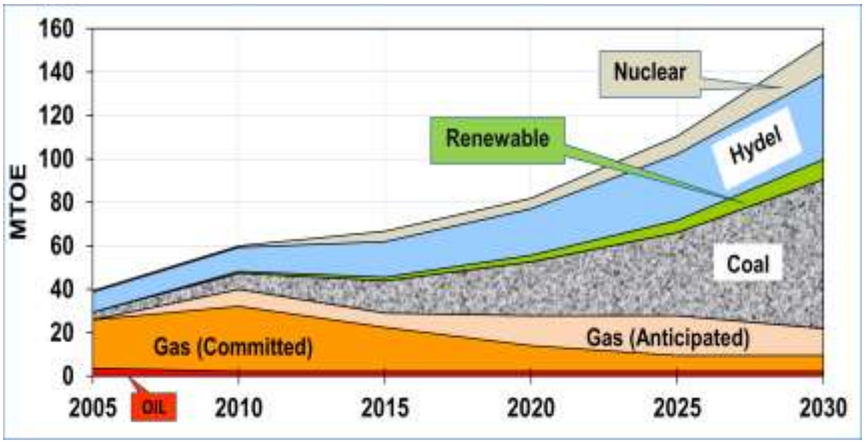
Given the shortfall in generation of up to 50 percent, the obvious first step is to ensure greater supply of energy and electricity. This includes coal, gas, hydel, nuclear and renewables, the choice being influenced by economics and time factors. The following is proposed:

a. Rehabilitate, upgrade and convert existing oil based thermal generation units as it is cheaper and quicker than setting up a completely new power plant. This can improve power generation efficiency within 18 months at about 30 percent of the cost of a new plant, and add over 3,000 MW to the system. The Public Sector GENCOs were initially built for gas, but are now running on furnace oil, with their output as low as 25% of capacity. A simple 1% improvement can generate Rs 6b in revenues.
b. Fossil fuels like coal and gas are first choice as these can quickly replace furnace oil for power generation in a time frame of about 4 years for a new plant or 2 years for conversion of oil based plants to coal or gas.
c. The recommendations made in the Energy Security Plan, 2005, (Fig 3) or the IEP (Integrated Energy Plan[6] 2009) regarding imported coal and gas have not been implemented with the result that major slippages have occurred in both the exploitation of coal or drilling for oil/gas, or importing gas from abroad.
d. Pakistan's mineral sector lacks expertise and technology for managing large scale extraction. Coal production is meager, fragmented, and unsafe. *Thar coal reserves* are estimated at 185 billion tons, but proven recoverable reserves are only 3.3 billion tons, up from 1.98 billion ton estimate in Vision 2030. Assuming 7 million tons per annum (1000 MW plant), the assured reserves can last 21 years for 20,000 MW plants.
e. Chamalang (Balochistan), the Chakwal/Salt Range (Punjab) and the Tribal Agencies possess high grade coal, all of which need to be exploited on a large scale, instead of small 'dog-hole' mines. The mineral sector is not playing its due role in our economy. It needs a major infusion of modern technology and processes, coupled with

[6] *Integrated Energy Plan 2009-2022* : Report of the Energy Expert Group, March 2009

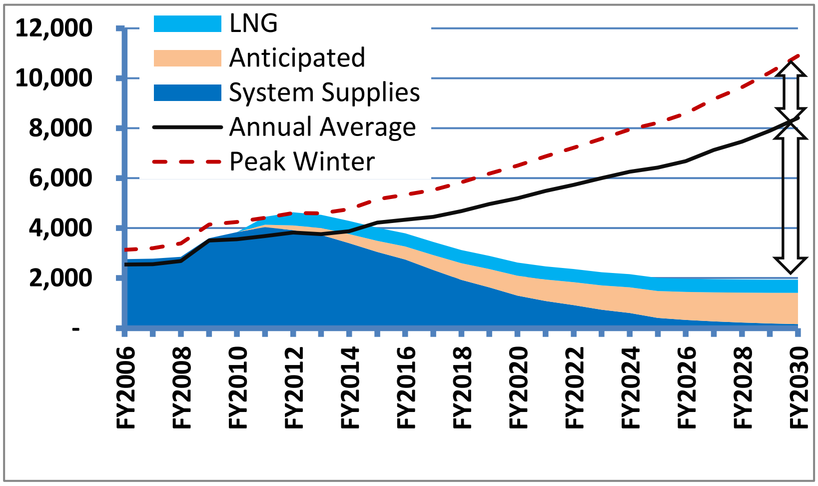
enhancement of skills of the miners as well as the provincial Mineral Directorates.

