Implementation of Efficient Windmill Water Pumping System for Water Storage in Pakistan

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Abstract

Due to mismanagement and improper storage system of water, Pakistan is facing many problems such as shortfall of electricity, agriculture growth rate, drinking water and livestock; which are directly affecting the economy of the country. To overcome these problems, a system is developed which is called "Windmill Water Pumping System". This system helps to store the water, to generate electricity, to increase agriculture growth, drinking water and livestock. In this research work, designed Windmill Water Pumping System has two phases. Initial step include windmill system and the next phase is water pumping System. Windmill system has a wind turbine and a generator while water pumping system has a DC motor and centrifugal pump to fetch the water from a source to the reservoir. This paper provides the efficient way of saving and storing water that can be utilized in different ways in order to raise the economy. In addition, proposed system can be a good source to generate electricity.

Key words – Wind turbine, Water storage, Generator, Centrifugal pump, Electric DC motor.

I. INTRODUCTION

One of the basic necessities of life is water. Water can be used in different aspects such as; domestic consumption, commercial/industrial use and usage for land irrigation. Pakistan is among the countries having world's largest glaciers like Karakoram and Himalayas. Pakistan has abundant water resources as rivers are flowing down from these large glaciers [1]. Pakistan has two large dams Mangla and Tarbela and number of small dams to store water. Due to lack of maintenance and improper management of these dams, storing capacity is decreasing year by year. In some months Pakistan has a huge amount of water in monsoon season but due to lack of dams and reservoirs, the country is not only wasting that water, but it also generates harmful effects in terms of loss of lives and destructing agricultural infrastructure.

From the last 10 years, Pakistan has faced floods which cost them billion dollars in terms of infrastructure, agriculture and loss of lives. Particularly floods hit Punjab, Sindh and hilly areas of Khyber Pakhtunkhwa, Balochistan and Gilgit Baltistan areas [2]. Table 1 below shows the injuries, deaths, people affected, damages and agriculture affected due to floods from the last 6 years.

Table 1: Flood Disaster in Pakistan [3]

YEAR	INJURIES	DEATHS	PEOPLE AFFECTED	DAMAGES	AGRICULTURE AFFECTED
2014	461	257	1.1 MILLION	$4 BILLION	$2 BILLION
2013	169	855	1.4 MILLION	$5 BILLION	$1.5 BILLION
2012	150	571	5 MILLION	$3 BIILION	$1.7 BILLION
2011	1180	520	9.2 MILLION	$3.7 BILLION	$1.8 BILLION
2010	2946	1985	21 MILLION	$10 BILLION	$5.1 BILLION
2009	2154	2113	20.35 MILLION	$9.5 BILLION	$5.0 BILLION

The second part which directly affect due to lack of water storage is agriculture growth. Pakistan is an agriculture country and 24% GDP growth rate depends on the agriculture sector [4]. There are various problems such as floods, shortage of water in rural areas of Sindh, Baluchistan and improper distribution of water affect the agriculture growth rate of Pakistan. Due to these problems, agriculture sector contributes average 2.5% in Pakistan GDP as mentioned in table 2 below.

Table 2: Agriculture Growth Rate in Pakistan

[5] Year	Agriculture growth rate (%)
2006-2007	3.4
2007-2008	1.8
2008-2009	3.5
2009-2010	0.2
2010-2011	2.0
2011-2012	3.5
2012-2013	3.2

The third main aspect due to lack of water storage is shortfall of power which causing problems in commercial and industrial areas. It directly affects Pakistan economy as in production of goods, services and installation of machines. From the last 10 years, Pakistan is facing shortfall of power. In Pakistan, demand of electricity is increasing year by year but the generation is somewhat constant from many years as shown in figure 1.

