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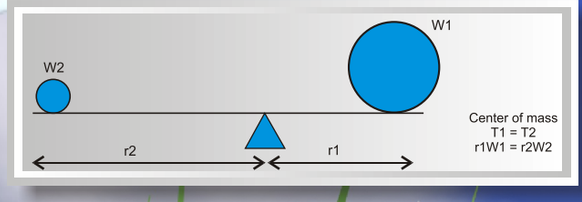

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Disseminate Technical Knowledge

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Conserve Electricity

CONTENTS

Editorial

Assalam-o-Alaikum

Dear Members,

The Journal policy is to publish high quality articles with permission from the Editorial Board. The principal aim of the journal is to bring together the latest research and development in various fields of technology such as Electrical & Electronics engineering, I am sure this time again Articles are covering all important issues like Selecting Senior Management for the Power Sector in practical & improvement of Distribution system by conversion of 3-Phase system to Single Phase system.

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We hope that you would like this issue as past practice!

Editor

Performance and Analysis of FSO link availability under different weather conditions in Pakistan

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Abstract: *Free Space Optics (FSO) can deliver an effective line-of sight, wireless, and high bandwidth communication between two places. FSO can be good alternative to provide bandwidth hungry communication. This paper mainly presents optical turbulence effects resulting from small temperature variations causing increased power losses from spreading of the beam or from the scintillation effects due to diffraction alone and due to temporal and spatial fluctuations of the laser beam. The FSO link is established using the cable free FSO equipment. The RSSI level of laser head versus distance and time are reported and experiments carried out to measure the link capacity of FSO in outdoor environment versus different distances. Furthermore, in this paper the performance of FSO link availability is measured under different weather condition and results are concluded to identify which atmospheric effect is more significant and necessary remedies are suggested.*

1. INTRODUCTION

As a communication system, FSO uses air as its core. The transmission process using FSO is relatively simple since it only needs a laser transmitter and a receiver. Each FSO system uses a high-power optical source such as laser plus a telescope that transmits light through the atmosphere to another telescope which acts as a receiver. An FSO link refers to a pair of FSO telescope, each aiming a laser beam at the other. Hence one telescope has duplex capability to act as a laser transmitter as well as a receiver [1]. Laser head are usually installed on the top of the building. Operating range of FSO communication is 0.7 nm to 1.6 nm which correspond to frequencies in the order of terahertz, lying in unlicensed band and they will not face any interference with RF frequencies band. Moreover, the narrow beam of laser allows placing two FSO systems nearby as they will not face any interference. FSO links are more secure and inherently possess anti-jamming capabilities.

Free Space Optical communication involves the transmission of data through a wireless medium using modulated near infrared light beam as carrier wave. The unique characteristics of laser such as its powerful coherent light beam, the possibility of modulating it at high frequency and the low beam divergence has made it the preferred light source for enhanced FSO applications. FSO communication is considered to be one of the key technologies for realizing very high- speed multi-gigabit-per-second large-capacity communications when fibre optic cable is impractical or too expensive. FSO communication can be of crucial advantage particularly because of its wireless nature and several applications, making it a viable alternative to the laying of fiber cable underground which is expensive and has environmental consequences. Unlike radio and microwave systems, FSO has higher data rate due to its high carrier frequency, low power requirements, no frequency license required. [2].

FSO is a line of sight technology that uses devices such as lasers to establish connectivity for video and voice communication. Currently, it can allow up to 2.5 Gbps of data rate but can be increased to 10 Gbps using Wavelength Division Multiplexing (WDM). FSO is based on connectivity between two stations consisting of optical transceiver to achieve full duplex communication. The light pulses are transmitted through the atmosphere in a small conical shaped beam by the means of low powered lasers or LED's [3].

The maximum range for terrestrial FSO link (FSO can be used for communication between space crafts and satellites) is around 2-3 Km [4] however, the quality of service of a FSO link in the atmosphere is strongly influenced by weather conditions. Weather condition is like fluctuation of atmospheric attenuation caused by a number of phenomena in the atmosphere, such as scattering, absorption, and turbulence. Scattering in particular, which is a product of fog, haze, or low clouds, causes large variation in the received optical power and limits the availability of FSO for a given transmission range[8][9].

2. ATMOSPHERIC EFFECTS ON FSO LINK

The performance of FSO link is significantly influenced by following channel impairments:

2.1 Atmospheric Scintillation

Scintillation is known as the optical turbulence resulting from small temperature variations Scintillation is caused by solar energy heating up small air pockets in homogenously, thereby creating varying refractive index along the FSO link. This results in the scattering of laser beams at various angles along the propagation path and a resultant fluctuation in both the intensity and phase of the received light. Atmospheric scintillation is less significant at distances less than 500 m but degrades performance of a FSO link at ranges of the order of 1km or longer [5] [9].

2.2 Physical Obstacles

Physical obstructions such as birds, insects, tree limbs, buildings or other factors can temporarily or permanently block the laser line-of-sight. Platform/building motion due to wind, differential heating and cooling, or ground motion over time can result in serious misalignment of fixed-position laser communication systems. Proper planning and site measurements are ways of avoiding this effect [6].

2.3 Sunshine

A bright sunny day will increase the background light level detected by the receiver i.e. the RSSI will be higher in the day than at night. During normal operation this effect is masked by other variations like temperature changes etc.

However, the effect of background light levels can be demonstrated (in an exaggerated way) by comparing the RSSI value when a Cable free unit is pointed at the sky or at the ground (NOTE: do not point Cable free laser products directly at the sun as this can damage the unit and direct facing of sunshine is not only cause of damaging the receiver but also can cause link unavailability because background noise dominates and RSSI falls down) [7].

2.4 Fog

Fog, low cloud, rain, snow, sand etc. attenuates the beam as it passes through the atmosphere. If the atmospheric effect is severe enough causing a greater attenuation than the available fade margin of the link, errors will be caused and ultimately even complete loss of communication. As general rule if the other side is visible to the human eye, then the link will operate correctly and pass data error free, in actual practice Cable free links perform far better than this. As a "rough rule of thumb" the naked eye can see through approximately 14dB of attenuation. [7]

2.5 Shimmer

Shimmer (heat haze) is atmospheric movement caused by heating of a surface such as tarmac or a flat rooftop. The hot surface causes a rapid increase in temperature of the air immediately adjacent to the surface; this in turn rises and is replaced with cool air. The boundaries between the hot and cold air causes the laser beam to be bent just slightly. On a large scale shimmer can cause two effects [7]:

1. The beam is bent enough to divert the majority of the power contained in the footprint away from the receiver at the remote end or

2. Constructive and destructive interference of the beam, which shows up as random "speckles" in the footprint, can cause errors in the data stream.

3. EXPERIMENTAL SETUP

Figure 1 illustrates the experimental setup developed to establish FSO link in the Mehran UET, Jamshoro. We have used the laser heads provided by the Cable Free company of UK [7] as shown in Figure 2.

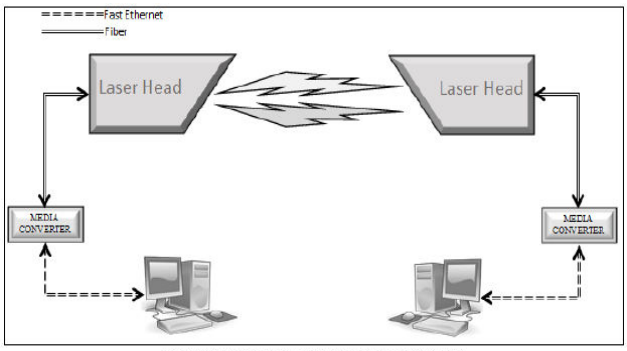

Figure 1: System Model of established FSO link.

Figure 2: Cable Free FSO Laser Head

3.1 Transmitter The FSO transmitter consists of a laser modulator circuit and the solid state laser device. The laser is a solid-state electro-optical device that emits light at a specific wavelength, which can be modulated with digital data signals at high speeds. The lasers used in Cable Free units emit light in the infrared part of the spectrum at 785nm (partially visible to the human eye) or 980nm (completely invisible). The 980nm lasers are capable of high output power but are restricted to low data rates, the 785nm lasers are capable of very high data rates but are restricted to low output power. Atmospheric conditions such as Fog attenuate 980nm less than 785 nm, hence 980nm is suited for longer distance links [7].

Table 1: System Specifications

Range	1000 m
Bandwidth	155Mbps
Power Consumption	25-35W
Operating Temperature	-25p…+60 deg
Optical Wavelength	980nm
Transmit Power	+19.0dBm
Beam width	8mRad
Safety Classification	Class 1M (IEC)
Receiver Type	Enhanced APD

3.2 Receiver The FSO receiver uses a precision optical lens to focus the incoming beam onto a very sensitive Avalanche Photodiode (APD). A photodiode is a device that converts photons (light) into electrical signals. The photocurrent depends on the amount of incident light. This detected current provides the received signal (both data and telemetry) and the receive signal strength (RSSI) readout value. Sophisticated electronic circuits remove distortion and interference introduced by the atmosphere, recovering the original transmitted data. The acceptance angle from which a received signal can be detected by the

photodiode is also nominally 0.5 degrees full angle (8mRad) [7].

3.3 Calculation of Atmospheric Effects Peak to peak scintillation is very important for a given observation interval we can easily calculate the Scintillation index means that refractive index which is varying by the energetic pockets of air or atmosphere. By using approximation in [4] we can approximate S.I "Scintillation index" as:

SI= (Pmax-Pmin)/ (Pmax+Pmin) (1)

Pmax =highest 3rd peak of received signal strength during observation interval and Pmin= 3rd lowest peak of received signal for given observation interval.

We can also calculate standard deviation by the formula

$$\sigma = \frac{(\sqrt{n\sum x^2-(\sum x)^2})}{n(n-1)} \quad (2)$$

Where n can be calculated as

$$n = 1 + 77.6(1 + 7.52 * 10^{-3}\lambda^{-2})\frac{P}{Te} * 10^{-6} \quad (3)$$

Where P is the atmospheric pressure in millibars and Te is the temperature in Kelvin. For all engineering applications the rate of change in refractive index with respect to temperature is given by: (4)

$$-\frac{dn}{dTe} = 7.8 * 10^{-5}P/Te^2$$

There is more significant parameter than SI which is defined in [4] as

$$S4 = \frac{\sigma_x}{m_x} \quad (5)$$

Where σ_x is standard deviation and m_x is mean.

3.4. **Methodology**

We used the equipment of Cable free company to perform the experiment. The link between two FSO heads which were supposed as relay station fitted at the roof of 40 feet high building separated by the distance of approximately 50 meter. The all data of one end side was aggregated and sent to the laser heads and then laser modulated the input data of fiber over air means free space. The LOS was maintained between the two laser heads and FSO link was successfully established. Data sent from the local network was successfully received at the remote network. Number of transmissions of different data files of various sizes was performed and the time to successfully transmit the data was recorded as shown in Table 2 and Table 3.

Table 2: Propagation Time v/s Size of File

S.#	Time taken by data file in seconds.	Data file size in (GBs)
1	12	1
2	22	2
3	43	4
4	85	8
5	170	16

Table 3: Values of RSSI v/s Time Clock

S. #	Values of RSSI (dBm)
1	0.1
2	-1.7
3	-2.2
4	-2.3
5	-2.4
6	-2.7

Note:

These values are taken at random interval. In the FSO head ATPC (automatic power control) system in integrated which was adjusting the power adaptively.

Table 4: RSSI v/s Distance

S. #	Values of RSSI	Distance
1	25	9
2	37.5	8.9
3	50	8.8
4	62.5	8.65
5	75	8.5
6	87.5	7.5
7	100	7

4. Result

During the experiments it was observed that only sunshine was found to be effective impairment out of all possible atmospheric effects in Jamshoro environment. This problem can easily be avoided if the FSO Link is designed in such a way that link orientation is from South to North. With this approach FSO heads will never face sun shine.

Figure 3 shows the performance of FSO Link established at the roof of IT building, in terms of data size versus time. The readings are noted in evening time at the distance of approximately 50 meters. Result obtained in the graph are according to expectations as time = size of date / link rate. According to the formula time taken to transmit the 8

GB file should be 80seconds assuming the link rate is 100Mbps. Experimental result are quite similar which is 85seconds.

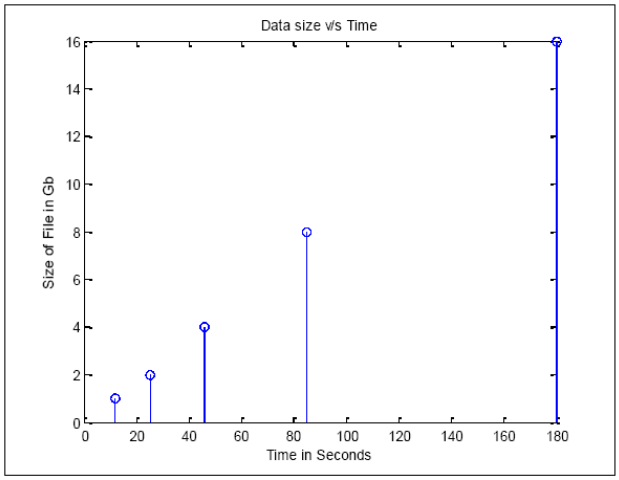

Figure 3: Data Size v/s Time

Figure 4 is indicating the Received signal strength intensity versus distance in meter and we can observe a well know relation of power with respect to distance that as distance between two relay station is increasing we can see the strength of the signal is going to decrease. Though signal strength seems to degrade but still this degradation is very low and we can easily communicate between two work stations which are shown in system model. We tested and verified as we have shown the successful transmission of various data traces with increasingly size and also shown in the previous discussion that increase in amount of time was obvious and just due to increase in size of relaying information and was almost independent of channel condition.

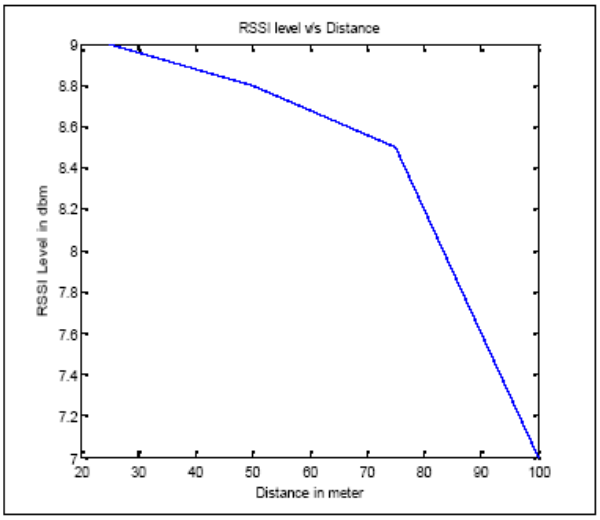

Figure 4: RSSI v/s Distance

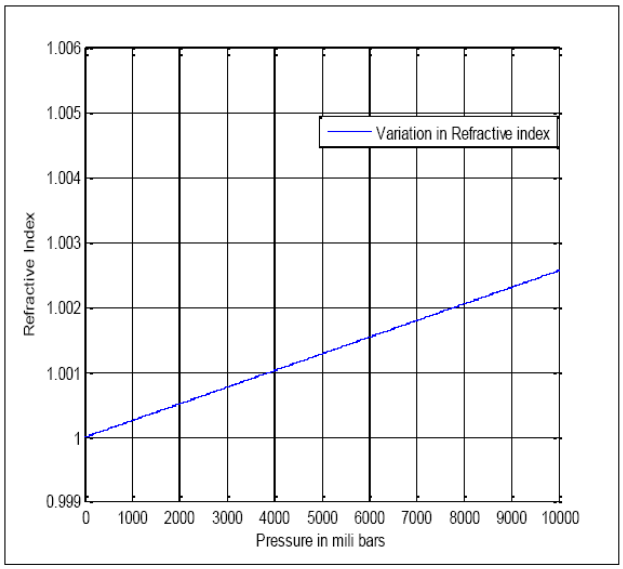

Figure 5: Refractive index v/s Pressure

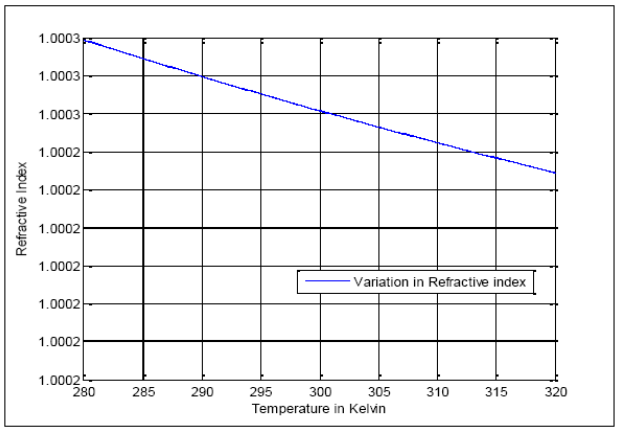

Figure 6: Refractive Index v/s Temperature

In the vicinity of Jamshoro the values of atmospheric pressure and temperature were recorded and then used to calculate the refractive index. As can be seen from Figure 5 and Figure 6 that variation in the refractive index is negligible. Both of these graphs were plotted using equation (3) discussed in literature review.