**Fig 3: Energy Security Plan, 2005**




f. It will be 5-7 years before Thar coal can be mined on a large scale. The recent 'experiment' for in-situ coal gasification has cost over Rs 2 b over three years, and no output is in sight. This may continue only as an R&D effort, but it is essential to import coal from, say, S. Africa until local coal production achieves economies of scale.

**Fig 4: Natural Gas Supply-Demand Balance in the Transmission Systems of SNGPL and SSGC; Updated 2011**




Source: PL.com

g. Indigenous natural gas, the backbone of the primary energy supply, started declining in 2011, and the current shortfall of about 25%, will reach 80% in 2030, *even when all currently planned imports (IP, TAPI and LNG from Qatar) are implemented* ( Fig 4). Gas imports are important not just for power production but for household and commercial use in order to utilize Pakistan's extensive transmission (9,300 km) and distribution (80,000 km) systems, built up since the sixties. The severity of the situation can be gauged from the fact that Pakistan drilled only 27 exploratory and 59 development wells in 2009, vs 20,000 wells in Canada the same year.

*Hydel Power*

It is cheap once the capital expenditure is made. It is worth emphasizing that hydropower in Pakistan is not available 24/7, since the major dams are basically meant to store water for agriculture, and the power availability from Tarbela and Mangla is around 55-60 % of the rated power generation capacity (same as the IPPs). Large dams are not renewable in the long run, and lose their storage capacity over time (Tarbela has lost nearly 25% of its storage capacity in the last forty years)

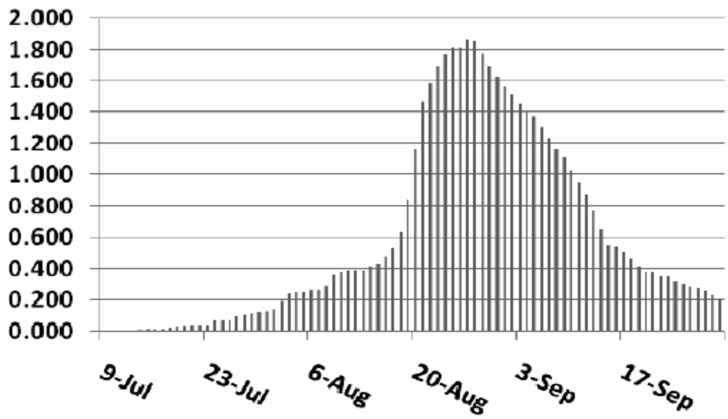
a. While there is a potential of over 40,000 MW along the Indus in the Northern regions, it takes 8-10 years for major dams to be built. No major dam has been initiated in the last 50 years, while India is building many such dams on the Indus and its tributaries. Another difference is that unlike India, Pakistan looks for 'foreign' aid or loans to build them, which means they are not likely to be built. Diamer-

Bhasha was initially estimated to cost US$ 7.5 billion in 2007, when it was first approved by the NEC; the cost has now escalated to over US$ 12 billion in 2013, and construction is yet to start .

b. Run of river projects are quite attractive especially for small local community application, and are a very useful supplement to the national grid; but it should be remembered that these too will not be available all the time because of intermittent water flow, when it is released for irrigation.

c. Hydel Power in Pakistan is closely tied up with global warming. Nine out of ten general circulation models of the Intergovernmental Panel on Climate Change (IPCC) predict much increased monsoon precipitation in Pakistan by up to 20 – 30 %. (see also CICERO Report, 2002). This suggests a bonus period during the next 25 – 30 years, with more waters in our rivers. We need to exploit this positive aspect of global warming, and must build major new water storage facilities as well as 'raise' many existing ones (Vision 2030). This was obvious during the massive floods of 2010, when as much as 51 MAF was lost to sea below Kotri (six time the storage capacity of Tarbela), and another 26.5 MAF between Sukkur and Kotri during the short period (August 9–September 30, 2010). Lost to Sea below Kotri: (August 9–September 30, 2010).