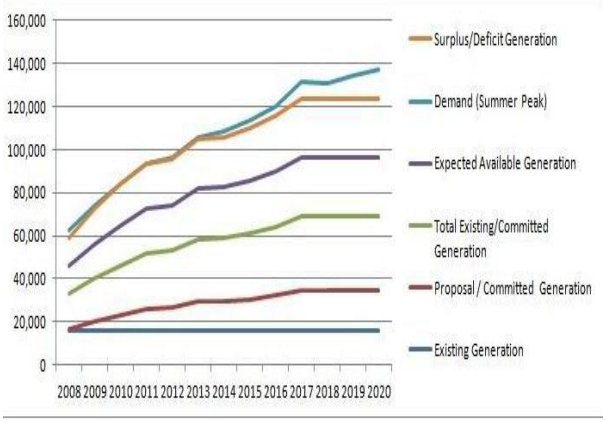


Figure 1: Supply and Demand of Electricity in Pakistan [6]

The fourth aspect is drinking water. According to medical sciences water is one of the best things to drink if it is pure but is very dangerous if it is impure. Due to lack of water storage system, water can't be filtered. The causes occur such as the health issues like Jaundice**,** Dysentery**,** Filarial disease**,** Typhoid etc**.** To solve the problem of water storage in Pakistan, system has been designed named ―Windmill Water Pumping System. This system is explained in section II, IV, V, VI and VII.

II. LITERATURE REVIEW

Recent trends show that renewable and sustainable energy has a significant impact in the field of energy. It also includes wind energy to produce electricity among others. In recent years, many researchers and scientists have developed and proposed different ways for wind water pumping system in order to fulfill the needs of people like water for drinking, to produce electricity and for livestock. With the improvements and modifications in the technologies, different techniques have been planned to pump the water wells to different suitable places. As shown in figure 2, in order to pump water from deep wells, a mechanical approach of windmill is developed in late 1800's. Wind turbines should be at high regions where the pressure of air should be maximum, because it will help to drive the pump through rotating the turbine blades. Wind water pumping system depends on cost, water source, maintenance and water requirements among others. Keeping these factors in mind, there are many issues, regarding site, cost, maintenance, water requirements so to tackle these problems researchers are finding different other feasible options [7]. An alternative solution is proposed by some researchers in late 1900's, which is known as wind-electric water pumping system. According to the design in [8] water pumping system is kept at ground while wind turbine is place at upper regions and these both system are connected via electrical cables.

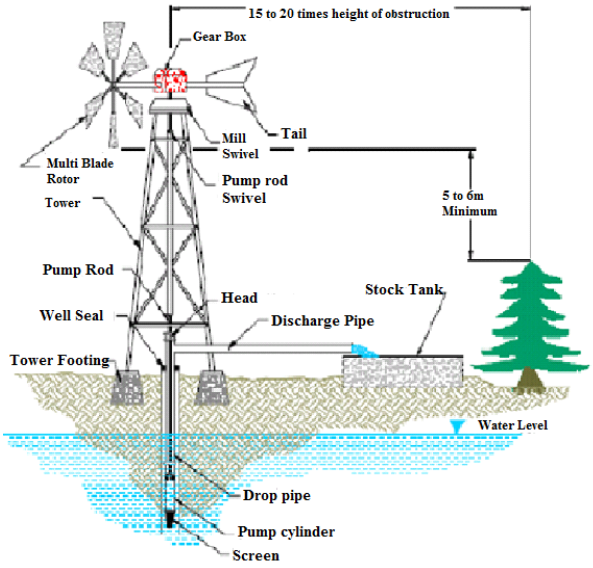


Figure 2: Wind Water Pumping System [9]

Some efforts have been done to pump the water from deep wells to tank with the help of electrically connected wind turbine. In [10] system steady state is examined and which was based on electrical water pumping system. With the help of electrical and mechanical behavior, wind water pumping system is discussed in [11]. It specially highlights the transient behavior based on the concept of steady state system. It is observed in [12] that there is an indirect way of producing electric power via driving pumps. By this wind turbine water pumping system, it can pump the water from far and deep wells in order to fulfill the needs of different villages, towns and agriculture areas. In order to test this system, it is installed 900Km south of the Muscat during December 1996 by the ministry of water resources (MWR) [13].