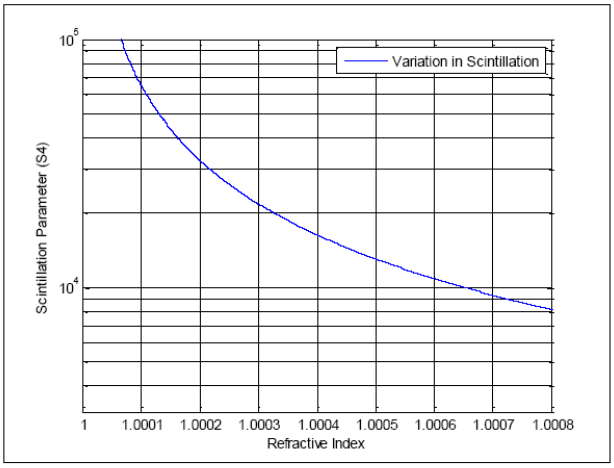

Figure 7: Scintillation Index v/s Refractive Index

The results shown in Figure 7 plotted using equation (5) and (2) further reaffirms that the effects of scintillation are insignificant. And this same behavior can be expected throughout the south region of Pakistan due to similar weather conditions. Hence, FSO becomes the ideal choice for short range (0.5km to 1.5 km) wireless communication with offered data rates comparable with traditional optical fiber networks cost efficiently.

5. CONCLUSIONS

The free space optics link is successfully established. The established link has very low size, weight and power requirements, and is very difficult to detect or jam. The link successfully transmits 8 GB data wirelessly in less than one minute at the distance of 100 meters which can be further extended up to 1500 meters. Thus strongly advocating the usage of FSO links in LAN range or in between of grounds of normal LAN and MAN boundaries because distance was sufficient to claim building to building information transference. The link performance can further be improved to terabytes per second with slight enhancement of 1Gbits NIC cards for FSO heads. Furthermore, it is observed that the south region of Pakistan is particularly suitable as it is naturally free of most of the channel impairments which degrades the performance of conventional FSO link. This is due to the fact that the temperature variations are very small and resulting refractive index is suitable for transmission of infrared light at 980 nm window. The only serious problem is that of shimmer which also can be easily rectified by setting the orientation of the FSO link as suggested.

Acknowledgments

One of the Authors (Prof Dr BS Chowdhry) acknowledges financial support of HEC for the project "Challenges on FSO wireless broadband networks for health care monitoring and disaster recovery".

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Renewables & Electric Power Deficit

A new strategy is required to overcome the crisis

Engr. Irfan Ahmad (Fellow IEEEP)

Abstract:

The latest supply demand projections of Pakistan show that in case of "business as usual", a continuous load shedding of more than 6000MW is imminent beyond 2014. This is an extra-ordinary challenge for Pakistan, which demands extra-ordinary measures. This position paper shows that the Energy issue is technically solvable. However, a complete review of policies and a change of our approach towards energy generation and distribution methods are required to reduce the increasing energy supply-demand gap and make the electricity affordable and sustainable. Considering various options, Renewables are the only short term alternative available to Pakistan to bridge the ever increasing demand supply gap. Renewable Energy Integration into the system is however technically the least understood subject by most of our stakeholders. This paper discusses in detail some new concepts of integrating Renewable Energy Power Plants into the utility transmission and distribution networks so that initial high price of Renewables is offset by its immediately exploitable advantages.

The position paper further discusses basic concepts to promote and further the utilization of renewable energy potential in Pakistan such as Generation hubs and Hybridization. The issue of Reactive Power Deficit has been explained in detail, and suitable measures to overcome it by strengthening of electrical networks have been discussed. The major emphasis is on the local value addition leading to complete local solutions from engineering design to production and operation.

1. Introduction

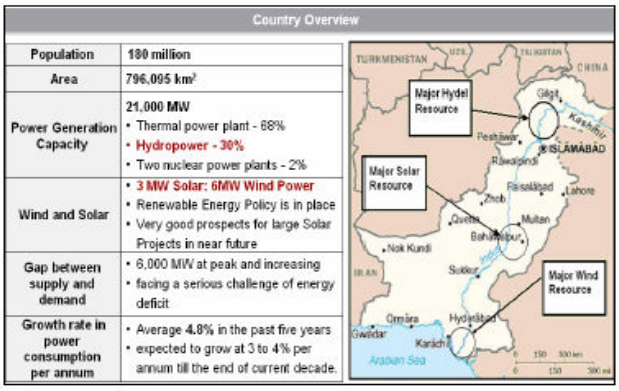
Electric Power situation in Pakistan will keep on worsening in the fore-seeable future unless a consolidated program is undertaken to improve it at all levels (Generation, Transmission, Distribution & Human Resource).

1.1. Current Situation

Installed capacity: 21,000MW
(68% thermal, 30% hydel, 2% nuclear)

Max. generation capacity: 15,000MW
Utility Losses: Average 30% or USD 2.3" per year (tech. 10%, non-tech. 20%)

High utility losses are the main reason for the "Circular Debt". The Circular Debt is the main reason for low investor interest in Pakistan electrical energy market despite GoP incentives. For further details, please refer to the Slide 1 below.



Slide 1: Situation at a glance
Source: Survey of Pakistan 1, AEDB ***2***

We in Pakistan may be sitting on the edge. There is a 50% chance for us to become a country like Somalia. A country, which is rich in energy resources like us, but where the electricity is now in large parts supplied by local businesses, using generators purchased from abroad. A customer is given a menu of choices for electricity tailored to his needs, such as evenings only, daytime only, 24 hour-supply or charge per light bulb.

In Pakistan, in the absence of reliable power from the utilities, most of our industry went on self-generation over the past 15 years using diesel or gas (which has now availability issues). This amongst others has made our local products expensive due to the increasing cost of oil-based self-generation.

With the current shortage of gas and high price of diesel, which unfortunately are going to prevail for the next several planning periods, the domestic consumers and the industry are left with the only choice of capital intensive Solar PV or

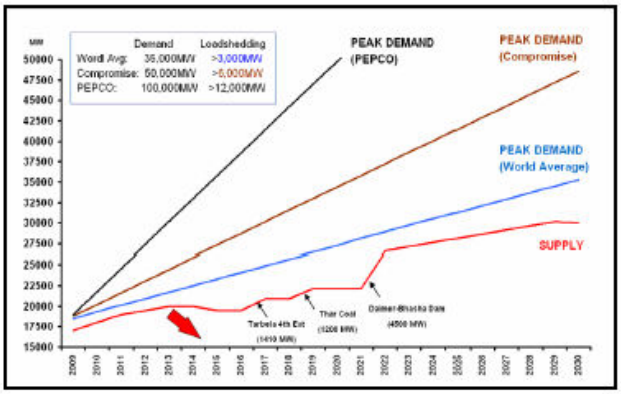
Thermal Energy as a short-term measure. The good news however is, that over their life cycle Solar Energy Projects come out to be much cheaper than Conventional Energy Projects.

Further only within a few years, close to 100% sustainable and affordable local production in Renewables can be made possible due to available engineering potential. A proper industrialization policy with supportive legislation is however a must in this regard.

1.2. The Crisis

Latest Electric Power Demand* & Supply** projections (Slide 2) show that the gap between electricity supply and demand in Pakistan will continue to grow even when all the projects in the pipeline come on line as planned. The current electricity shortfall being faced by Pakistan will worsen till 2020 when hopefully 4500MW

Diamer Bhasha Dam Power Plant or the run of the river Dasu Power Project comes on line.Considering the current progress on the supply side, we should brace ourselves for a continuous load shedding of more than 6000MW from 2014.



Slide 2: Pakistan Power Demand-Supply Projections
Data Source: PEPCO Projects List, Position Paper – IEP 2010-2025 ***3***
**) Demand: based on average 3% growth rate. The increase is similar to world demand increase.*
***) Supply: Including also power plants which are likely to achieve financial close*

The demand and supply gap shown in Slide 2 may not be as accurate over 20 years as depicted because sufficient verified data is not available to project a number of important variables (E.g.: GDP and population growth in Pakistan beyond 5 years). Even ADB's Integrated Energy Model 2011**4** is only as good as the basic assumptions of the econometric model it is based upon.

Demand projections based on 3% growth rate are close to overall world increase in electricity demand. However demand projections from PEPCO depict a beyond the control situation and may please be considered as information only.

The Energy Policies of major political parties declared in early 2012 show a peak demand of 50,000MW by 2030. Further, though updated recently, the timelines given for future projects may seem quite optimistic to those who have closely followed the energy development in Pakistan over the years.

1.3 The Reasons

Hydel (Major problem: politics)
- Potential: 50,000MW
- Planned: 30,000MW — Expected Total Cost = 30 bn USD

Wind (Major problem: infrastructure)
- Potential: 346,000MW
- Planned: 3,500MW — Expected Total Cost = 7.5 bn USD

Solar (Major problem: initial cost)
- Potential: 1,200,000MW
- Planned: 1,000MW — Expected Total Cost = 2.5 bn USD

- Pakistan does not have the MONEY, neither Investors nor Consumers
- 1) Investors have to borrow expensive money which needs to be paid back.
- 2) The above costs to be recovered as "electricity tariff" from consumers

Slide 3: Major Reasons – Upside Down Planning and No Money
Data Source: Survey of Pakistan, AEDB

Apart from misplanning or upside down planning depicted in Slide 3 above, the crisis is deepening due to:

- Delayed induction of new power plants in the system is not sufficient to replace a large number of retiring power plants. More than 6000MW of continuous load shedding is therefore expected from 2014.
- Failure of Rental Power Plants.
- High oil prices in the world market. Even conservative estimates show that current prices at around USD 100 per barrel may double by 2020 and triple by 2030.
- Average Hydro generation is much below the installed capacity due to increasing shortage of water in our rivers and indecision of the responsible due to political reasons as regards large dams.
- Current shortage of gas of about 30% would reach 50% by next year. Short-term (3-5 years) situation remains bleak according to the latest newspaper reports.

2. The Strategy

After the failure of Rental Power, the only shortterm solution left is Wind & Solar Energy implementation. For the medium and long term, small and large Hydro Power Plants have become necessary.

Therefore, any future strategy must have Renewable Energy Solutions as a main stay. These solutions should be technically implementable, financially affordable and politically viable. The major emphasis should be on the local value addition leading to sustainable and reliable selfsufficiency in Electric Power.

To pin point the correct solutions, we need to understand the major shifts in the Pakistan Energy Market over the past 20 years as shown in Slide 4. Due to these shifts, certain policy changes are now required to support the Pakistan Energy Market to achieve the goal of reliability and affordability of Renewable Energy.

To pin point the correct solutions, we need to understand the major shifts in the Pakistan Energy Market over the past 20 years as shown in Slide 4. Due to these shifts, certain policy changes are now required to support the Pakistan Energy Market to achieve the goal of reliability and affordability of Renewable Energy.

1990	2012
Peak Demand 9000MW	Peak Demand 17000MW
Hydro/Thermal : 70/30	Hydro/Thermal : 30/70
IPP Policy supporting Thermal Generation introduced	High oil price and water storage requirements favour Hydro power
Small PV Solar only for special applications	Large PV projects with prices comparable to thermal possible
Even small wind turbines were facing technical issues	Lender driven wind Market is facing complex techno-commercial issues
Limited domestic A/C load – not even separately considered	Additional A/C load increase of 500% (1500MW) in Summers
No Regulator	NEPRA exists
Electricity as Federal subject	Electricity as Provincial subject

Slide 4: Why a change in strategy?

3. Wind Energy – What is hindering its integration into the System

In a recent development HESCO as utility operator has shown its inability to evacuate the electric power to be

generated by Wind Farms being installed in the Gharo Wind Corridor.

HESCO says that it was not informed timely and substantial time would now be required for strengthening/replacement of its power evacuation network and to cater for Wind Energy Integration.

The weakness of HESCO network has always been known, at least to the electrical engineers involved in the business. Over the last 4 years, in several of its Seminars, IEEEP did ask the stakeholders to go for appropriate grid supporting Wind Technology which was termed a must for successful Wind Power Plants (WPPs).

The real issue is, however the Wind Technology. HESCO's weak network demands state-of-the-art, grid-supporting Wind Technology, which may not be the case with the current WTG's being installed.

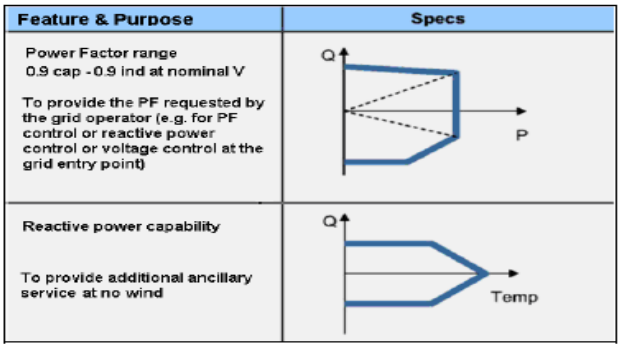
3.1 The Technology

About 4 years ago fixed speed type 2 Wind Turbine Generators (WTGs) were being offered in Pakistan. These WTGs could not support the electrical utility network in keeping its active and reactive power balance. The WTGs were rather dependent on the network itself for their stable operation.

Meanwhile the Wind Technology has developed fast. It took only 15 years to come from the fixed speed type 1 WTG to the state of the art type 4 WTG supporting the network like a conventional power plant with almost 100% speed and voltage control. Type 4 WTGs have been in commercial operation for more than 6 years already.

Type 4 WTGs with Full Scale Frequency Converters (FSFC) specially designed for IEC Class II wind regime like that of Gharo Corridor are the ones we need to support our network.

These type 4 WTGs not only support the network (almost like a conventional power plant in most cases) but can also provide the HESCO network with much needed reactive power throughout the year, when the WPPs are running below capacity in case of less or no wind. The technology has developed so far that very soon the frequency response of WTGs with FSFC will match conventional power plants.



Slide 5: WTG Technology – Type 4 with FSFC
MVARs at Low or No wind (100% Plant Factor)
Data Source: Siemens Net Converter Brochure ***5***

All good WTG manufacturers have Type 4 WTGs but because of the sophistication of their integral Full Converters, they are not prepared to market these WTGs in Pakistan. nfortunately, these are the kind of WTGs, we require in Pakistan considering:

- our very weak HESCO network

- increasing Reactive Power requirement due to relatively less hydro generation (the main source of our reactive power) over the years.

In case of low wind or NO wind, the remaining output or the entire MW output of the WTG can be delivered in MVARs by the Full Converter (Slide 5), thereby bringing the WPP's plant factor theoretically close to 100%. Reactive power thus supplied will be close to the load centers in HESCO network relieving the Utility of huge transportation losses.

3.2 Network Compatibility Issue:

WTGs should be compatible to the network (HESCO) as per Cl. 3 of the Grid Code Addendum No. 1 approved and issued by NEPRA in April 2010**6**. Since HESCO network can be rated between very weak and weak networks, ensuring compatibility as per Cl. 3 above is very important. Just consider one of the several important parameters mentioned below:

Though Active Power & Frequency Control is exempted as per Cl. 7 of the above code, the Frequency Response Time (FRT) of the WTG needs to be checked for network compatibility reasons anyway as it effects the AEP. In case network compatible FRT is not achieved which is very likely for type2/type3 WTGs feeding into HESCO network, the only solution for stable operation will be to run the WTG with active power reserve. This would make the WTG network compatible but would then reduce the AEP of the wind farm at the same time.