**Fig 6: Water lost to the sea (in MAF) between Aug 9-Sep 30, 2010**

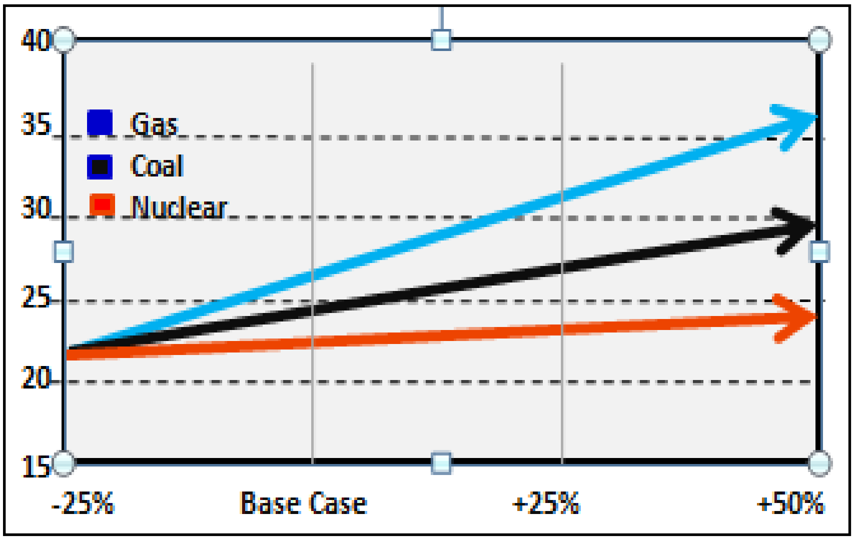



*Nuclear Power*

It is attractive for Pakistan as it has built up an extensive capability to design and operate such plants efficiently and safely. The capital costs are high, but the levelised cost of electricity (LCOE) from nuclear operating is nearly the same as modern advanced coal fired plants. Currently, three power plants are operational (730 MW), with an availability factor over 80 percent which compares favourably with thermal plants operating at 55-60 percent. An additional 650 MW will be operational by 2020. Even if the Energy Security Plan of 2005 is followed, the targeted 8800 MW of nuclear power by 2030 will contribute only about 5% to electricity generation at that time.

a. The economics of nuclear power is attractive, and the cost of fuel is far less sensitive than gas (x4) or coal (xx2.5) to price increases (ref: OECD Energy Analysis, 2011). Recent tariffs for Chashma 3, 4 are set at around Rs 5.6/KWh, which is lower than all other fuels except hydel power.

**Fig 7. Sensitivity to Fuel Price**




b. The Pakistan Atomic Energy Commission, will need to seriously consider spinning off its power plant section into a separate corporate body, so that nuclear power can achieve its true potential in the country through private sector investment.
c. While managing the front and back-ends of the nuclear fuel cycle have always been matters of concern, serious issues have come to the fore after the recent Fukushima disaster. These relate to site selection and safety aspects of nuclear power plants in general, and the aspects of decommissioning, and safe, long term disposal of high-level waste in

particular. The recent Blue Ribbon Commission[7] by the US President acknowledges the absence of adequate storage sites everywhere, and recommends international efforts to find the right solution. Pakistan is no exception.

d. Pakistan faces the additional barrier of the Nuclear Suppliers Group (NSG) in its desire to obtain safer and larger reactors. This is of course entirely discriminatory in nature, as is clear from the exemptions given to India by the NSG.