III. PROBLEM DEFINITION

The significant objective of this research is to make an efficient system to store water. Following are the problems of Pakistan which caused due to inefficient storage capacity of water.

i. Flood is the one cause as Pakistan has abundant water due to having large glaciers.

ii. Shortage of power in Pakistan. Pakistan can generate enough Hydro power to meet the demand.

iii. Lack of storage of water and improper distribution affects agriculture growth rate.

iv. Drinking water is also the main issue due to lack and improper water storage.

IV. PROPOSED METHODOLOGY

To overcome these problems, steps should be taken to build a water storage system. The system which helps to store water is "Windmill Water pumping System" as

shown in Figure 3. This system has two parts: one is Windmill system and another is Water pumping System. Windmill system consists of Wind turbine and Permanent Magnet Synchronous Generator (PMSG) while Pumping system consists of AC Induction motor and Centrifugal Pump. Both the systems are connected electrically to make a system efficient. For electrically connected transformer be used to match the characteristics of both systems.

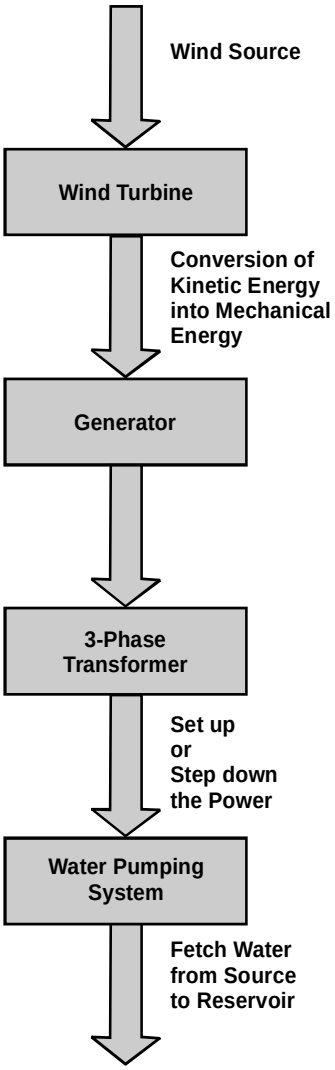


Figure 3: Block Diagram of Proposed Windmill Water Pumping System

V. WINDMILL SYSTEM

Wind Turbine: Wind turbines convert kinetic energy from the wind into electrical power. There are two types of wind turbine which can be used.

(i) Horizontal axis wind turbine

(ii) Vertical axis wind turbine

In this proposed project horizontal axis wind turbine will be used. Because vertical axis has low rotational speed having higher torque, low power coefficient and difficult to model accurately as per system requirement.

Wind turbine Generator: Wind turbine has a rotor which converts kinetic energy into mechanical power and a generator which converts mechanical power into electrical power. There are three types of generator.

(i) Squirrel-Cage Induction Generator.

(ii) Doubly Fed Induction Generator.

(iii) Synchronous Generator.

Usually synchronous generator is used in the wind turbine as the shafts are directly coupled with the rotor of wind turbine. In wind turbine two types of synchronous generator used; electrically excited synchronous generator or permanent magnet synchronous generator. In this proposed project, PMSG will be used because it is relatively secure and stable and doesn't need any external source to excite the set-up and doesn't need slip ring.

VI. WATER PUMPING SYSTEM

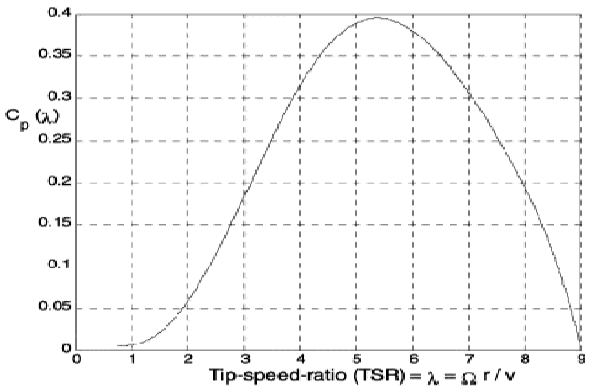
Centrifugal Pump: Centrifugal pump converts input power into a kinetic energy. It helps to pump liquids or liquids with suspended solids from the surface, wells etc. The revolving device called Impeller rotates at the rated speed to pump the fluid and it makes the impeller vanes to rotate and hence it gives the motion to the fluid trapped in the passage of the vanes. Fluid therefore passes outwards in high pressure pipeline (delivery). The continuous evacuation of fluid from impeller makes it to repeatedly draw fluid from the low pressure (suction) pipeline into the casing. The impeller is mostly driven by an electric motor [14].