The Network Compatibility and actual AEP figures can only be ensured if the **Grid Interconnection Study is done using WTG specific controller models.**

Developers, NTDC and NEPRA should confirm if the Grid Interconnection Study has been done using WTG specific controller models and if FRT of the WTGs satisfies the HESCO network. Unfortunately, none of the current Suppliers have provided their turbine specific controller model for the stability studies. They made use of our soft Grid Code Addendum and the fact that for Contracts signed in Pakistan the due diligence is the responsibility of the Buyers i.e. Project Developer and NTDC.

3.3 High Tariff:

The cost plus tariffs being worked out by NEPRA**7** are not affordable. The WPPs are pioneering projects. Each stakeholder tries to pass on his notknown risks to the next in the line. The Lender likes the Developer to insure all the risks. The Developer passes on even the project risks to the EPC Contractor.

Some Developers have gone for the cheapest machines available, to create a sufficient head room, in their favour, between the cost and the tariff. Further, almost all the WTG suppliers are product suppliers. They do not have EPC experience. EPC condition is a basic requirement of the Lenders in Pakistan, as they want a Single Point Responsibility on the Contractor side. The main Contractor, who is generally the WTG supplier, keeps on stacking all the risks in his prices. The cost plus tariff thus goes beyond the affordability limit of a common consumer.

Annual Energy Production (AEP) calculations done by Lenders are on P90 (90% exceedance probability) basis. This shows only a 10% risk of the calculated/guaranteed energy yield not being met thereby helping Lender's decision in favour of the investment.

On the other hand, the AEP calculations submitted by the Developer for tariff determination to NEPRA are on the P50 basis, which show an increased AEP as compared to P90. In P50 case, the 50% un-calculable risk that the guaranteed yield will not be met is passed on to the energy purchaser and eventually to the end consumer. These risks are due to:

- highly probabilistic nature of wind regime including extrapolated short term actual site wind data. Our base calculations are done on the site wind speeds. The other losses including wake losses (Slide 6) and shear effect which can together result in 20% to 30% less output are generally considered as a certain smaller percentage of the total output on an average basis due to nonavailability of actual measurements.
- weak HESCO network. As a thumb rule, a sufficiently strong network should have S/Pn ratio of more than 25 at the point of common coupling of the Wind Farm and the Network. On all the sites, within the Gharo Wind Corridor, this ratio is much below the desired level.
- in-sufficient references and service experience of the selected WTGs in similar site conditions, specially temperatures, dusty and corrosive environment.

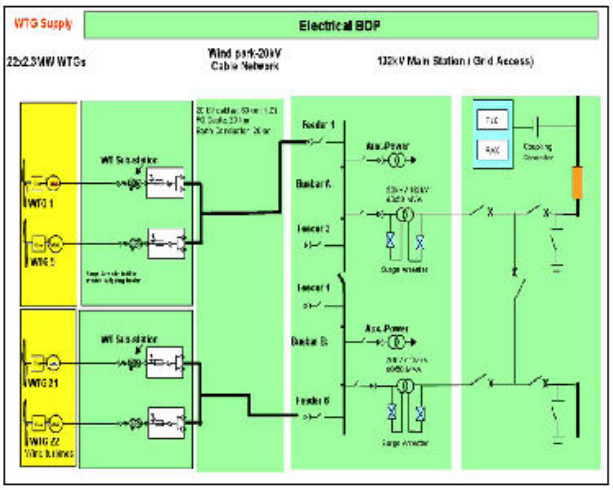
In case the above aspects have not been thoroughly looked into and proven, it will be advisable to go for the lowest value of AEP calculations. At the most an average of the exceedance probabilities P50 and P90 may be considered, otherwise the end consumer will have to bear the brunt of lack of due diligence by Developers, NTDC & NEPRA.

Slide 6: Wake Losses
Source: Siemens Wind Power

Affordability of WPPs can be achieved by:

- Feed in Tariff (FIT) only, as this will give an incentive to the Developer to go for more efficient machines.
- Optimizing EBoP design and thereby reducing its cost. The following major should be considered with reference to Slide 7:

1) Use of Air Insulated Switchgear (AIS) instead of Gas Insulated Switchgear for the main station as specified by the Consultants.
2) Use of one power transformer instead of 100% redundancy.
3) Use of 20kV operational voltage level for the collection system as against 33kV recommended by some consultants.
4) Use of good but unbranded fire protection equipment.



Slide 7: Overview (Line Feeder Arrangement)
Scope of Electrical BOP (Excluding Wind Turbines)

3.4 Role of Reactive Power

The most common industrial load i.e. electric motors require reactive power to rotate. Energy savers and computers also require reactive power to operate properly. Currently the Hydro Power Plants up North are being used as a cheap source of reactive power though there is a considerable transmission loss due to long distances from the load centers.

Records show that most of the black-outs in the World, including the tripping of grids in most advanced countries like USA, were because of scarcity (leading to imbalance of power) of Reactive Power in the utility networks. In recent months, grid stations tripping in Pakistan has also been attributed to the reactive power demand of the Industry, not being met by the Generation.

Most of the Reactive Power requirement is met by hydro generation in many countries, as it is a cheaper source of Reactive Power due to various technical reasons. This was

somehow forgotten while the thermal IPPs were being introduced in large numbers in the 90s. The changed ratio of hydro to thermal from 70/30 to 30/70 over the years has resulted in the scarcity of Reactive Power in our Networks.

As deliberated in the National Conference on Electric Power Deficit held by IEEEP in Lahore, the existing hydro/thermal ratio needs to be reversed for various very pressing reasons, one of them being also the supply of Reactive Power. Large Hydro Plants if conceived now will take at least 10 years to come on line. Diamer Basha is one of them. Meanwhile it should be planned that sufficient reactive power is provided by the small hydro power plants in the pipeline.

However, as already explained, the urgent requirement of Reactive Power can mostly be met by Type 4 Wind Turbine Generators available at competitive prices and which should be a must for any future WPP being installed in Pakistan.

Further, a tariff for Reactive Power should be worked out (as is quite normal in other parts of the World e.g. UK as shown in Slide 8), as it will encourage the investors to go for a technology, which is very much required for the stability of our utility networks leading to increased reliability of the electric supply to the consumers.

Both the Energy Purchaser and the Utility Operator had (still have) the apprehension that, as per policy[8] they will still have to pay for the WPP generated energy not evacuated due to the weak network condition. Therefore, they had (still have) little interest in Wind Energy Integration into their system as they still think that their own weak network will have to support outdated WTGs being allowed because of a soft WPP Grid Code approved 3 years ago by NEPRA.

3.5 Tariff for Reactive Power

A Reactive Power Tariff needs to be worked out for investors to bring in network supportive technology.

Slide 8: Feed-in Tariff for Reactive Power

Source: U.S. Department of Energy

In winter months when there is little or no water in the dams, the reactive power is provided by conventional plants at higher generation costs.

Further in winter months the Gharo corridor has less or no wind. During these months when WTGs are producing less active power (MWs), the type 4 WTGs can give out the remaining capacity as the much-needed reactive power (MVARs). Type 4 WTGs with FSFC are being used all over the World including India for reactive power generation when the WPPs are running below capacity because of less or no wind.

Another major advantage for HESCO would be that the network would have a cheap source of reactive power very near to the load centers.

The maximum plant factor of WPPs in Pakistan is around 34%. To cover a shortfall of more than 2000MW between 2014 and 2020, WPPs of 6000MW capacity will be required. It may however be noted that here supply with peak demand is being compared. The peak demand is more in summer months and during evening hours Luckily, during this time due the geographical position of Gharo wind corridor we have sufficient wind and a much higher plant factor.

Rough calculations have shown that 2700MW of WPPs will be sufficient to cover the dip during the peak hours. A detailed study is however required to see if energy conservation through "day light saving" can also play a role in peak shaving thereby giving further relief to the supply side.

Thus if appropriate WTG technology (type 4) is chosen, WPPs can go a long way in diffusing the perpetual energy crisis which has resulted because of years of improper and ad-hoc planning. A tariff for Reactive Power is therefore required in order to provide an incentive to the investors to go for the state of the art technology.

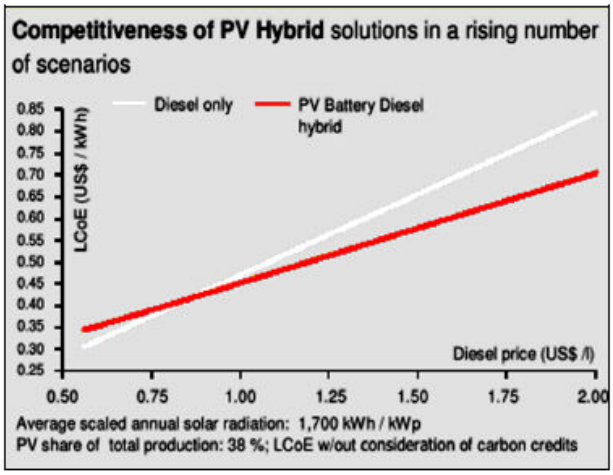
4. Solar Energy – Why it should be part of the new strategy

With a large population of over 180 million and a developing economy, Pakistan's energy needs are huge. The country is presently confronting a critical situation as its population continues to grow while the industry is coming to a grinding halt due to energy shortages.

Even in major urban areas such as Karachi and Lahore, power outages are frequent and in the summer, citizens can be without electricity for over 12 hours a day. The most common coping mechanism for citizens is to purchase portable electricity generators, which have relatively high running costs.

Whereas PV Solar is an appropriate technology for domestic use for the more effluent urban population, it can now be used in industry as well help to overcome electricity supply shortages as the prices of PV panels have almost halved over past 2 years.

A PV power plant can be hybridized easily with a hydro, coal or diesel power plant. With diesel generators it makes economic sense if the diesel prices are above USD 1/litre as shown in Slide 9.



Slide 9: Hybridization makes economic sense

Source: Presentation by Philipp Sonnauer at IEEEP International Symposium 2012

Solar Energy has a bright future in Pakistan due to the following reasons:

1) Pakistan has very good solar radiation (5kWhr/sq. meter/24 hrs) and minimum sunless days.

2) Solar PV energy is more predictable. Using neural networks exact prior prediction of available Solar output can be done 24 hours before.

3) PV Plants of range 1MW to 100MW are now economically feasible for captive use or grid connection.

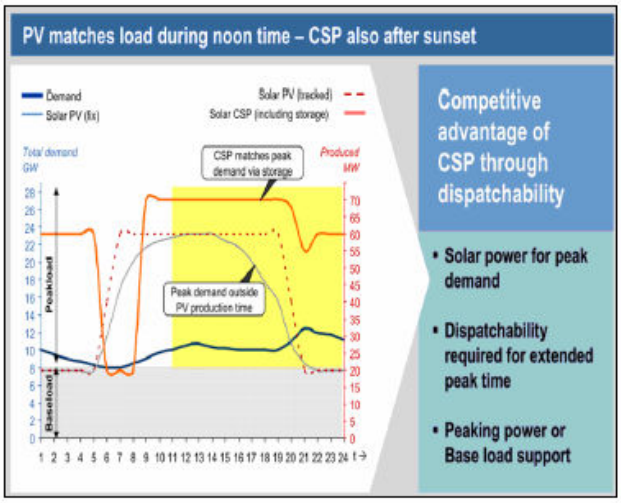
4) Financial outlay is easily affordable by a large number of investors/developers

5) Solar technology is simple (stationary) and can be managed locally.

6) Dispatchability for peak demand is easily achievable by using Concentrated Solar Power (CSP). Please refer to Slide 10.

7) Our MV distribution system feeders can be easily upgraded to evacuate even up to 10MW of electricity generated by Solar PV Plants and bring it to the consumers.

During the past few months Pakistani industry has shown increasing interest in hybridizing PV Solar with their gas/diesel generators plagued by fuel shortage. Hybridizing Solar with conventional resources of energy makes environmental and economic sense.



Slide 10: Role of Renewable Energy Dispatchability for peak demand in Pakistan

Source: DLR; REE; Concentrix; ACS; Goetzpartners

5. Further actions to be integrated in the new strategy.

5.1 Reduce demand by loss reduction

The total electricity losses (technical and nontechnical) in Pakistan are close to 30%. Technical studies of 3 DISCOs have shown that a two-third of the losses is non-technical losses (in most cases electricity theft).

By improving their metering systems, countries in Africa and South East Asia (including India and Bangladesh), could show drastic reduction of these losses and the utilities in these were again made profitable. With our local expertise, we do not require any outside help to successfully implement such systems in Pakistan.

The following is urgently recommended:

1) Pre-paid metering for domestic & commercial customers

2) Automatic Remote Metering for industrial customers.

5.2 Improvement in Transmission & Distribution Efficiency – NTDC & DISCOs

Up till now the concentration has been on the generation side only. Though Pakistan is one of the few countries in the world which have a national grid, the network is mostly overloaded and voltage profile and stability issues exist even on the 132kV distribution level.

It is a fact that none of the grid stations in Pakistan, more than 1000 in number, meet the n-1 criterion as far as transformer firm capacity is concerned.

When the generation would increase and factories would start functioning again, the reliability and availability of the transmission & distribution networks will drastically drop further due to their overloading.

Instead of going for very expensive expansion programs, network optimization by using simulation and management software can help us to achieve the required reliability by simultaneously reducing the maintenance costs also.

The following software packages are available in the market:

1) Transmission network simulations

2) Distribution network simulations

3) Grid Station Maintenance Management

4) Network Asset Management

First step to improve DISCOs performance is to determine the exact technical losses and non-technical losses by using network simulation software.

As a second step, proper Asset Management measures can reduce maintenance costs at the same time increasing the reliability of the system.

The above measures to improve a DISCOs performance can be mutually worked out with the utility operator.

5.3 Reduce demand by Energy

Conservation

Energy conservation is another issue that is perhaps not so tangible but equally important. A dollar worth of energy conserved is equivalent to 2 dollars saved, considering the environmental loss in the energy supply chain. We may need to change our entire approach towards life to come to terms with our increasing energy supply-demand gap. Training from the childhood will be required to make the energy conservation plans work. Energy conservation should be a subject in schools and universities. Awareness needs to be generated by using all possible means.

USA has reduced its oil requirement by 30% over the last 5 years by applying energy conservation measures.

We are wasting 3 times more energy than the world average. Therefore, we need to stop being wasteful immediately. It only involves switching of the equipment and gadgets not required. In a small country like Austria, 200MW could be saved by not keeping the household gadgets and office equipment on standby. We should know that what we are spending today in Pakistan is being borrowed from the future of our children.

5.4 Human Resource

Utilities need to work with Engineering Universities to get a new generation of engineers who understand Renewable Energies and Energy Economics.

The suppliers for Renewable Energy goods are invariably product suppliers and do not understand our utility network requirements and grid interconnection problems. The foreign consultants have similar limitations. The engineering and consultancy services therefore can be best supplied by our local engineers, who should be accordingly trained in our engineering institutions.

Two subjects should be introduced at the undergraduate levels. Outline of the courses can be provided as a basis of discussion.

o Renewables

o Engineering Economics

6.0 Conclusion:

If we want to expedite the use of our huge Renewable Resources and avert a full-blown crisis in the next few years, we will have to rethink our entire approach towards generation, transmission and distribution of electric power.

The main reasons are:

1) We do not have many financially strong investors.

2) Borrowed money is expensive and resulting tariffs are unaffordable.

3) Law and order situation in the region will remain volatile; therefore, self-dependence is called for i.e. maximizing use of local energy and human resources.

4) Opportunity costs of gas and water resources for forced electricity production are high.

In the light of the above, the following measures are suggested:

- Cooperatives for Wind Power Plants: Investors may even own a single WTG. With the modern monitoring and communication possibilities, they may not be required to visit the plant even. They can get their returns as cash or in equivalent amount of electricity delivered to their industry elsewhere. Such models are operating successfully in many parts of the world. Only grid supporting, state of the art wind technology should be allowed.

- Instead of cost plus tariff, only an attractive Feed in Tariff (FIT) should be made available. This will encourage investors to go for high efficiency state of the art wind turbines. A feed in tariff for reactive power needs to be worked out as well to provide incentive to the investors to get the grid supporting wind technology.