*New Renewable Energy (RE)*

It includes wind and solar**,** may be inevitable in the (very) long run, but it is just not able to offer base load (available 24/7); only fossil fuels or nuclear offers that capability. The RE output is intrinsically <u>variabl</u>e — even intermittent — which is the biggest challenge for its integration with existing electricity supply chain. Overcoming such fluctuations and providing 'BASE-LOAD' equivalence is, therefore, crucial to wider acceptance. This requires storage systems, to allow shift in 'time', none of which currently meet the required targets for large scale deployment of RE.

**Fig 8: Hourly Variation, Texas Wind Farm**

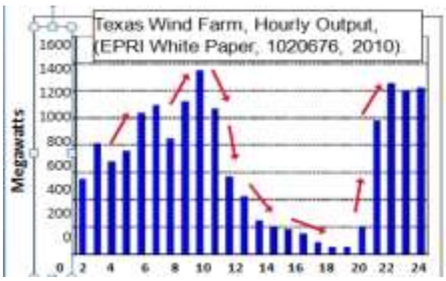



**Fig 9: Offshore Wind Farm. North Sea**

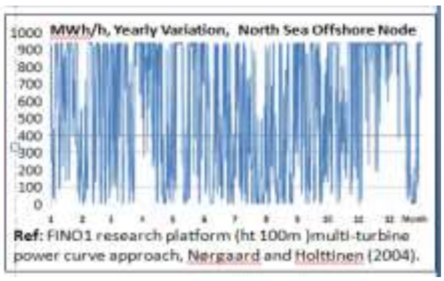



**Fig 10: Daily Variation, Tehachapi Wind Farm**

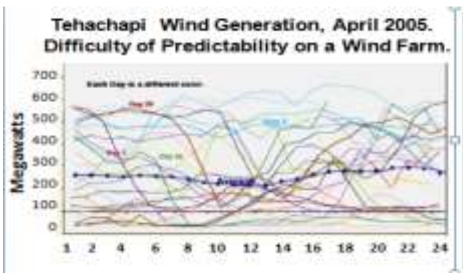
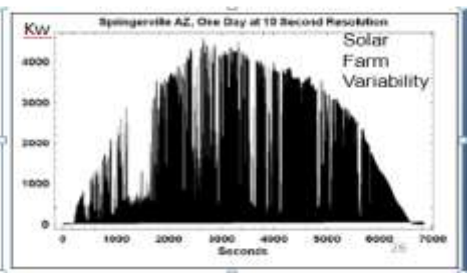



**Fig 11: Arizona Solar Farm**




[7] *The Blue Ribbon Commission on America's Nuclear Future* (BRC), Final Report, Jan 2012

The search for better storage systems and the requirements of grid integration is incidentally having a major impact on the design of flexible T&D systems suited to the mixed source requirements of the 21st Century. This is one area where Pakistani academia could be encouraged to join international efforts.

*Biogas Plants in Pakistan*

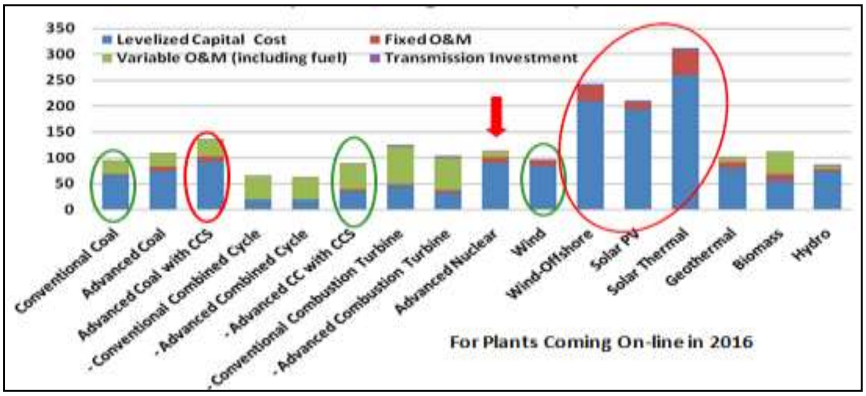
Quite a few units are being installed[8] in the rural areas, based on cattle manure. There are 165,000 farms with more than 20 head of cattle, while 40,000 plus farms possess over 50 cattle each. The manure is an appropriately local RE resource, and can meet part of the on-farm requirements of electricity and thermal energy for milk chillers, water pumping, space heating and cooking. With an IRR of 35-42%, the payback period can be as low as 2.5 years. The terms become even more attractive if carbon credits are leveraged into the system.