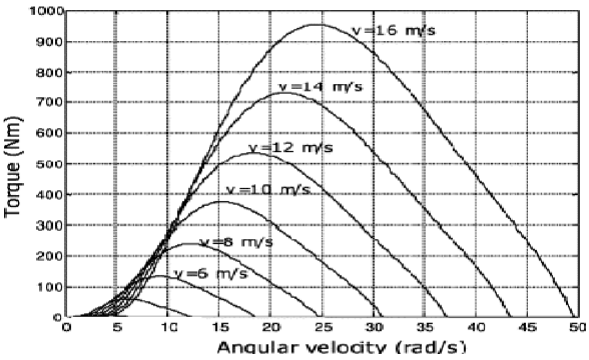
Centrifugal Pump Motor: Impeller helps the centrifugal pump to pump the fluid and impeller is driven by an electric motor [14]. To drive the impeller to pump the water from source to reservoir, 3-phase one pole pair induction motor can be used.

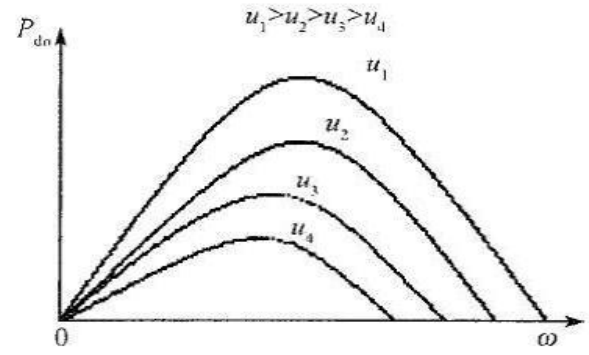
VII. DESIGN AND OPERATION OF WINDMILL WATER PUMPING SYSTEM

PMSG will be driven by a wind turbine via with rotating shaft. From the Wind turbine mechanical power is generated and PMSG convert mechanical power into electrical power. Electrical power will go to the AC induction motor of the water pumping system which is connected to the PMSG by electrical cables via transformer. Transformer will be used to step up the electrical power coming out from the PMSG to operate the AC induction motor efficiently. AC induction motor converts electrical power into mechanical power. It drives the impeller to rotate and fetch the water from the source to the reservoir as shown in Figure 2.

Initial step is to make a simulation model to check the system efficiency. Instead of wind turbine, DC motor will be used as characteristics are same as wind turbine as shown in figure 4 and figure 5.







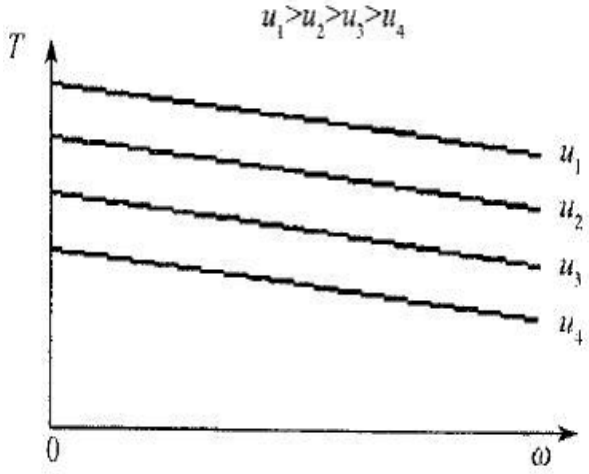


Figure 5 (a and b): Characteristics of DC Motor [16]

Permanent-magnet synchronous generator (PMSG) assembled that has been driven by the DC motor via a torque transducer, and connected to a DC drive, so that the speed can be maintained at the desired values and the mechanical input power can be measured. The output of the PMSG has been connected to a 3-phase power supply analyzer as a source and resistive load has been connected as a load as shown in figure 6.