- Since HESCO has recently shown its inability for various reasons to evacuate power generated by WPPs in the Gharo corridor, as an immediate measure, the WPPs should be allowed to invest in setting up transmission lines from Wind Farm sites to the National Network. This investment can be adjusted in the tariff and would be much better than the huge IDC to be paid by the WPPs ready for power evacuation. Other 18th amendment related issues, need to be resolved on priority basis with a win-win situation for both energy generating province and energy consuming province.

- Generation hubs for Solar PV Plants (2MW to 20MW), Solar Thermal Plants (20MW to 200MW) and Wind Power Plants (30MW to 100MW) should be installed in government provided secure areas with good solar radiation & wind speed areas. The power evacuation and

strengthening of the network by adding base load plants should be pre-planned and prearranged.

The time schedules should be adhered to at all costs, otherwise serious Lenders and Suppliers would go away never to come back. Investors can get their returns as cash or equivalent amount of electricity delivered to any industry with which they may have an agreement. Wheeling agreements with utilities should be supported as a policy.

 Hybridization of Solar with Wind, small Hydro and Fossil fired Power Plants need to be promoted. As an example, a 10MW PV Solar Plant with our standard 50MW WPP is technically most suited under the circumstances as it would:

o Provide ancillary services for the WPP

o Help in supporting the weak utility grid

o Improve the overall availability and predictability of the hybridized plant

 Only Renewable Energies including small Hydro offer a local value addition of the desired level. As a matter of principle, we should invest only in those energy projects that can achieve a 70% local value addition within a decade. This is easily possible in case of small hydro, wind and solar.

 Large hydro storage projects are necessary for our Country. A program for maximizing local content here should form a corner stone of any future energy policy. A politics of creating winwin situation can expedite an amicable resolution of internal non-technical issues.

The engineering community headed by PEC should seriously look into this issue and resolve it within the real time. Our engineers amongst the politicians need to accept their responsibility regarding the nontechnical issues.

According to conservative estimates, the Pakistan Energy Market requires a financial outlay of 150 billion USD over the next 20 years to generate, transmit and distribute 50,000MW, provided we have a local value addition level of close to 70%. This is the minimum electrical energy required by us to remain to a viable Country. Most of this money has to come from the private sector, which will also be the major beneficiary of this expenditure. In case of "business as usual" i.e. no local value addition, the financial inputs can be 3 times higher.

These are extra-ordinary times for Pakistan, which demand extra-ordinary measures. Though the electricity issue is technically solvable, but each one of us needs to walk an extra mile to make electricity affordable and sustainable.

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N.E.C (U.S.A) and Protective Devices Considerations For Electrical Motors

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Abstract

NEC (USA) is being used in the U.S.A for well over hundred years. It pertains to issues related with distribution of electrical power in Domestic, Industrial and Commercial areas.

In power houses, we come across many electrical motor circuits. There are some protective devices i.e. fuses and circuit breakers which are involved.

In this paper, a case study is included wherein the ratings of the various protective devices have been calculated with the help of NEC tables.

INTRODUCTION

The National Electrical Code, abbreviated as NEC, is a very important document and a design guide to understand and construct all electrical installation in the U.S.A.

In the U.S.A, and in some other countries too (for instance Saudi Arabia, Kuwait etc.) where the above cited code is employed, all equipment and wiring must conform to the NEC Standards. The NEC is user's friendly and even a person who can read and write English and has some technical know-how can easily understand it and make full use of it.

In NEC, there are hundreds of very useful tables. Out of those a few tables particularly pertaining to "electrical motors" are discussed in detail.

The NEC sets forth the minimum standards for electrical wiring in the United States. The standards contained in the NEC are enforced by being incorporated into the different city and community ordinances that deal with electrical wiring in residences, industrial plants (e.g. factories and chemical plants etc.) and commercial building. Therefore, these local ordinances conform to the standards set forth in the NEC.

Just to give an idea to those engineers who are not familiar with NEC, only a page from Table of Contents is attached herewith as Annexure – 1. This partial listing provides an over-view of the organization of the NEC. It is important for all electrical engineers as well as brilliant students of Electrical Engineering to learn as to how to fruitfully use the NEC.

SOME BACKGROUND OF NATIONAL ELECTRICAL CODE (U.S.A)

The National Electrical Code (abbreviated as NEC) is one of many codes and standards that are published by the National Fire Protection Association (NFPA), a not-for-profit corporation. The First Edition was issued during the year 1896. The code is revised every three years in order to keep up with new materials, tools, and methods that are constantly being developed. This work is performed by 21 separate committees, each consisting of approximately 10 to 15 persons, the majority of them engineers. Members of each committee meet several times, discuss all proposed changes, accepting some and rejecting others, and rewrite (as required) the sections of the Code that were assigned to their committee. Then, they circulate the changes among the various committees, coordinate the changes, and rewrite again. So, obviously, the updating of the NEC is a tedious task. But the real difficulty is that it must remain applicable to all types of electrical installations, leaving no "gaps". Because of this, it becomes rather difficult to interpret in some instances. For this reason, Handbooks are also available which are written by prominent and experienced persons and these Handbooks are very useful.

The engineers who write the Code and the Handbooks are deeply concerned with technical accuracy and completeness.

NEC is being used not only in U.S.A but also in some other countries such as Saudi Arabia and Kuwait etc.

In Saudi Arabia historically the Eastern Region has more American influence due to the presence of ARAMCO which has been carrying out the trade of crude oil for the past 80 years. The author happened to see some contracts regarding Thermal Power Plants which were awarded by SCECO East (now it is called S.E.C) and which contained reference of above said NEC. In Dammam area, sockets, switches and wiring devices are generally in accordance with N.E.C (U.S.A).

The above said extremely useful code is available on the internet for free down-loading at the following website:

ESSENTIALS OF A MOTOR CIRCUIT

If one happens to see the Single Line Diagram pertaining to a power station, it will be observed that there are many circuits which feed a.c. motors. The motors employed are invariably three-phase type; this is particularly true for large hp motors. Further, those motors which need large starting torque must be wound rotor a.c. motors. There are some other motors which do not need large starting torque, for instance those which are used in exhaust fans etc. Such motors are squirrel cage type a.c. induction motors.

Let us take an actual study case for a motor. Refer to Figure – 1 wherein a complete feeding circuit for a 10 H.P. squirrel cage induction motor is shown. The motor is having a Service Factor of 1.15 and it is a 40°C temperature rise motor. Since all American motors, which are made in accordance with NEC, must have a NEMA Design Code letter (for example A, B, C, D etc., which indicates as to how much is the starting current of the motor). While "A" has the minimum starting current, "B" will have more starting current than "A". This feature goes on increasing in the ascending order.

A 10 hp motor is not a large hp motor and it can be directly connected to a.c. power supply. But large motors say one having a rated output of 100 hp is started through reduced voltage starting equipment (for instance, a star-delta starter is utilized for this purpose). As explained in Reference – 2, if the kVA rating of the motor, which can be ascertained from the hp rating of the motor, is less than 15% of the capacity of the distribution transformer which is feeding it, only then it can be connected directly to the a.c. supply. For example, if the distribution transformer is having a rated capacity of 25kVA then even a 10 hp motor cannot be directly connected, i.e. without some reduced voltage starters, since it is more than 15% of the rated capacity of the transformer.

In the following paragraphs methodology as well as pertinent aspects of motors and their protective device are explained.

METHODOLOGY

The following methodology is used for ascertaining the ratings of Protective Devices etc.

1) Refer to Figure – 1. The motor is a 10 hp direct on line 3-phase a.c. squirrel cage induction motor.

   Refer to NEC Table 430-150 (attached herewith). In this Table against 10 HP, the value which is appearing below 460V is 14 Amps. A few notes are provided in the table and according to one of those, if the power factor is taken as 0.8 then the above found value (i.e. 14 Amps) has to be multiplied by 1.25.

   Further the voltage which is prevailing in WAPDA system is 400 V. So we will make the above said current for 400 V in this way:

(14 x 1.25) x 460/400 = 20.125 Amps - - - - - - - - - - - - - (i)

2) Now for ascertaining the rating of the Inverse Time Circuit Breaker which is for short circuit and Ground Fault Protection, refer to Table 430-152. This circuit Breaker will be installed in the Main Distribution Panel appearing in Figure -1. Since the above said motor has a NEMA Design code "A" (which is so stated on its name plate, we will read against "squirrel cage other than Design "E", and the value is 250%. In other words, the rating of the circuit breaker will be 20.125 x 2.5 = 50.3125 amps. This is, ordinarily, the maximum size of the circuit breaker which is allowed for Figure – 1 motor.

   As per NEC Section 240-6, the next higher standard size of circuit breaker which is 60 A can be used. The same is selected and should be employed for the intended purpose.

   Usually 60 A should be able to allow the above said motor to start and come to its full speed. However, in case this 60 A circuit breaker does not allow the motor to start and the former unnecessarily trips then for such motors whose full load current is 100 amps or less, the absolute maximum size of the branch circuit breaker (i.e. the one which is installed in the Main Distribution Panel) can be 400% of the full load current. For those motors, whose full load current is more than 100 amps, there are different rules and for that purpose NEC should be consulted.

3) Regarding overload protection which is also called Running Protection, there are two types of motors. In the first category are those motors which are 40°C temperature rise over 40°C ambient temperature and which have a Service Factor of 1.15. The overload protection (i.e. fuse or C.B) should not be more than 125% of the full load current. The second category motors are all other motors which do not fall in the first category and for these the overload protection should not exceed 115% of full load current of the motor.

   In our particular case, the full load current as read from the name plate of the motor is 19.0 amps. So, 19 x 1.25 = 23.75 amps. Since NEC allows to utilize next higher standard size, therefore, from NEC section 240-6, the selected size will be 25 amps.

4) It must be borne in mind that while selecting overload protection of motor, the full load current which is to be used in the calculation is the one which is indicated on the name plate of the motor. It may be recalled that while selecting Short Circuit and Ground Fault Protection, the value of the full load current of the motor was taken from NEC Table 430-150 and in this particular case it will be wrong to use the value of the full load current of the motor which is appearing on the name plate of the motor.

5) Regarding overload protection of the motor, refer to Table 7-3(A) which is attached herewith. Since the Motor's ampere rating as found by (i) above is 20.125 Amps therefore, the rating of the Dual-element fuse will be 25 Amps.

6) The last thing which is yet to be determined is the size of the Disconnector. As per NEC it should not be less than 125% of the full load current of the motor. Since full load current of the motor, as found from Table 430-150 is 20.125 amps, so the size of the Disconnector will be 20.125 x 1.25 = 25.16 amps. Again selecting the next higher size from section 240-6, we choose 30 amps size.

SOME ELABORATION ABOUT VARIOUS COMPONENTS

(a) Electrical Motors

For converting electrical energy into mechanical energy, A.C. and D.C. motors have been in vogue in the industry for well over 100 years.

So far as A.C. motors are concerned, the principal types of three-phase motors are:

(1) Induction Motors (these are further subdivided into two categories i.e. squirrel cage type and wound-rotor type)

(2) Synchronous motors

Three phase A.C. induction motors specially squirrel cage type have the following advantages and due to these are very much popular in the industry:

(1) Low initial cost

(2) Easy operation and maintenance

(3) High Efficiency

(4) High power factor (when these are about 90 to 100% loaded).

(5) Rugged construction

(6) Reliable operation

(7) Simple control gear for starting and speed control.

So far as Synchronous motors are concerned, these are similar in construction to an alternator i.e. there is a D.C. field winding on the rotor and a three phase winding on the stator. The problem with a synchronous motor is that it is not self starting and first of all it has to be brought to synchronous speed by some other means such as a diesel engine or an induction motor etc. and only then it will start revolving with the help of incoming a.c. supply.

Synchronous motors are suitable for constant speed applications such as frequency changers etc. These have been used in Thermal Power Station for driving compressors required for Gas Turbines etc.

(b) Protection Devices

For protection against overcurrent, two types of devices namely fuses and circuit breakers are commonly employed. In the U.S.A, the National Electrical Manufacturers Association, abbreviated as NEMA, has established standards for the ratings, types, classifications and testing procedure for fuses and circuit breakers.

As per NEC, the ratings of fuses and non-adjustable circuit breakers are 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, 90, 100, 110, 125, 150, 175, 200, 225, 250, 300, 350, 400, 450, 500, 600, 700, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000 and 6000 amperes.

In addition to above, the following standard ratings are also applicable for fuses: 1, 3, 6, 10 and 601 amperes.

In the case of externally adjustable trip circuit breakers, the rating is considered to be the breaker's maximum trip setting, and in this regard refer to NEC Section 240-6. However, there are three exceptions to this rule as explained below:

(1) If the breaker has a removable and sealed cover over the adjusting screws, or

(2) If it is located behind locked doors accessible only to qualified personnel, or

(3) If it is located behind bolted equipment enclosure doors.

In above mentioned three cases, the adjustable setting is considered to be the breaker's ampere rating. For example the rating of an adjustable circuit breaker is 100 A but it is indicated on it that it can be adjusted to make it a 50, 60, or 80 A breaker. Suppose someone has adjusted it and made it a 50 A breaker but it has not been installed in the ways indicated above under (1) or (2) or (3) then even after adjustment this circuit breaker will be considered as 100 A circuit breaker for the purpose of providing protection to a circuit or equipment.

It may be noted that the NEC's ratings for fuses and circuit breakers mentioned above are quite different from IEC ratings. For instance IEC ratings for fuses are 2, 4, 6, 10, 12, 16, 20, 25, 32, 40, 50, 63 etc.

(c) Motors Disconnectors and Ratings

As per NEC, switches with fuses as well as switches without fuses are available. The latter are commonly called "Safety Switches". Both type of above mentioned switches are available in rating of 30, 60, 100, 200, 400, 600, 800, 1200, 1600, 2000, 2500, 3000, 5000 and 6000 amperes in both 250 and 600 volts class. They are for use with copper conductors unless marked to indicate that the terminals are suitable for use with aluminum conductors.

Quite often Labels are exhibited on Disconnectors that indicate their intended application. A few examples are as stated below:

- Disconnectors intended for isolating use only are marked "For Isolation Use Only – Do Not Open Under Load".
- When a switch is marked "Motor – Circuit Switch", it is only for use in motor circuits.
- Enclosed switches with horsepower rating in addition to ampere ratings are suitable for use in motor circuits.

(d) Dual-Element Fuses

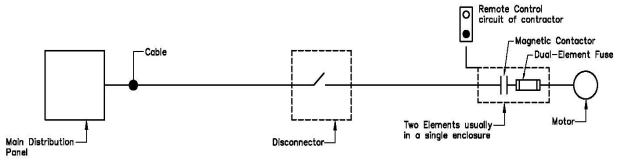
The starting current of an electrical motor is very high for a few seconds (say first 4-5 seconds till the motor attains its full speed).

For the overload protection of motors, fuses or circuit breakers can be used. Dual-element time delay fuses are an excellent choice for the overload protection of motors. They can be sized close to the ampere rating of the motors. When the motor has integral overload protection then dual-element time delay fuses are selected to provide back-up overload protection.

Dual-element time delay fuses will carry five (5) times their ampere rating for at least 10 seconds. As a result, this feature allows the motor to start and then provide good overload protection while it is running.

For example, a motor whose full load current is 4 amperes could have a starting current as high as 24 amperes. The fuse must not open needlessly when it encounters the inrush current of 24 amperes. In such a situation, a 15 – ampere ordinary (i.e. not having time delay feature) fuse or breaker might be required to allow the motor to start. Certainly it would not provide overload protection for the appliance since the overload protection has to be 125% of the normal full load current of the motor.

The solution is to install a dual-element time delay fuse that permits the motor to start yet on a continuous overload it melts and thus protects the motor. Type "S" fuses (which are as per U.S.A practice) as well as Type S adaptors are inserted into the fuse holders and installed in the motor's feeding circuit.



Figure–1

Note: The Disconnector must be visible from the location of motor and should not be more than 50 feet away from it. Otherwise, it must be lockable.

CONCLUSION:

NEC (USA), which is being used in U.S.A for well over 100 years is an excellent design guide and it can be profitably used in Pakistan.

In all types of power stations, the auxiliary power supply system has to provide a.c. power supply to many electrical motor circuits. In this paper a study case regarding a 10 hp induction motor has been included to ascertain the sizes of the various protective devices, in accordance with NEC (U.S.A). The necessary tables which are required for the calculations are also included.