## Levelised Cost of Electricity

It would be appropriate to compare cost of generating electricity from different sources. Since Pakistan must need to follow international pricing for fuel as well as power plant equipment, international analysis would be helpful.

The EIA, US in its Energy Outlook, 2011, examined power plants[9] which would have started in 2011 and could be expected to come on line in 2016. All costs were examined including capital, operation and maintenance, fuel, as well as transmission investments, Fig 12.

**Fig 12: Levelized Cost of New Electricity Technologies, 2016 (2009$/MWh)**



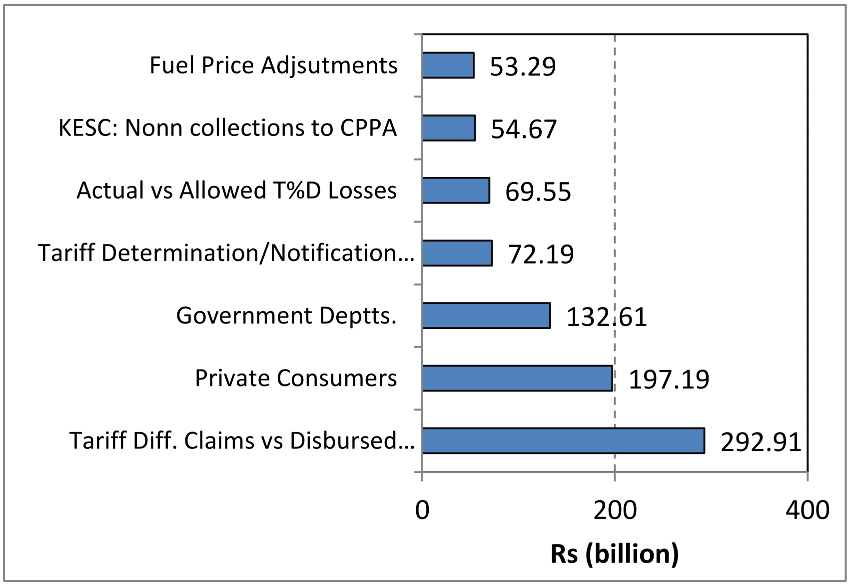

[8] Qamaruddin & Subedi, Int, Islamabad Energy Conference, 29-30 March 2012
[9] EIA, Annual Energy Outlook 2011.

This shows that in economic terms coal, gas and nuclear are equally competitive, while renewable are unable to compete on purely economic terms for the foreseeable future.

## Breaking the Circular Debt

The circular debt (Fig 13) exceeded Rs 872 b in 2012, the biggest contribution coming from the difference between subsidies claimed by the generation company and the amount budgeted for payment. This is intimately tied up with the Transmission and Distribution (T&D) losses, but thefts actually, and non collection of bills.

**Fig 13: Contributors to Circular Debt, 2012**




In 2011-12, the revenue collection by the Distribution Companies (DISCOs) was only 36% in Quetta, 60% in Hyderabad and 68% in Peshawar; it remained between 97-98% in Islamabad, Lahore, Gujranwala, Faisalabad, and Multan.

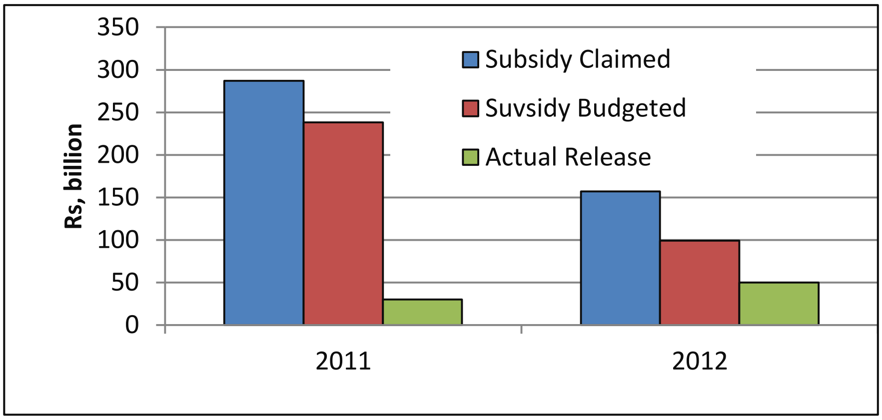
International benchmarks for T&D losses is ~ 6-7%, and this was followed in Pakistan thirty years ago. Now it has reached nearly 35% in Hyderabad, Quetta and 28% in KESC. While the better revenue collecting DISCOs also have lesser thefts ranging between 9.5-11% for Islamabad, Gujranwala, and Faisalabad, and 13.5% for Lahore.