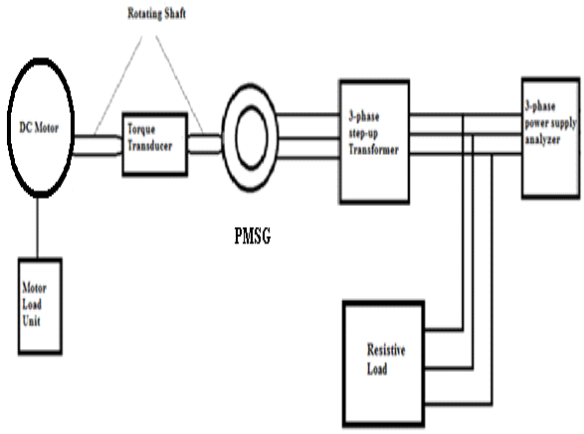


Figure 6: Windmill System [17]

3-phase transformer has been used to investigate the matching the voltages of PMSG and AC motor. After measuring the characteristics of windmill system, to measure the mechanical characteristics such as flow rate, pressure, hydraulic power; flow transducer and pressure gauge has been connected to the bucket side and to measure the speed of the centrifugal pump motor; optical pick-up has been connected to the blades of the centrifugal pump motor as shown in figure 7.

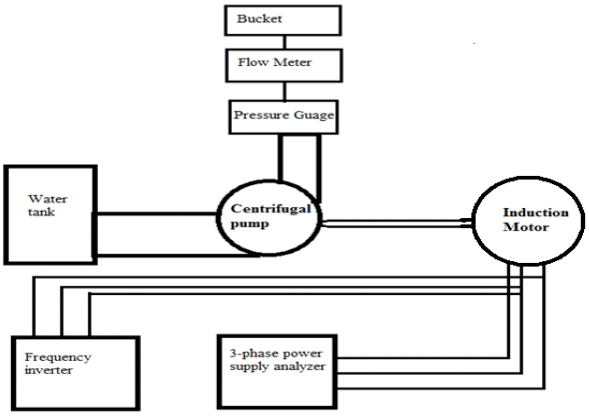


Figure 7: Water Pumping System [17]

After measuring the characteristics of water pumping system, connect the output of PMSG to a 3-phase AC induction motor on the water pumping system through an electrical cable via 3-phase transformer as shown in figure 8.

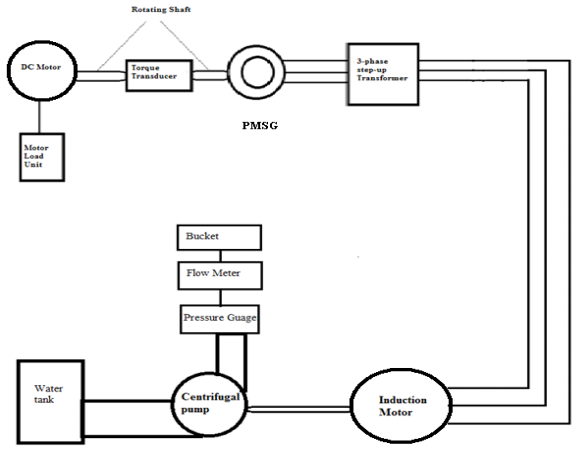


Figure 8: Wind-Electric Water Pumping System [17]

By implanting whole system and taking electrical and mechanical characteristics, system efficiency will be measured. After investigating the system performance, Wind turbine can be selected according to the efficiency.