REFERENCES:

1) National Electrical Code, published in year 2011, Published by National Fire Protection Association, U.S.A

2) Electrical Engineer's Portable Handbook, 2nd Edition, Published by Mcgraw-Hill Book Company, U.S.A.

3) Electrical Wiring Commercial, 10th Edition, Published by Delmar Publishers, U.S.A.

Note:Multiplier for using 400 V at 0.8 p.f is = (460/400) x 1.25 = 1.4375↔ Factor find value from above table. Then multiply by the multiplier. (For example for 100 HP motor, current under 460 V = 124 A.

Then 124 x (460/400) x 1.25 = 178.25A will be motor's F.L current at 400 Volts.

(C) Rating or Setting.

(1) In Accordance with Table 430.52. A protective device that has a rating or setting not exceeding the value calculated according to the values given in Table 430.52 shall be used.

Table 430.52 Maximum Rating or Setting of Motor Branch-Circuit Short-Circuit and Ground-Fault Protective Devices

	Percentage of Full-Load Current			
Type of Motor	Nontime Delay Fuse[1]	Dual Element (Time-Delay) Fuse[1]	Instantaneous Trip Breaker	Inverse Time Breaker[2]
Single-phase motor	300	175	800	250
AC polyphase motors others than wound-rotor				
Squirrel cage – other than Design E or Design B energy efficient	300	175	800	250
Design E or Design B energy efficient	300	175	1100	250
Synchronous[3]	300	175	800	250
Wound rotor	150	150	800	150
Direct current (constant voltage)	150	150	250	150

Note: For certain exceptions to the values specified, see 430.54.

[1]The values in the Nontime Delay Fuse column apply to Time-Delay Class CC fuses.

[2]The values given in the last column also cover the ratings of nonadjustable inverse time types of circuit breakers that may be modified as in 430.52 ©, Exception No. 1 and No. 2.

[3]Synchronous motors of the low-torque, low-speed type (usually 450 rpm or lower), such as are used to drive reciprocating compressors, pumps, and so forth, that start unloaded, do not require a fuse rating or circuit-breaker setting in excess of 200 percent of full-load current.

Exception No. 1: Where the values for branch-circuit short-circuit and ground-fault protective devices determined by Table 430.52 do not correspond to the standard sizes or ratings of fuses, nonadjustable circuit breakers, thermal protective devices, or possible settings of adjustable circuit breakers, a higher size, rating, or possible setting that does not exceed the next higher standard ampere rating shall be permitted.

Exception No. 2: Where the rating specified in Table 430.52, as modified by Exception No. 1, is not sufficient for the starting current of the motor:

Table 430.150 Full Load Current, Three-Phase Alternating-Current Motors

The following values of full-load currents are typical for motors running at speeds usual for belted motors and motors with normal torque characteristics.

Motors built for low speeds (1200 rpm or less) or high torques may require more running current, and multispeed motors will have full-load current varying with speed. In these cases, the nameplate current rating shall be used.

The voltages listed are rated motor voltages. The currents listed shall be permitted for system voltage ranges of 110 to 120, 220 to 240, 440 to 480, and 550 to 600 volts.

	Induction-Type Squirrel Cage and Wound Rotor (Amperes)							Synchronous-Type Unity Power Factor* (Amperes)			
Horsepower	115 Volts	200 Volts	208 Volts	230 Volts	460 Volts	575 Volts	2300 Volts	230 Volts	460 Volts	575 Volts	2300 Volts
½	4.4	2.5	2.4	2.2	1.1	0.9	-	-	-	-	-
¾	6.4	3.7	3.5	3.2	1.6	1.3	-	-	-	-	-
1	8.4	4.8	4.6	4.2	2.1	1.7	-	-	-	-	-
1 ½	12.0	6.9	6.6	6.0	3.0	2.4	-	-	-	-	-
2	13.6	7.8	7.5	6.8	3.4	2.7	-	-	-	-	-
3	-	11.0	10.6	9.6	4.8	3.9	-	-	-	-	-
5	-	17.5	16.7	15.2	7.6	6.1	-	-	-	-	-
7 ½	-	25.3	24.2	22	11	9	-	-	-	-	-
10	-	32.2	30.8	28	14	11	-	-	-	-	-
15	-	48.3	46.2	42	21	17	-	-	-	-	-
20	-	62.1	59.4	54	27	22	-	-	-	-	-
25	-	78.2	74.8	68	34	27	-	53	26	21	-
30	-	92	88	80	40	32	-	63	32	26	-
40	-	120	114	104	52	41	-	83	41	33	-
50	-	150	143	130	65	52	-	104	52	42	-
60	-	177	169	154	77	62	16	123	61	49	12
75	-	221	211	192	96	77	20	155	78	62	15
100	-	285	273	248	124	99	26	202	101	81	20
125	-	359	343	312	156	125	31	253	126	101	25
150	-	414	396	360	180	144	37	302	151	121	30
200	-	552	528	480	240	192	49	400	201	161	40
250	-	-	-	-	302	242	60	-	-	-	-
300	-	-	-	-	361	289	72	-	-	-	-
350	-	-	-	-	414	336	83	-	-	-	-
400	-	-	-	-	477	382	95	-	-	-	-
450	-	-	-	-	515	412	103	-	-	-	-
500	-	-	-	-	590	472	118	-	-	-	-

*For 90 and 80 percent power factor, the figures shall be multiplied by 1.1 and 1.25, respectively.

Solar Energy Applications in Industrial and Commercial Sectors in Pakistan and Barrriers in its Growth

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Pakistan is an energy deficient County. Energy Crisis in the country is the result of continuous negligence and mismanagement of the successive governments. Energy crisis has crippled economy of the county. In Pakistan, this crisis is increasing day by day and everyone is thinking ways to resolve this crisis. Some have the view that it can be resolved by energy conservation and some have the view to increase the use of Alternate Energy in Pakistan and some have the view to generate electricity through Hydro and coal resources. Every strategy has its own merits and demerits.

The shortest possible way to combat energy deficit is to enhance the use of solar energy applications in Industrial and commercial sectors. There are many barriers in its growth like upfront costs because of lack of incentives, right designing, awareness & quality standards which need attention of the Government to remove them. Alternate Energy sector cannot grow without the Government commitment towards this. We discuss below solar energy technologies and its applications to understand their use.

SOLAR THERMAL

Solar thermal is the technology by which the solar energy is converted into heat energy and its major applications in industrial and commercial sectors are ; Hot water usage for bathing and washing, Pre-heated water up to 80 degree to Boilers, Pasteurization, condensation and cleaning in Milk Dairies, Drying and tanning in leather process industries, Degreasing and phosphating in metal finishing industry, Resin Emulsification in Polymer Industry, Drying in food, wood, live stock and pharmaceutical industry, Swimming pool water heating etc.

SOLAR THERMAL APPLICATIONS

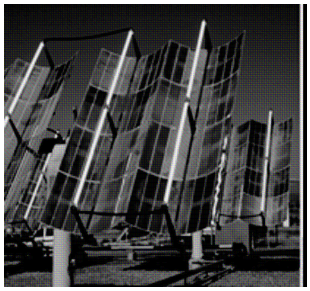
Solar water heating is one application of the Solar Thermal. Solar Water Heaters (SWH) are of two types; one is non-pressurized solar water heating (SWH) and other is Pressurized Solar Water Heating. In non-pressurized solar water heater, the collector (Vacuum tubes or flat plate) and tank are mounted on one fixture and are in one integrated unit. Tank is mounted at top of the collector. There is no pump used in this type of system. This system works on flow of water through gravity from overhead tank to solar water heater tank (stainless steel tank with 55 mm poly-urethane insulation) and from this tank onward to vacuum tubes and by natural convention process, the hot water circulates and heats up the whole tank. It usually takes four hours to heat up the water of 300 litters up to 45 Degree in peak winter season and 60 Degree in moderate season and 90 degree in peak hot season. So the temperature of water varies as per ambient temperature. Usually 50 Litters per person per day is taken while designing the system for domestic use. For industrial application of washing and cleaning, the total water load in terms of flow is calculated to design the system. The total number of solar water heaters connected in parallel or series depends upon the daily water consumption and temperature requirement.

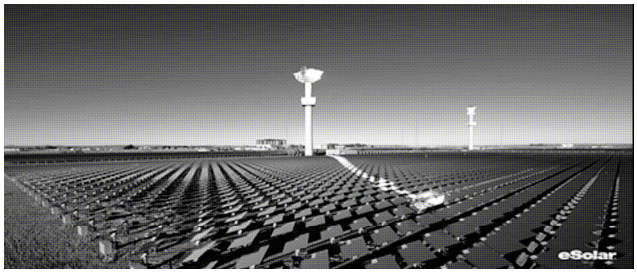
The collectors used in Pressurized Solar Water Heaters can be flat plate or vacuum tubes. In pressurized solar water heaters, the tubes are made of copper and these are closed tubes and the upper top has bulb dipped in water tank through which heat radiates into the water in tank. The copper tubes are filled with ether which expands quickly when sun radiations fall at tubes. So in this type of system water does not enter into the copper tubes and therefore no chance of rusting. In pressurized systems, tank is separate than the collector unit and no gravity is required. There are two circuits one is primary circuit and other is secondary circuit. In primary circuit the glycol moves through circulatory pump by controller and in secondary circuit the water moves through pump or without pump to end points .These kind of systems are used in Solar Swimming Pools, Solar pre-heat for Boiler, Solar space heating, De-greasing applications in industries and buildings. The tanks in pressurized systems can have one cooper coil or two coils depending upon the type of applications. In large systems where quick heat exchange is required, the heat exchangers are also used.

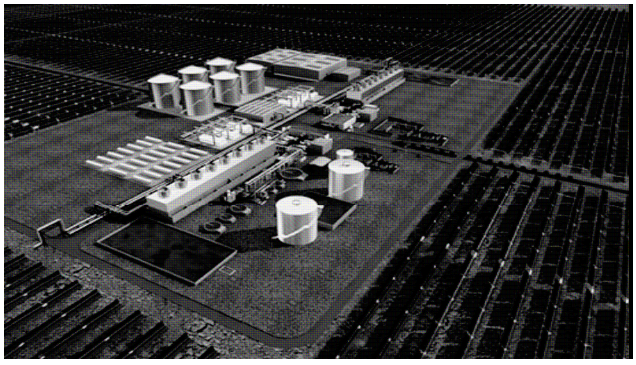
There are four myths which are creating problems in the growth of solar water heaters in commercial and industrial sectors. One is that if you install SWH, the hot water is available all the times. This is not true. The hot water is a resource which is limited as per size of the SWH. If you install one 300 ltrs of SWH, in 24 hours you will get 300 ltr hot water which you use once or use slowly whole of the day. If you need more water, you have to have more than one SWH as per hot water load requirement. Second myth is that it can be installed anywhere. It is not true. It can be installed where south direction is available, whole day sun is available and space for placing the SWH is available. So site analysis is the pre-requisite of installing solar water heaters. Third myth is that every plumber can install this system. It is not true. Only trained person can install such systems. Get installed your systems from REAP certified technicians only. Forth myth is that if solar water price is Rs.40,000,

this is total cost. It is not true. The total cost is the cost of SWH, piping and plumbing accessories which can vary from Rs.2000 to Rs.10,000 depending upon site conditions. Scaling is another issue in SWH which has to be considered during performance monitoring of systems. Amount of scaling depends on water quality. In industrial applications, water softeners are required to soften the water before they enter into solar collectors. Get your systems de□scaled once in two years as it will improve its performance. Cleaning it on weekly basis the collectors as in our country dust is too much.

Solar Thermal Power Plant is another application of solar thermal. Solar thermal power plant consists of solar collectors which can be of Dish, parabolic or tower type formation, steam generation process and steam generators for converting steam into electric power. These thermal power plants are very economical way of generating power as compared to solar electric power generation. The operational expense is more than that of solar electric systems. Space requirement is more than Solar electric. High power upto 200 MW can be generated through this solar thermal power plants.

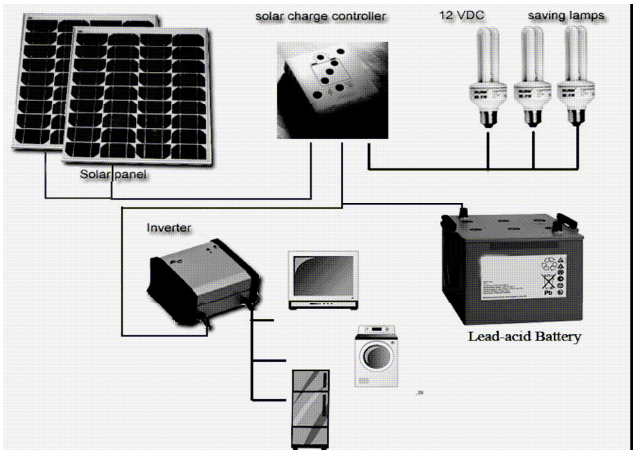






SOLAR PHOTOVOLTAICS

Solar Photovoltaic is the technology by which solar energy is converted into electrical energy and its major applications in industrial and commercial sectors are; Solar Homes Systems upto 2000 W, Solar Lighting, Solar Power Plants from 10 KW to 20 MW, Solar Parks upto 20 MW, Solar UPS, Solar Roof Based On Grid Power Generation, Solar Traffic Signals Lights, Power for Remote Terminal Units, Power for Telecommunication Towers and BSC and MSC, Building Integrated Photovoltaic System, Military signaling applications, Solar water Pumping, Solar Lighting for Parking lots, Solar Lighting for Bus Stop Shelters etc.



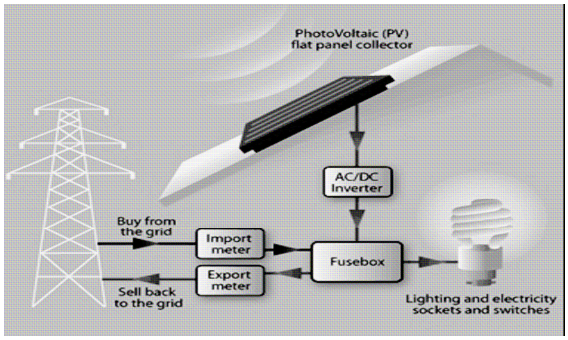
SOLAR PHOTOVOLTAIC APPLICATIONS
SOLAR ELECTRIC POWER GENERATION

Solar Electric Power can be generated varying from 100 Watts small solar home systems to 100 MW Solar Power Plants or sometimes more than that. The solar power systems are of two types; one is off-grid and other is on-grid systems. In off-grid systems, the system has no link with Utility grid and components used in Systems are Solar Panels, Charge Controllers, Inverters, Deep Cycle Batteries, mounting and electric accessories. Solar Panels convert solar radiations into electric current and this current passes through charge controllers which charges the battery by controlling current for the battery. Charge controllers maintain control on charging the battery for its long life. So the DC power is stored in Batteries and this stored energy is converted into AC Power to operate the AC appliances. The DC appliances can be operated directly with the battery. So DC and AC load can be operated through a solar power system.

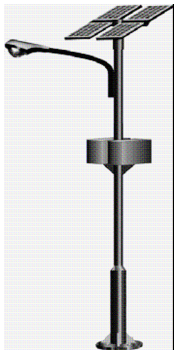
Un-professional and Un-trained people in the market are selling under-designed and low quality systems because of which the customers are losing confidence in solar technology. On the one hand, solar technology has high upfront costs and on the other hand people are selling low quality and under-designed systems to cut down the costs. The most important thing in solar Power systems is its right design and putting high quality system components which should guarantee faultless operation of the whole systems for 20 years. The other important thing for customers is that they should not buy system in watts but systems in watthours. For example 500W system can work for one hour and can work for 24 hours. If it

generates power for one hour, the system capacity will be 500 Watt□Hours and if the system works for 24 hours, 12000 Watt□Hours (12 KWHR per day means 12 units per day). Now both systems are of 500 W but their operational hours vary. The cost of the system is calculated as per watt□hours, not as per watt. So customers should not buy watts but watt□hours as they are buying not watts but watt□hours which is real energy as they pay their electric bills in watt□hours or Kilo Watt Hours which is called the Units in common language.