The role of the regulator, NEPRA, is crucial not just for the efficiency of generation and transmission, but also for efficient disbursement of subsidies. NEPRA allows T&D losses of up to 25% and 28% respectively for

Peshawar and Hyderabad DISCOs, but these are exceeded even then (33.4% and 35.1% respectively).

The circular debt is actually a third of the total amount of Rs 872 billion as it is travelling between the fuel supplier (PSO) the generation companies (GENCOs), and the Government Departments who also default on payment. First, all government dues must be paid, which removes 22% of the debt. Non-collection from private consumers can be managed through shutting off the feeders to an entire community which can pressurise defaulters to pay up. The differential between subsidy claimed and subsidy disbursed needs far better monitoring. Better use of technology such as 'smart meters' can reduce losses and thefts, resulting in better revenue/bill collection, a more auditable quantity for subsidies.

**Fig 14: The Subsidy Differentials**




## Regional Energy Grids; Gas pipelines and Electricity

Transborder pipelines and regional energy flow is always vulnerable to regional politics and instability, or the ancient custom (and greed) of toll collectors. The ssituation becomes more difficult as global hydro-carbon energy reserves draw down, which they must during the next 30 years or so.

*A Transnational Pipeline*

It is most successful, when it is a bilateral .arrangement between two nations, with the next best option involving the case when the transit country is either powerful and friendly — or small enough to be friendly (Example: the BTG pipeline from Baku to Cehan in Turkey through Tiblisi).

The Iran -Pakistan gas pipeline, will deliver only 0.75 bcfd by 2015-16, whereas the current shortfall already exceeds 2.5 bcfd (billion cubic feet per day). The cost at the Pakistani border will be ~ US$ 11/MMBtu. The gas from Turkmenistan promises to bring in 1.1 bcfd at a slightly higher cost, with the added constraint of 'maintenance shutdown' during winter when our demand is at its peak. Instability in Afghanistan is another unknown factor.

While the 0.75 bcfd from Iran will be small compared with our long term needs, it still needs to be implemented quickly as it can meet a major part of our conversion of oil-fired plants to gas.

The pricing of LNG imports from Qatar go against international price trends. The US is exporting LNG at US$ 8-9 per MMbtu compared with the US$ 16-18 negotiated by Pakistan so far.

*Electricity Imports from India and Central Asia.*

There is some talk of importing electricity from India, and figures from 50MW to 1000 MW are being quoted. This is quite surprising as India has far fewer electrical accesses to its people than Pakistan, and still suffers a shortfall of around 19-20 percent. India has no electricity to export. Similarly, the Central Asia-South Asia Regional Electricity Market (CASAREM) project of importing 1000 MW from C. Asia across the violence racked and hostile Afghanistan, where the terrain is prone to regular earthquakes is not sustainable. We can access more than 1000 MW simply by rehabilitating our own thermal plants.