The formula of mechanical power of the wind turbine is:

$$P_m = \frac{1}{2}\rho A C_p V_m^3 \quad (1)$$

From the results, mechanical power will be calculated and in wind turbine,$\rho = 1.225$, C_{pmax}=0.45 andπ_{opt}=5. From all these values area will be calculated. Area is $A=\pi R^2$ and from area formula, radius will be calculated. After calculating the radius, tip ratio of wind turbine can easily be calculated. In that case, practical has been done and on 90m dynamic head, wind turbine having the tip speed ratio of 3.68 and the radius 0.35m should be installed to work the system efficiently [17].

Figure 9 shows the complete wind-electric water pumping system that includes a wind turbine at upper regions and water pumping system placed at ground level. Both of these are connected by 3-phase transformer. The water which is supplied from any source to reservoir by water pumping system can be utilized regarding electricity generation, increasing agricultural growth rate among others.

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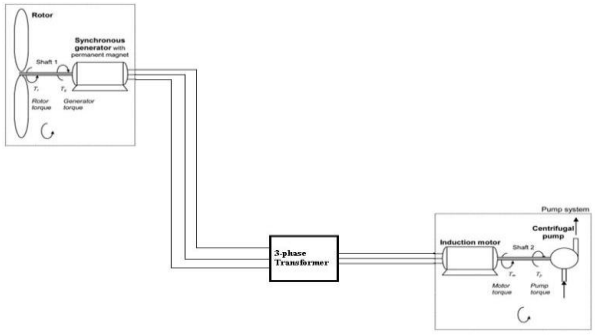

Figure 8: Wind-Electric Water Pumping system [17]

VIII. CONCLUSION

By planting the windmill water pumping system, all four main problems can be solved of Pakistan which affects the economy directly or indirectly. Through Windmill water pumping system, water can be stored and it can be utilized to reduce the flood conditions in Pakistan, generation of power, increase in agriculture growth rate and pure drinking water. When water goes to the reservoir, hydro turbine can be installed to generate electricity, water filter system can be installed to filter the water and canals or distribution of water can be improved to increase the agriculture production.

IX. FUTURE SCOPE

Windmill water pumping system is implemented in this work. In future, there is wide scope to integrate hydro turbine and filtration system with our framework in order to get maximum efficiency from the system.

X. ACKNOWLEDGEMENT

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Quotations

- The author who speaks about his own books is almost as bad as a mother who talks about her own children.

  Disraeli

- An incurable itch for scribbling takes possession of many, and grows inveterate in their insane breasts.

  Juvenal, Satires

- You do not publish your own verses, Laelius; you criticise mine. Pray cease to criticise mine, or else publish your own.

  Martial

- The ink of the scholar is more sacred than the blood of the martyr.

  Muhammad , Tribute to Reason

- The melancholy days have come, the saddest of the year, Of wailing winds, and naked woods, and meadows brown and sear.

  Bryant, The Death of the Flowers

- The year's in the wane;
  There is nothing adoring;
  The night has no eve,
  And the day has no morning;
  Cold winter gives warning!

  Hood, Autumn

- O, it sets my heart a clickin' like the rickin' of a clock, When the frost is on the punkin and the fodder's in the shock.

  James Whitcomb Riley,
  When the Frost Is on the Punkin

- What can you conceive more silly and extravagant than to suppose a man racking his brains, and studying night and day how to fly?

  WILLIAM LAw, A Serious
  Call to a Devout and Holy Life (1728)

- The birds can fly, An' why can't I?

  TROWBRIDGE, Darius
  Green and His Flying Machine (1869)

- He rode upon a cherub, and did fly: yea, he did fly upon wings of the wind.

  PSALMS. XVIII. 10

- Here we have baby. It is composed of a bald head and a of lungs.

  EUGENE FIELD, The Tribune Primer

- Where did you come from, baby dear? t of the Everywhere into here."

  GEORGE MAGDONALD,
  Song in At the Back of the North Wind

- Rock-a-bye baby on the tree top,
- When the wind blows the cradle will rock,
- When the bough bends the cradle will fall,
- When comes the baby, cradle and all.

  OLD NURSERY RHYME