On-grid systems are common in the world and world is moving toward on□grid technology. On□Grid system is that system which is connected with Utility Grid with built in two meters one is export meter and one is import meter and in some case one bi□directional meter which reverses when electricity is sold to Grid and at the end the user pays for the net meter reading. In two meters system, when energy is sold to Grid, the export meter counts and when energy is bought from grid, import meter counts the power consumption and user has to pay the net reading of both meters. User/Power producer will be paid by the Utility if Utility has bought more and sold less. To make legal such systems, there is FIT (Feed□In□Tariff) policy by which the solar power generation is governed. Through FIT policy, the Government fixes up the rate of buying from solar power producers as per slabs. In Pakistan, there is no net□metering policy and there is no FIT policy. On□Grid power is cheaper and does not have batteries. One of the barriers in FIT in Pakistan is the continuous load shedding because such systems stop working as such systems have no back up when grid is off.

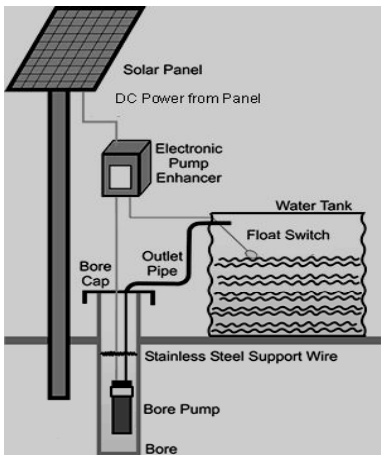


SOLAR LIGHTING



Solar Lighting is another application of solar photovoltaic. Solar Lighting has many types. The solar lighting can be solar street lighting, solar flood lighting, solar garden lighting or some special applications of lighting. In solar lighting, very important thing is the designing of solution so that the lights work automatically and remain on as per requirement. Most of the solar lights, we see un□lit in the nights or they lit for some hours and then go off against the timing requirement. The reason for this is that the un□professional people have designed and sold under□designed and low quality systems. While purchasing the solar lighting systems, define your specifications and then buy systems accordingly and monitor their operational hours continuously.

SOLAR PUMPING



Solar Pumping is another application of solar photovoltaic. The solar pumping systems are of two types, one is DC solar Pumping system and other is AC solar Pumping system. DC solar pumping systems are small systems which are for domestic purposes, offices and irrigation of small lands up to two Acres. These DC solar pumping systems are very reliable and cheaper. In this system the pump motor is DC motor and one controller controls its operation which is MPPT controller responsible for smooth operation of the pump without the need for batteries. The maximum flow with DC systems can be upto 10,000 Gallons per day with maximum head of 200ft. Solar AC Pumping system consists of AC Pump, Pump Controller and solar panels. These are big systems of motor power varying from 2KW to 60KW and their up□front costs vary from Rs.1M to 20M. These AC pumps are for all kinds of agriculture and big farming applications. The flow can vary from 10m3 per hour to 300 m3 per hour with head varying from 100 ft to 600 ft.

Solar Pumping is very specialized job and calls for high technical expertise starting from pump design & selections to installation and commissioning of systems. The customers should buy systems from professional companies and get installed from trained pump technicians.

Solar pumps are very economical if you compare operational costs with the conventional pumping system working through Diesel generators or Utility Grid. The payback varies from three to seven years depending on the type of system you are buying.

SOLAR POWER FOR TELECOMMNUCATION NETWORKS

Solar power for telecommunication networks is another application for solar photovoltaic. The telecommunication BTS towers have power supply from Diesel Generators in areas where no grid is available and have back up diesel generators where grid is available. Operational Expense of power generator is very high. The best replacement of the diesel back up is the solar power which is clean energy. These systems can be hybrid (solar and wind) where wind is available. Many telecom operators have installed solar systems and they are very much satisfied and many are still in the process of planning for purchase of solar power systems. Again designing of solar solution for BYS towers is a specialized job.

SOLAR POWER FOR REMOTE TERMINAL AND SURVELLIANCE UNITS

In Oil and gas production and processing plants, the parameters are controlled and monitored remotely through remote computerized terminal units. In surveillance systems, mostly the monitoring is remote and solar power application in this area is very reliable and cost effective.

BARRIERS AND CHALLENGES

The barriers in the growth of solar energy applications are; upfront high costs because of lack of incentives and policies, Lack of customer awareness, Lack of designing and installation Skills, Lack of Subsidy and bank financing, Lack of promotion and will at Government Level, Lack of FIT (Feed in Tariff Policy), Lack of Grid Interconnection Policy, high Pay back ranging from 10 to 13 years etc. By enhancing the use of solar technology in industrial and commercial sectors, we can overcome energy crisis in Pakistan in a very short time as compared to other power generation options.

BREIF INTRODUCTION OF ENGR. FAIZ MOHAMMAD BHUTTA

Faiz Mohammad Bhutta is an engineer plus MBA. He has 30 years of experience of serving at technical and managerial posts in national and multinational companies; He is currently serving as General Manager Izhar Energy Services, Izhar Group of Companies. Apart from his professional career, he has served as visiting teacher on engineering and management subjects in Air University, COMSATS University and UMT.

He has also contributed as PEC Task force member on Building Energy Code 2011.

He is chairman of Renewable and Alternate Energy Association of Pakistan Lahore Chapter. He is member of organizations namely International Solar Society Germany;

ASHRAE USA, Executive Member of REAP, Life member of PEC , Life Member of HVACR Society, Life Member of IEP and Life member of IEEP.

He is a writer & Trainer also and his articles are published in EIR, HVACR Journal, TechnoBiz, Engineering Horizon, Alternate Energy Magazine, HVACR Journal etc. He is also editor of REAP Newsletter.

He has attended lot of national and international EXPO and Conferences on Alternate Energy in China and Germany.

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Center of Mass of Earth through Mass Balancing and Torque Balancing Latitude: An Analysis

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Abstract *This research paper presents the proof of concept of locating the center of mass of earth using basic physics principles. The underline argument in this paper is that the geometrical center of the earth i.e., Equator cannot be the center of mass of the earth.*

Keywords: *Center of mass of earth, crust mass, Mass Balancing technique, Torque balancing Latitude*

1. INTRODUCTION

The center of mass is the point where all of the mass of the object is concentrated. This point can be different from the geometric center of the object. For example, a car's center of mass is closer to the ground rather than in the geometric center of the car and due to this, car is balanced in a better way. The center of mass of objects plays very important role when there are number of interrelated objects in a system. For example in case of satellite communication, the complete system consists of two objects, the earth and the artificial satellite. Now for the purpose of having a very stable system it is a required condition that the satellite must revolve around the center of mass of the earth therefore the correct estimation of center of mass of earth can help to achieve more stable artificial satellite systems.

Another important thing about center of mass of any object is that it can be used as a frame of reference and with the help of an accurate frame of reference number of unknown parameters can be approximated. For example in case of earth the accurate frame of reference can help to approximate the rate of change of continental drift in a better way and hence the earth quakes and some other natural hazards can be estimated more accurately.

From above discussion it is clear that the estimation of an accurate center of mass of earth is very important for number of purposes. The center of mass of the earth has been discussed by many researchers and scientists but yet not discovered [1]. Sometimes equator is considered as center of mass of earth by merely considering geometrical shape of the earth, which is not justifiable in any ways because there are few conditions that need to be satisfied by a point to be the center of mass of the object and it would be clear in the remaining sections that the equator is not satisfying any of those conditions.

In this paper, the proof of concept of locating the center of mass of earth using basic physics principles has been presented. Following this section, section 2 discusses the method to locate the center of mass of earth and applies the relevant tests on the equator. Finally section 3 provides the conclusions to this short paper.

2. METHOD

The conditions that need to be satisfied by any point to be the center of mass of an object are:

١) The mass of object must get balanced at that point

٢) The effect of net torque must be zero at that point

Any point satisfying above two conditions will be in static equilibrium.

The formula for torque is:

$$T = r \times W$$

where r is the moment arm and W is the weight. It is possible to locate the center of mass of a system by placing a pivot at the theoretical center of mass and using the formula for torque by setting the torques on either end of a long, rigid body equal to each other.

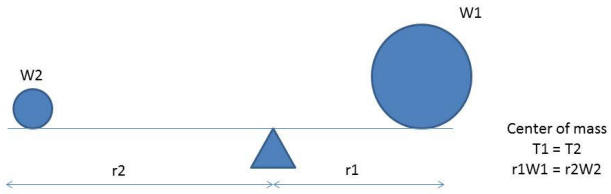

Figure 1: Center of mass point illustration

Therefore, the center of mass of earth would be around the latitude on the earth's surface where the above two conditions will be satisfied. So firstly it is required to find out the latitude on the earth where the mass of earth is getting balanced Secondly, at that latitude the torque must also get balanced.

Test 01: Mass balancing latitude

The Earth's interior is divided into three main layers namely core, mantle and crust. The outer most layer of Earth is crust which is divided in to two parts, the oceanic crust and the continental crust. The mass of mantle and core layer is not considered in our calculations because these two layers are not fully discovered yet and it is not known exactly that from where these layers start and where they end. As the outermost layer (i.e., crust) is almost fully accessible and discovered therefore it is better to consider it only in the calculation and assume that the others are uniformly distributed inside the earth. The estimated center of mass of earth using this method would be at least better than equator which is merely a consideration based on the geometric shape of the earth.

So here we have considered the mass of continental crust and the oceanic crust along with hydrosphere. The oceanic crust is very thin as compared to continental

crust, so for achieving the constant level of earth's surface, the hydrosphere is used along with oceanic crust. The mass of continental crust is 0.374% of the earth's mass, the mass of oceanic crust is 0.099% of earth's mass and mass of hydrosphere is 0.023% of earth's mass [1, 3]. For Northern hemisphere, the land to ocean ratio is 1:1.5 and for Southern hemisphere it is 1:4 as given in [4].

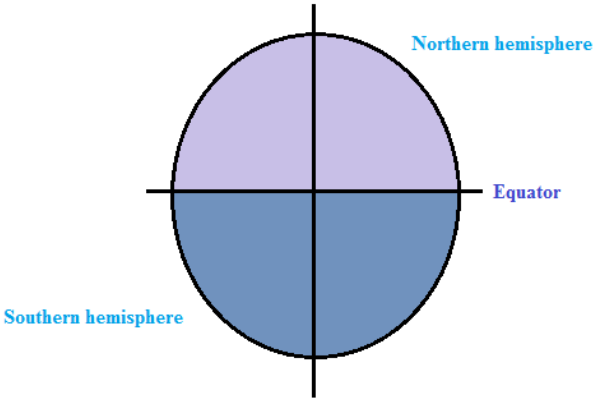

Figure 02: Basic earth model

As the earth is divided in to two hemispheres (i.e., the northern and southern hemispheres) and the equator is lying in between the two (see Figure 02), therefore, firstly the mass of these two hemispheres would be calculated by using oceanic crust mass along with hydrosphere mass and the continental crust mass.

The argument here is that the northern hemisphere mostly contains the land while on the other hand the southern hemisphere mostly contains oceans. As the continental crust is heavier than the oceanic crust therefore, it is quite likely that northern hemisphere contains more mass than the southern hemisphere and thus dividing the two regions exactly at center i.e., equator perhaps would unbalance the two masses. Therefore, the equator cannot be the center of mass; the actual center of mass should be slightly above then this line somewhere in the northern hemisphere as it is heavier than the southern hemisphere.

Test 02: Torque balancing latitude

Since elaborated in the section above that, at equator the masses of two hemispheres are unequal and therefore the weights would also be different. Since r1 and r2 are same for two hemispheres and their weights are different therefore, the net effect of torques would not get cancelled at equator. Hence, this condition also fails to prove that equator is the center of mass of earth. The authors have verified mathematically that the mass balancing and torque balancing latitude is 21.5 as shown in Figure 03. The mathematical proof is presented separately elsewhere [6].

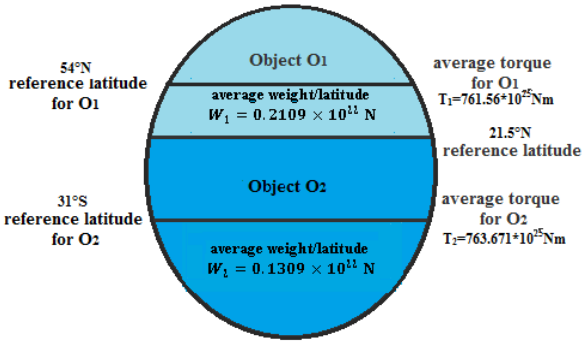

Figure 03: Torque balancing latitude

3 CONCLUSIONS

After applying the conditions of center of mass on the equator it can be fairly concluded that this cannot be the center of mass of earth as conventionally assumed. The center of mass of earth lies somewhere above the equator in the northern hemisphere since it is heavier than the southern hemisphere. By using above results many other advantages can be achieved in various fields related to earth such as in the study of global sea level change, earthquakes and volcanoes. These are the topics of future research by the authors.

4. ACKNOWLEDGEMENT

The authors would like to thank Engineer Zulfiqar Ali Arain, Asstt Professor, Department of Telecommunication engineering for providing guidance regarding satellite communications.

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Optimal Pitch Control Design of an Airplane with Analysis and Verification using MATLAB/Simulink

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Abstract
Though airplane has a number of important factors, its stability and control is a key design parameter that must be met. In an airplane the stability is defined in three angles i.e. pitch, yaw, and roll. The control pitch has been focused in this paper, for which the low cost optimal PD controller is designed and compares control result with uncontrolled ones. The percentage overshoot, steady state error, settling time, and rise time of Boeing Commercial Airplane are reduced and also analyses the results through root locus and frequency response. MATLAB/Simulink plays an important role in monitoring the results of designed controller.

I. INTRODUCTION

It is fact that, [1] an airplane pitch controller is designed to change the pitch of an aircraft using the deflection angle of the elevators. [2] As aircraft is a rigid body, which moves freely through space, it can be defined by six coordinates, three in translation rest in rotation. Keeping in mind the assumption of six degrees of freedom (6DOF) nonlinear differential equations, [3] the transfer function for Boeing airplane obtained is:

$$G(s)=\frac{1.151S+0.1774}{S^3+0.739S^2+0.921S} \qquad (1)$$

Fig. 1 implementing this transfer function in MATLAB and observing the step response authenticate it to be highly unstable. Thus a controller is to be designed which is less complex, cost effective and highly effective for the system.

II. CONTROLLER DESIGN

The controller is designed to make the system stable. There are a number of controllers like P, PD, PI and PID. [3] PID controller proves to be the best option and highly suitable for the system but at the same time it is also quite complex to use. Thus, in order to minimize the complexity of controller, optimize PD controller is used, which is not much complex as PID and fulfills all the requirements. Fig. 2 the PD controller placed in the system has got unity feedback. [4] The values of PD are to be changed so that the system becomes quite stable and can also satisfy the limitations i.e. minimum settling time, percentage overshoot and steady state error.

First, [5] solving for PD controller
PD Controller= Kp+ S Kd

$$G(s)=\frac{(Kp+SKd)(1.151S+0.1774)}{S^3+0.739S^2+0.921S} \qquad (2)$$

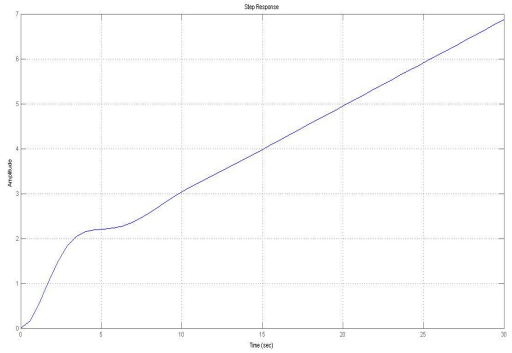


Figure 1. Step Response without controller

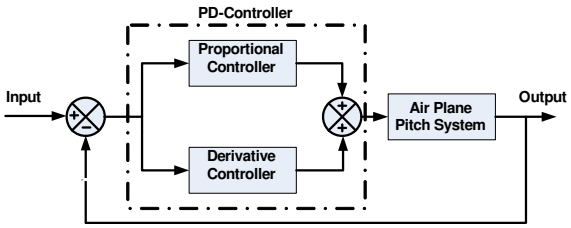


Figure 2. System with PD Controller

After calculating the unity feedback system:

$$G(s)=\frac{1.151S^2Kd+(0.1774Kd+1.151Kp)S+0.1774Kp}{S^3+0.739S^2+0.921S} \qquad (3)$$

[1] Extensive simulation on MATLAB gives the stability of the system under desired specification, and the concluded P and D values come out to be:

Kp=208.3 and Kd=163.6

$$G(s)=\frac{188.3S^2+268.8S+36.95}{S^3+0.739S^2+0.921S} \qquad (4)$$

Fig. 3 its step response. These setting were seemed to be highly balance for the rapid stability of the system. This will fulfill the requirements. From the figure it can be concluded that rise time is 0.0115 sec and settling time is

0.02 sec which are very fast, and especially the steady state error and overshoot is minimum.