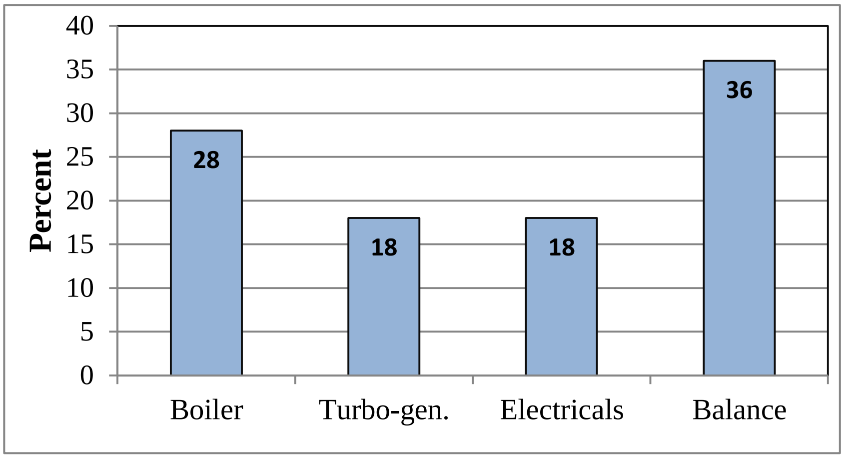
## Who Pays for Additional Power Generation and Transmission

All estimates point to a bill of around US$ 210 billion which Pakistan needs to invest in the power sector infrastructure alone by 2030, or approximately 4-5% of the GDP. This presents an opportunity for Pakistani industry to leverage this amount to develop indigenous capability either alone or in partnership with reputed multinationals.

*Plant Hardware and Software*

The author has estimated that nearly US$ 170 billion of the total cost is hardware and software. Pakistan already has the capability to execute 15% or US$ 25.5 billion worth of activity within existing expertise and resources. This will have a salutary effect on local industry, supply chains, and employment.

**Fig 15-Breakdown of Hardware Cost in a Typical Power Plant**




Another 7-8 % is possible in the design and fabrication of control rooms for the power (Ref: PAEC), which can also make several key components portions of the plant balance. The local fabrication industry has also matured in the areas of heavy casting and machining, boiler design and fabrication, high capacity pumps, and heat exchangers. The local capability may be gauged from the figures in the following page.

## Leveraging the Clean Development Mechanism: Carbon Trading

An interesting market for carbon trading has emerged in recent years under Article 17 of the Kyoto Protocol, which allows countries that have emission units to spare - emissions permitted them but not "used" - to sell this excess capacity to countries that are over their targets after due registration and verification processes.

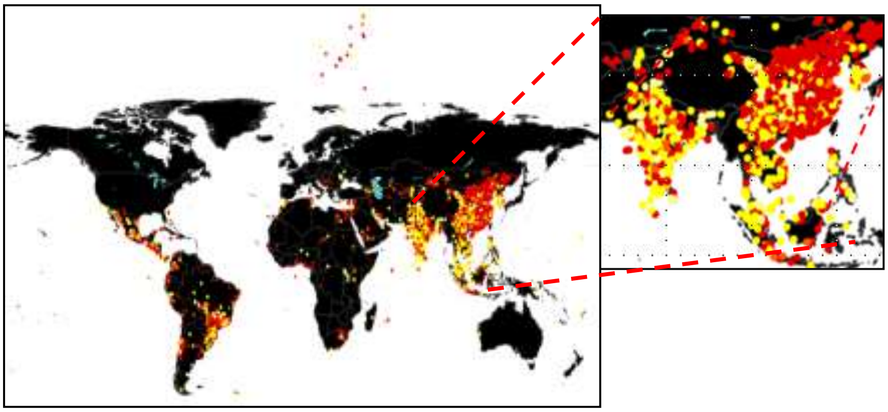
Trading is not restricted to emission units only. It includes other units equal to one tone of $CO_2$ such as a *Removal Unit* on the basis of Land Use, Land-use Change And Forestry (LULUCF) activities such as reforestation, an emission reduction unit (ERU) generated by a joint implementation project, or a certified emission reduction (CER) generated from a clean development mechanism project. These can be large or small scale, and can be one or several locations. The Eu is the biggest 'buyer' globally[10].

China , India and S.E Asia are the biggest beneficiaries/markets for the Clean Development Mechanism ( Fig. 15). Small programmes in Asia are worth emulating such as small hydro (2x17 MW hydel projects in Nam Toong ,Vietnam with a trading of US$14,962/year), or CFLs in Dubai. Biogas, waste-

[10] "Mobilizing Climate Finance"; J. Ebinger, World Bank, July 2012.

to-energy projects, gas capture/flaring, and wind all qualify for such trading. If managed properly, this can benefit biogas, solar and wind activities in Pakistan.