Rise Time = 0.0115 sec
Settling time= 0.02 sec
Percentage overshoot= min
Steady state error= min

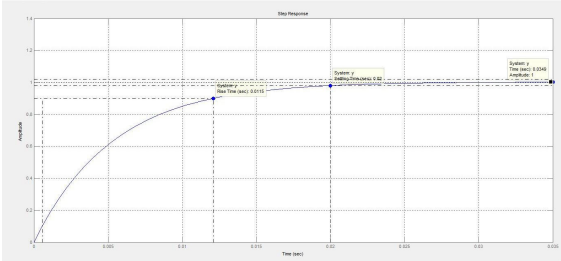


Figure 2. Step Response with PD-Controller

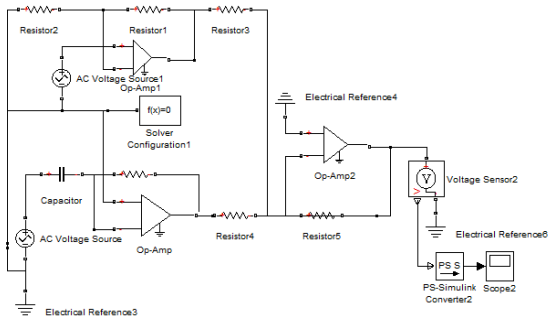


Figure 3. PD Controller on Simscape

III. PD CONTROLLER USING OP-AMP

The PD controller is designed using Operational amplifier in Simulink Simscape. Fig. 4 the resultant.

IV. STATE SPACE WITH CONTROLLER

Any system can be represented in time domain or a frequency domain. In frequency domain the system is called as the transfer function while in time domain it is known as state space. Though in frequency domain it is easy to solve the system but time domain analysis becomes much easier for some systems. This paper, thus, also focuses the state space of the desired system, [6] which is represented in the form of matrix as:

$$\dot{x}(t)=Ax(t)+Bu(t) \qquad (5)$$
$$y(t)=Cx(t)+Du(t) \qquad (6)$$

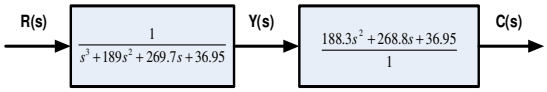
Where,
Matrix A is the system matrix
Matrix B is the control matrix
Matrix C is the output matrix
Matrix D is the feed-forward matrix

In trying to resolve the system, it is divided into two parts as shown:

$$\frac{Y(s)}{R(s)}=\frac{1}{S^3+189\,S^2+269.7S+36.95} \qquad (7)$$

$$(S^3+189\,S^2+269.7\,S+36.95)\,C(S)=R(S) \qquad (8)$$

$$\dddot{C}+189\,\ddot{C}+269.\dot{C}+36.95\,c=r(t)$$



$$x_1=C$$
$$x_2=\dot{x}_1=\dot{C}$$
$$x_3=\dot{x}_2=\ddot{C}$$
$$\left.\begin{aligned}\dot{x}_3&=-189\,x_3-269.7x_2-36.95x_1+r\\ \dot{x}_2&=x_3+0\,x_2+0x_1+0\,r\\ \dot{x}1&=0x_3+x_2+x_1+0r\end{aligned}\right\} \qquad (10)$$

$$\begin{bmatrix}\dot{x}1\\ \ddot{x}2\\ \dddot{x}3\end{bmatrix}=\underbrace{\begin{bmatrix}0 & 1 & 0\\ 0 & 0 & 1\\ -3695 & -2697 & -189\end{bmatrix}}_{A}*\begin{bmatrix}x1\\ x2\\ x3\end{bmatrix}\underbrace{\begin{bmatrix}0\\ 0\\ 2\end{bmatrix}}_{B}*r(t)$$

$$\frac{C(s)}{Y(s)}=\frac{188.3S^2+268.8S+36.95}{1} \qquad (11)$$

$$(188.3S^2+268.8S+36.95\,C(S)=Y(S) \qquad (12)$$
$$188.3\dddot{C}+268.8\ddot{C}+36.95C=y(t) \qquad (13)$$

$$x_1=C$$
$$x_2=\dot{x}_1=\dot{C}$$
$$x_3=\dot{x}_2=\ddot{C}$$

$$188.3\,x_3+268.8\,x_2+36.95\,x_1=y(t) \qquad (14)$$

$$\underbrace{[1883 \quad 2688 \quad 3695]}_{C}*\underbrace{\begin{bmatrix}x1\\ x2\\ x3\end{bmatrix}}_{D}+0=y(t)$$

[7] State space for the desired system can also be represented by a block diagram as:

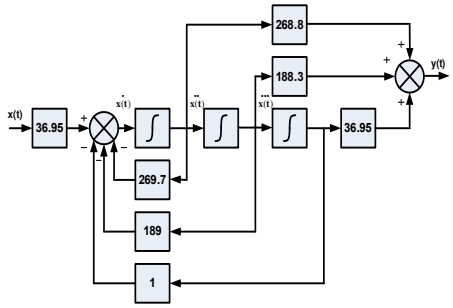


Figure 4. State Space in Block Diagram

V. ANALYSIS USING ROOT LOCUS

The root locus technique is one of the design analysis tools used in this paper for controller synthesis of Boeing airplane. Root locus is essentially a combination of two words "Root" and "Locus". Root is something which satisfies the equation and locus signifies the path. Thus, root locus is a path or a locus of all the roots of a close loop transfer function depending upon the values of *k*. When the value of *k* is zero, the points on root locus plot are poles, and for *k* infinity, the points on root locus plot are zeros. In other words, by changing the value of *k* from zero to infinity, root locus moves from poles toward zeros. The number of branches of root locus depends upon number of poles. [8] These branches start from poles and end at zeros. Manual calculations for root locus of closed loop transfer function are as follows:

Initially, σ (known as centriod) is calculated:

$$\sigma = \frac{(-0.36+0.88i-0.36-0.88i+0)-(-1.2734-0.1541)}{3-2} \quad (15)$$

$$\sigma = 0.7075$$

$$\Theta = \frac{(2q+1)}{\text{Na}}\pi \quad (16)$$

$$\Theta = \pi$$

Break away point

$$P(s) = \frac{1}{G(s)H(s)}$$

$$P(s) = \frac{S^3+0.739S^2+0.921S}{188.3S^2+268.8S+36.95} \quad (17)$$

Taking Derivative

$$\frac{dP(s)}{ds} = \left[\frac{(188.3S^2+268.8S+36.95)(3S^2+1.478S+0.921)-(S^3+0.739S^2+0.921S)(376.6S+268.8)}{[188.3S^2+268.8S+36.95]^2}\right] \quad (18)$$

Putting the derivative equal to zero and simplifying,

$$188.3S^4+537.6S^3+136.06S^2+302.175S-213.53 \quad (19)$$

Solving the above equation, the roots come out to be:

$$S1 = -2.8482$$
$$S2 = 0.2243+0.9225i$$
$$S3 = 0.2243-0.9225i$$
$$S4 = 0.4417$$

The point of arrival is -2.8482.

Simulating root locus, fig. 3 and fig.4 shows the system before and after the PD controller respectively. On comparing, it can easily be concluded that the system will become stable for infinite range after adding the PD controller in the system.

VI. FREQUECY RESONSE USING MATLAB

After introducing the controller with the system, the frequency response is found on the bode plot. Fig. 8 Noise margin and gain margin are observed to be infinity in this plot, which shows that the system is stable.

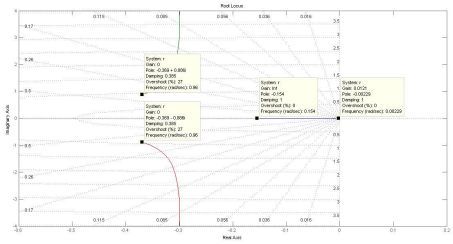


Figure 5. Roots Locus without Controller

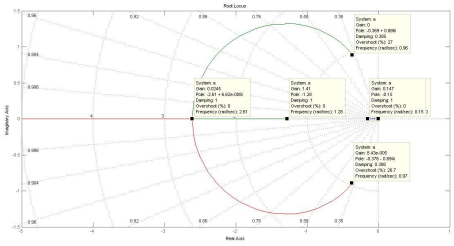


Figure 6. Roots Locus with PD-Controller

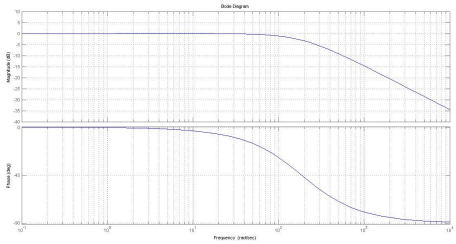


Figure 7. Frequency Response

VII. SIMULINK

[9] The system is verified using simulink which gives a quick response as well. Fig. 9 and fig. 10 shows simulink and its output respectively.

VIII. CONCLUSION

Among various numbers of important factors, an airplane's stability and control is major design parameter that must be met. In an airplane the stability is defined in three angles i.e. pitch, yaw, and roll. This paper only focused to control the pitch. Overshoot, rise time (0.0115 sec) and settling time (0.02 sec) of a pitch are minimized by designing an optimal controller. MATLAB played an important role in analyzing and comparing the results of

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the designed controller. The paper also describes the flight control mechanism of an air plane using simple MATLAB algorithm, as more and more airplane functions can be controlled through this algorithm.

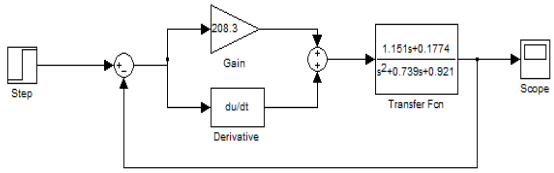

Figure 8. Simulink

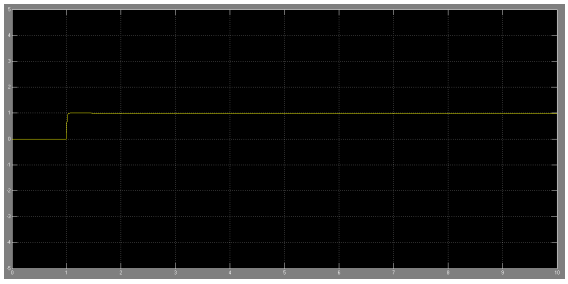

Figure 9. Simulink Output

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Improvement of Distribution System by Conversion of 3phase System to Single Phase System

Dr.Engr.Faisal Nafees Yousaf

1. ***Introduction:***

As investigated through practical experience during field works in DISCO'S (Distribution Company's) to analyze the system and also find out the causes of failure/interruption in the distribution system. By analyzing 70% of faults/failure occur due to poor maintenance and also use the substandard material as along as poor workmanship. The DISCO'S (Distribution Company's) un-necessarily extended the HT and 3phase LT lines to all the domestic consumers where the load is not required as per line and not meet with next five years but the company invested the high cost of the 3phase system is converted in to single phase systems then the DISCO's (Distribution Company's) sustain less capital cost and minimize the loss. The single phase system is cheaper than 3phase system which is approximately 45%. By adopting this method or idea, distribution system improved and reduces interruption system which is more reliable than the 3phase system. [1, 4]

٢. Basic structure:-

The distribution system is defined as HT line, LT line and consumers premises. The power system consists of generation transmission and distribution system. But being electrical engineers well known the type of system which are not discussed

Here. All the connections such as domestic, commercial and industrials areas are existing in 3phase system.

In most developed area system must be under ground which is more reliable in modern area/developed area the LT system is eliminated and installed all connection with single phase transformers as per load demand. [1, 3]

٣. Existing Distribution system in DISCO,s (Distribution Company's)

Mostly the distribution system in all DISCO's is over head and redial. In Pakistan system is design with growth rate of five years with BC ratio above one percentage. Actually the growth rate/demand with increasing approximately 35%.

٣,١. In DISCO's (Distribution Company's) distribution system has the lowest priority and to less investment in the distribution system. Actually all revenue is collected from the distribution. More interruption more loss. It means that proper investment is alone in distribution system.

٣,٢. 99% of the DISCO's (Distribution Company's) distribution system is 3 phase and over head. Due to the over head system interruption in DISCO's (Distribution Company's) by lighting, accidents, dust storms, kitting and etc. For reduction of losses ELR (energy loss reduction) and DOP programmes are carried out in DISCO's (Distribution Company's). The programmes based on the BC ratio which are not suitable for improvement of systems. If the system is converted from 3 phase system to single phase system with same rating of single phase T/Formers are installed in maximum capacity instead of extension of lines by proper planning desired results are achieved. Mostly T/Formers are damaged due to improper planning and loose heavy units which generate the high revenue loss.[3]

٤. Causes of system failure.

The DISCO's (Distribution Company's) have no priorities. It always in hurry up position, no proper planning management also mismanagement of resources. The efficiency of system will be it always in hurry up position, no proper planning management also mismanagement of resources. Improved with least cost. The operational management collected the accurate data of interruption from some operational offices and then the expertise analyses and find out their solutions. Interruption is main causes of failure of supply system. Which cause the main loss of DISCO's? (Distribution Company's) Mostly faults are visible like, lose jumper, deteriorated connections, improper clearance, poor earthing, and lose bindings, broken/cracked insulations, improper sag non compliance of standards and etc. 80% faults are visible as discussed above. These faults are removed with least cost and in minimum period. Therefore 10% faults are difficult such as switching, lightning harmonics, corona and etc. Also the remaining faults are beyond the control of human being like wind storm accidents, and etc. These types of faults are expensive.

٥. COST COMPARISON BETWEEN 3/PHASE AND SINGLE PHASE SYSTEM.

Suppose if the feeder having 5 KM length in the 3/Phase system the estimate of the HT line & LT Line is as under with 1 No 200 KVA transformer & 2 No 100 KVA Transformers.

5.1 COST ESTIMATION OF 3/PHASE SYSTEM.

Cost estimation of 5 KM HT line (High Tension) and 2 KM LT line with connection is as under.

5.2 HT Line Cost (High Tension)

DESCRIPTION	QTY	RATE PER UNIT	COST IN Rs.
PC Poles	10	16842	168420
Conductor (DOG)	15000 Mtr/15 KM	95	1425000

X-Arms	18	2705	48690
Pin Insulator	39	159	6201
Pin for above	39	275	10725
Disc Insulator	6	716	4296
200 KVA T/F	1	619360	619360
100 KVA T/F	2	419932	839864
Double Plate Form	2	7475	14948
D-Fuse cut out 3 set	9	6445	58005
TOTAL			3195509

5.3 LT Line Cost.

DESCRIPTION	QTY	RATE PER UNIT	COST IN Rs.
LT PC Poles	10	12263	122630
Conductor (Wasp)	4000 Mtr/4KM	84	336000
Conductor (Ant)	4000 Mtr/4KM	47	180000
D-Strip	40	103	4120
Spool Insulator	40	35	3605
3/P No of Conn: with 19/.037	25	20000	500000
1/Phase No of Conn:	250	4000	1000000
TOTAL			2146355

Total estimate cost Rs. 5341864/-

٦. ESTIMATION OF 1/PHASE SYSTEM.

6.1 Cost of HT Line.

DESCRIPTION	QTY	RATE PER UNIT	COST IN Rs.
PC Poles	10	16842	168420
Conductor (DOG)	5000 Mtr/5KM	95	475000
Pin Insulator	39	159	2067
Pin for above	39	275	3575
200 KVA T/F 1/Phase	1	402713	402713
100 KVA T/F	2	310000	620000
TOTAL			1671775

6.2 Cost of LT Line.

DESCRIPTION	QTY	RATE PER UNIT	COST IN Rs.
LT PC Poles	10	12263	122630
Conductor (Wasp)	2000 Mtr/2KM	84	168000
Conductor (Ant)	2000 Mtr/2KM	47	94000
D-Strip	20	103	2060
Spool Insulator	20	35	700
3/P No of Conn: with 19/.037	25	20000	500000
1/Phase No of Conn:	275	4000	1100000
TOTAL			1987390

Total cost of single phase system is (6.1 & 6.2) 3159165/-.

The Rs. 2182759 is less than the 3/Phase system in addition the cost of single phase system is more less than three phase system by redesigning of poles. In this product cost is saving more than 50% [2]

7 LOSS COMPARISON OF 3/PHASE SYSTEM AND SINGLE PHASE SYSTEM.

By analyzing the load flow analysis of the 3/phase and single phase system show that annual energy losses is 2681 KWH for 275 No connections and in 3/phase system the annual energy loss is 3224 KWH for the 100 KVA transformer. Total power loss is 1.6 KW for the 3/phase system and 1.3 KW for single phase system. That calculation is carried out for 100 KVA transformer with 76% loading position [1,2].

8 IMPROVEMENT OF SYSTEM.

In my point of view and analyses the system most of the faults are removed at least cost are without any type of material. All these problems are resolved with proper

operation and planning. These are so many options to improve the system.

8.1 All the 3 phase system is converted into single phase system. The interruptions are minimizes. LT Lines are finished/eliminated from the filed.

8.2 When the LT Line eliminated then connections are provided to consumers with single phase T/Formers are per requirement of the load of said consumers. Single phase is the supply of consumers depends on the geographical position of the load.

8.3 By applying this methodology to eliminate the LT Line from the system, pilferage of energy will be controlled at level of line losses will also be reduces. The system will also be maintainable. But it is very difficult in a developed country.

8.4 Cost of the single phase system is less than 3 phase system approximately 35%. This percentage will also be maximizing by designing as per requirement of single phase system. [1, 3, 4]

9. CONCLUSION.

All DISCO's introduces the programmes and electrifying the new modern designed area on these lines especially commercial area and new colonies. The cost of line will be minimize up 35% and reduce the line losses and also help to overcome the energy crises. Reduces the interruption and prolonging the life of system and equipments. Developing the cause effect with scope of error to be analyzed. Most of the effect reveals the problems deselected for analysis be selected.

REFERENCE

[1] www.WAPDA.Com

[2] www.GEPCO.Com

[3] Paper published in IEEEP Newsletter in oct.2009

[4] Alternating current electrical Engineering by Philips Kemp.

[5] Transformers by coral H. Dunlop

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Quotation

- If wishes were horses, beggars might ride.

  John Ray

- There is always some madness in love. But there is also always some reason in madness.

  Friedrich Wilhelm Nietzche

- Stupidity often saves a man from going made.

  Oliver Wendell Holmes, Jr.

- The only difference between intelligence and education is this: intelligence will make you a good living.

  Charles F. Kettering

- To the dull mind all nature is leaden. To the illumined mind the whole world sparkles with light.

  Ralph Waldo Emerson

- The height of cleverness is to conceal one's cleverness.

  Francois de La Rochefoucauld

- Knowledge itself is power.

  Francis Bacon

- In expanding the field of knowledge we but increase the horizon of ignorance.

  Henry Miller

- Integrity without knowledge is weak and useless, and knowledge without integrity is dangerous and dreadful.

  John F. KIennedy

- The acquisition of knowledge is the mission of research, the transmission of knowledge is the mission of teaching, and the application of knowledge is the mission of public service.

  James A. Perkins

Words: 1,102

Resurrection of the Pakistani Power Sector !

By

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President

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It was only a few days ago that a senior official of the Finance Ministry proclaimed that the Pakistani Power Sector sucks up-to 2.5% of the GDP amounting to Rs. 300-350 billion every year. The same official told that over Rs. 1.0 trillion had been gobbled-up by this sector during the last three years. One the other hand, the GoP takes the credit for removing a huge financial burden from the books of various DISCOs / NTDC/ WAPDA, which amounts had earlier been secured as loans from various Banks in order to fill the gap between the revenue based on the then near frozen power tariff and the actual cost of supply during the period 2006-08 (and had subsequently resulted in the creation of the now in famous circular debt). Additionally, there seems to be a large majority amongst politicians and business executives who categorically subscribe to the concept of the governments leaving businesses to the private sector. They vehemently consider utilities like power, telecommunications, WASA, health and education and so on as having nothing to do with the social obligations of the governments. That, they are only correct in the developed world's context, is sadly forgotten. That, private sector foray into the utility business depends upon a very strong regulatory regime is also ignored. That all the above may take quite some time to resolve is another issue which is never discussed or debated.

Leaving aside the issues of placement of the power sector and others, it is of prime importance that specially the Power Sector has necessarily to be resurrected. As the Sector is highly technical and beset with issues of technology and introduction / assimilation thereof, the need is for the sectorial professionals to deliver the solutions. Once the experts are allowed to present the solutions, the present non-technical and non-professional edicts would automatically take the back seat. Incidentally, non-professional solutions especially of the last one year have resulted in great loses and the backwards march on the gains of 2009 and 2010.

In this context, the Institution of Electrical & Electronics Engineers Pakistan (IEEEP) has taken the lead and held the National Conference on Power Deficit in late October, 2011. The IEEEP, having a membership of over six thousand engineers relating to the fields of electrical & electronics engineering, inclusive of avionics, mechatronics, medical engineering and computer engineering disciplines, was able to attract the best of scientists, engineers and economists to the conference. Additionally, over 400 hundred delegates from all over Pakistan and abroad participated in the Conference. The fact that the event had the backing of the Country's premier technical university viz the UET Lahore, further provided impetus to the event.

Coming to the caucus, we see that as many as 16 research papers were presented in the daylong conference. The papers broached the subjects of Reservoirs in the National Economy, Hydrocarbon & LNG Route, Coal Power Generation, Hydro Power Short Term & Medium term Solutions, Large Hydropower Projects, Genocide on the Indus & the Hydro Bomb, Hydrocarbon Scenario in the short term, Solar Thermal and Geo Thermal Solutions, Coal Gasification, Initiatives of the GOP in the RE Sector, RE as part of the Energy Mix, Plans for Nuclear Power, Engineering Management, Power Demand Projection, Issues & impediments in Thar Coal development, and Thermal Fuel Mix etc.. All the speakers were clear and focused on one point viz. that it is only the professional who can overcome the ongoing power crises.

As a first, the IEEEP had setup an independent panel of experts / committee to firm-up recommendations of the Conference. These recommendations have since been forwarded it to the Federal Government. All the speakers and the huge number of delegate also concluded that implementation of these recommendations would take the country out of the crises it is facing at the moment. The recommendations were very clear, all encompassing and based on ground realties and the requirements of the country.

These are as under :-

- Need to evolve a National Energy Policy with participation of all stakeholders to generate 100,000 MW by 2030.
- The main pillar of this policy would be to utilize local fuel sources like, coal, large hydel, small & micro hydel and using local technology under a planned indigenization programme.
- Development and utilization of Thar Coal as a National Policy, with the Federal Govt. and all Provincial Governments pitching in as necessary stakeholders.
- A new focus on RE like solar, wind has to be developed to leap frog the technological curve and join the ranks of the developed countries in generating power with minimum carbon footprint.
- Create industry-academia-government linkage to develop local human resource which can perpetuate the energy autarky plan by designing, development and production of all phases of power generation projects / re-designing of existing curricula / syllabi on the need basis.
- Development of infrastructure necessary to support the growth of energy sector in general and power sector in particular must be included in PSDP funding each year

and amount of Rs.100 Billion must be allocated for infrastructure development in the power sector alone.

- Immediate mitigation of circular debt by paying off Rs.300 Billion and appointment of competent professionals in the power sector, which is to be followed by allocation of gas on a priority basis (UFG gains to be diverted to power sector) and conversion of Oil Fired GENCOs to coal within 12 to 18 months. This will bring in the presently stunted foreign investment into the country.

- Regulatory authorities NEPRA / OGRA must be restructured and will be staffed by competent professionals.

- Harnessing of 2000 MW from the sugar power from the private sector by notifying upfront tariff. Additionally, State bank of Pakistan to arrange for low interest finances for this effort as a National Policy.

The above 11 recommendations actually form the road map for recovery and also a detailed plan for arranging an appropriate power sector infrastructure in Pakistan. The recommendations also provide answers to the affordability issue and the National quest for attaining the needed semblance of autarky in the power sector. As the conference pinpointed the present disconnect between the government, academia and industry and also the relegation of National needs to the back burner, correction thereof would have a laudatory effect on our development. This last point alone would assure the availability of the needed technical resource in the country as against the need for possible imports. More so, when the energy requirements are growing at a stupendous pace and when renewable energy has to make its mark on the Pakistani horizon in the immediate further.

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Quotation

- The greatest obstacle to discovery is not ignorance-it is the illusion of knowledge.

  Daniel J. Boorstin

- Knowing others is wisdom. Knowing the self is enlightenment.

  Lao-tzu

- Knowledge which is obtained under compulsion obtains no hold on the mind.

  Plato

- The great end of life is not knowledge but action

  Thomas Henry Huxley

- Youth longs and manhood strives, but age remembers.

  Oliver Wendell Holmes, Sr.

- The true are of memory is the art of attention.

  Samuel Johnson

- A retentive may be a good thing, but the ability to forget is the true token of greatness.

  Elbert Hubbard

- The only place where success comes before work is in a dictionary

  Vidal Sassoon

- Behind every successful man thee are a lot of unsuccessful years.

  Bob Brown

- Nothing fails like success because we don't learn from it. We lean only from failure.

  Kenneth Boulding

- All you need in life isi ignorance and confidence, and then success is sure..

  Mark Twain

- Hard work without talent is a sharne, but talent without hard work is a tragedy.

  Roberty Half.

Words: 1224

Selecting Senior Management for the Power Sector!

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Power sector reforms are in the air since the last one decade. Incidentally, the meaning of reform seems to have different connotations for different segments of government, society and the MLDAs. And the sad part being that presently the reform is being forced in the midst of the ongoing energy crises. It is like reforming an army while in battle. Another serious issue is that none of the drivers has ever had any experience of change management in a power sector like ours. PEPCO, which was mandated and could have changed the face of the sector, was subjected to a strange-hold firstly by WAPDA (which did not let it operate independently) and then by various arms of the GoP who thought that they could do the things in a much better manner. Unfortunately, such control of the last one year has not yielded any results – rather has spoilt the broth with political interference calling the shots to the detriment of the sector. Now further change is being contemplated through executive search for the position of the CEOs of the nine DISCOs in the country.

In this regards, recently quarter page ads have appeared in the national print media soliciting applications for the positions of CEOs and the CFOs of DISCOs. The solicitations are so perfunctory that one would but think that these are actually for special assistants of the existing CEOs and for middling financial officers. As the smallest of the DISCOs has a revenue base of above Rs. 36-50 billion, with LESCO/MEPCO both touching Rs. 135 and Rs. 90 billion respectively, it is strange to see such open ended solicitations that are bound to attract over a 100,000 applications (imagine so many persons claiming competence to the nine chairs). These ads very innocently quote the areas of the responsibility to the effect that the applicants should be thoroughly familiar with the economic, social, legislative and political environment in which today's electric utility industry operates. It is further said that the prospective chief executive should be conducive to the legislative and community relationship which are essential for the productive communications and support essential to the utilities growth. Furthermore, having experience in working with a union (?) is a plus. The qualification and experience part states that the candidate should hold a professional degree (any) from a recognized institution, while preference will be given to candidates holding a Master's Degree in business management, accounting, communication or engineering. Lastly the candidate should have overall minimum of 15 years of professional experience, 10 of which (should be) in public/private sector serving in a senior management position. In the end, the ad states that the power sector experience will be considered (?).

Leaving aside the cavalier manner in which these ads have been formulated and then published – surely due to lack of good advice, there is need to study the actual job description of the CEO of any DISCO as formulated by consultants commissioned by the World Bank in late 1990s – the time when actual corporatization of WAPDA's Power Wing took place. It is seen that the chief executive officer shall be responsible for the over-all management of company operations to ensure achievement of company's service and revenue targets. He will lead the company management in setting and achieving higher operational performance targets and formulate plans for further improving the same with special emphases on load management, loss reduction, theft control and significant augmentation/improvement of distribution network and services to customers in a new paradigm of customer friendly culture. He will ensure adherence by the company to NEPRA performance standards and meet relevant regulatory operational requirements. In this regard, the original authors of the Power Sector reforms in Pakistan sought pro-active, results-oriented professionals with established credibility and performance record, who could take the above challenging assignment. The candidates were required to have strong leadership, inter-personal and communications skills with a high drive for performance targets. In the qualification and experience part, the candidate was thought preferably to be a professional engineer registered with the PEC or a senior power utility management expert. Additional engineering and management qualifications, experience specifically in Power Utility operations was considered to be an added plus. Minimum 20 years experience in the employment level, with a minimum of 5 years in senior management position was then considered essential. And the age was ideally thought to be in the band of mid to late 50s. In other words, the candidate had to be an expert instead of any person likely to learn the trade after taking over as the CEO.

Additionally, a window was also created so that competent WAPDA/ PEPCO Chief Engineers and above could also apply for the position. It was decided that WAPDA, PEPCO and the Corporate Entities' senior officers who met the criteria were eligible to apply through proper channels. Officers recently retired or those retiring within three/four months time were also considered eligible to apply for the position (s). The tenure of the selected CEOs was to be for a period of three years, extendable with mutual agreement on satisfactory performance.

Looking around and also considering the ground realities, we see that such professionals are not available in Pakistan other than in the relevant Ex-WAPDA PSCEs viz the DISCOs and in the KESC. More so, when we see that the incumbent CEO of a DISCO has to additionally be privy to ten specific attributers, reproduced here under as: *Deep insight and under-standing into dynamics of core-responsibilities, ability to dip into the current and future trends, come equipped with knowledge of the weaknesses*

and strengths of the specific sub-sector he is to manage, be adept at and be privy to the level of expertise at the disposal of the resource/cadre, have the means to fast up-grade the same, be able to build upon the existing expertise (and not start learning about the core requirements),enable the organization to jump even higher by breaking earlier constrictions and barriers, effect change management in a structured manner, arrange conversion to the next generation of technologies and be able to arrange for a mix of science and sociology leading to innovations and improvisations that favor the people - a must, when we see the havoc played by the current reliance on oil for generating electricity and the ensuing unbearable cost of service.

In other words, the DISCOs are bound to flounder in case the CEO does not possess the above experience, exposure and the depth/intellect to deal with the requirements. As a former MD PEPCO, I had the chance to look into the selection of CEOs (especially when a large number of such positions in early 2009 were held by persons who had long ago attained the age of superannuation). And looking around the National landscape did not yield any result and resultantly in-house search was conducted to post the CEOs of the DISCOs. The search based on merit lead to good results and the sector was able to look strong by the end of 2010. That, thereafter, the situation changed can be attributed to various reasons about which separate space is needed for any meaningful discussion. Consequently, the selection process of CEOs of DISCOs should restrict itself to the above methodology and not become open ended as is likely to happen if the current process is accepted as the one that has to be followed.

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Quotation

- The common idea that success spoils people by making them vain, egotistic, and self-complacent is erroneous; on the contrary, it makes them, for the most part, humble, tolerant, and kind. Failure makes people cruel and bitter.

  W. Somerest Maugham

- We must use time creatively… and forever realize that the time is always ripe to do right..

  Martin Luther King, Jr.

- Time heals what reason cannot.

  Seneca the Younger

- An honourable defeat is better than a dishonourable victory.

  Millard Fillmore

- The man who is swimming against the stream knows the strength of it..

  Woodrow Wilson

- If we had no winter, the spring would not be so pleasant; if we had not sometimes taste of adversity, prosperity would not be so welcome.

  Anna Bradstreet

- The greater the difficult, the greater the glory.

  Cicero

- When people agree with me, I always feel that I must be wrong.

  Oscar Wilde

- A single lie destroys a whole reputation of integrity.

  Baltasar Gracian

- The greatest incitement to crime is the hope of escaping punishment.

  Cicero

- He who does not prevent a crime when he can, encourages it.

  Seneca the Younger