**Fig 15: Global Trading in Carbon. China and India are presently the Biggest Beneficiaries**



**A Snapshot of Local Capability**

DESCON; EPC Power Projects

| | | | |
|---|---|---|---|
| 16 m Dia. Vertical Lathe | 12 m Boring & Milling Machine | Heat Exchangers/ Air Coolers | Turbine Blade Carrier |

Desalination Plant Evaporator Dia = 3.2 m, Length= 16.4 m Weight = 50 ton
Capacity = 1,600 $m^3$/day

Plant Control Room Simulator, Chashma Complex

*Some items related to the Boiler, some of which are already being made while others are ready for manufacture in Pakistan:*

- Steam drums, headers, furnace (Membrane walls), superheater, evaporator, economizer etc.
- Steel Structure
- Air Heater, Stack, Air flue, gas ducts

## Conclusion

1. Transition from one fuel to another takes many years
   a. The world has still not transitioned from away coal, which will dominate the energy sector.
   b. Baseload or man-controlled power available only from fossil fuels
   c. Hydel power in Pakistan is also seasonal, as it is secondary to water storage for agriculture
   d. Nuclear is still only a small percentage of world energy consumption, and has a small share in Pakistan's electricity production.
   e. New renewables also have small global shares (wind, solar), which are intermittent and expensive, and require special subsidies/Feed-in-Tariffs for large scale acceptance, in addition to expensive storage devices to allow for a 'shift' in time.
   f. Also, 'new' renewables require fossil fuels for their 'creation', tied very much to the current system. Significant contribution is likely to take many years
2. Address the Supply Side Constraints which are:
   a. Rehabilitate and Upgrade Existing Plants

   b. Stop Electricity Theft ( T&D Losses)
3. Coal is the Best Option
   a. Convert From Furnace Oil to Coal ( ~ 30% cost of a New Plant, 18 months)
   b. Import Coal , as Thar coal is at least 5-7 years from large scale production
   c. Go for Supercritical Pulverised Coal based Plants ( ~ 50% efficiency)
4. Increase efficient use of energy ( buildings, mobility, emissions)
5. Spread biogas plants based on farm manure; these have high IRRs
6. Launch major HRD programme for efficient / skilled operators and maintenance people. The PAEC operates the only training centres in the country and is ready to help.
7. Financing required to meet Energy Programmes requires US$ 210 b by 2030
   a. This is an excellent opportunity for the manufacture of power plant equipment by local industry, as US$ 170 b relates to hardware and software:
   b. While nearly US$25.5 billion can be done with existing expertise and resources, strategic alliances (local + foreign) can bring in more opportunities.
8. Launch a big push in oil/gas E&P, ( foreign concessions, Incentives, pricing regime)
9. Plan for long term contracts for imports of gas, but price them better
10. Improve energy efficiency, in generation, use, and T & D, by focusing on the built environment, and public transport. Solar thermal can provide a useful hybrid in collaboration with fossil fuelled plants to pre-heat steam.
11. Prepare for global warming and climate change through reduced emissions by:
    a. Increase public transportation/mobility infrastructure
    b. Major increase of forest covers: CC&S
    c. Increased urban green space/eco-buildings
    d. Major programs in carbon credits/trading/CDM
    e. In view of anticipated precipitation under the climate change models, build more dams, higher in height.

12. **Water Matters**

    a. Energy and water have a strong nexus, and it is becoming an even more thirsty business. As power plants grow in number, water requirements also goes up for power generation; and in the extraction, transport and processing of oil, gas and coal, which impacts upon the needs for households and food.

b. Hydraulic Fracture technology for shale gas is very water hungry, apart from fears of contamination of underground water.
c. For Pakistan this is quite a challenge, as our per capita availability of water is now only 900 cubic meters (water scarce economy) compared with 5000 cubic meters in 1947.■

## CONTRIBUTORS

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