FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

HYDROMETEOROLOGY: ENHANCING THE CAPACITY FOR HYDROELECTRICITY GENERATION IN OUR HOMES AND INDUSTRIES

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AHMED SADAUKI ABUBAKAR
BTech, MTech, PhD (Minna)
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INAUGURAL LECTURE SERIES 36

27TH AUGUST, 2015

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PROF. AHMED SADAUKI ABUBAKAR

B Tech., M Tech., PhD (Minna)

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1.0 INTRODUCTION

Nigeria is endowed with sufficient energy resources to meet its present and future development requirements. The country possesses the world's sixth largest reserve of crude oil. It is increasingly an important gas province with proven reserves of nearly 5,000 billion cubic meters. Identified hydroelectricity sites have an estimated capacity of about 14,250MW. Nigeria has significant biomass resources to meet both traditional and modern energy uses, including electricity generation. The country is exposed to a high solar radiation level with an annual average of 3.5 to 7.0 $kWh/m^2/day$. Wind resources in Nigeria are however poor to moderate and efforts are yet to be made to test their commercial competitiveness. Hydropower is one of the leading sources of electricity production in many countries, including Nigeria. It is clean and renewable (Mohammed, 2013).

Slogan for Sustainability:

> *"You can't always get what you want,*
> *But if you try sometimes, you just might find*
> *You get what you need."*

Surface water is the main natural source of water for hydropower generation. Nigeria is blessed with a number of rivers and streams which are either seasonal or perennial. The Rivers Niger and Benue with several tributaries such as Sokoto, Gurara, Gongola and Kaduna constitute the Nigeria river systems which offer some potential renewable sources of energy for economically viable large hydropower development. The total potential surface water resources of Nigeria from these rivers and streams are estimated at 240,464 m^3/sec (Mohammed, 2013).

In the glorious Qur'an, Surah, Al-Anbiya, 21:30 that every living thing has been made from water. Allah said *"We made from water every living thing."*

There are many problems associated with hydropower generation in Nigeria; the current infrastructure of the hydropower plants are in dire need of rehabilitation and the actual energy output of the plants are far below their projected capacity. The current installed capacity of grid electricity is about 6,000MW, of which about 67 percent is thermal and the balance is hydro-based. The combined installed capacity of the three major hydropower dams (Kainji, Jebba and Shiroro) is 1,900MW. The systems have been performing below expectation and could be as low as 30 percent. For example, power output in Nigeria in recent times has been erratic despite the fact that electricity came to Nigeria in 1896; 15 years after it was introduced in England. However, to date, the total electric energy generated in Nigeria has been lingering between 3,000 megawatts and 4,000 megawatts. Climate form a significant part of this problem. Other causes include maintenance, financial and political problems. Generating plant capability is low and the demand and supply gap is crippling. This poor performance has negatively affected the industrial, commercial and domestic sub-sectors of our national economic lives.

Adequate preparations to forestall the adverse impact of hydrology and meteorology on hydroelectric power generation in Nigeria can only be meaningful if they are backed by proper scientific research (Mohammed, 2013).

2.0 HYDROMETEOROLOGY

Hydrometeorology is the science that studies the cycle of water. It is intimately related to the science of meteorology, hydrology and climatology. The hydrometeorology studies the processes of the hydrological cycle that occur in the atmosphere (evaporation, condensation and precipitation) and in the ground (rainfall interception, infiltration and surface runoff) and their interactions. The science of hydrometeorology studies the behaviour of hydrologic elements, such as rivers, ponds and dams. It also concerns the physics, mathematics, and statistics of processes and phenomena involved in exchanges between the atmosphere and ground that typically occur over hours or days, and how the time average of these exchanges combine to define hydrometeorology. This science aims to understand the hydrometeorological phenomena. It is also its realm, to develop tools for water management and for the observation and prediction of hydrometeorological phenomena and to develop models to help in the early detection and warning of floods.

2.1 Hydrology Defined

In its broadest sense, hydrology is the scientific study of water. Because water is an important element of the physical environment, it is studied in one form or the other by practitioners of various disciplines concerned with the physical environment. Water occurs in various forms and locations in the environment and these are connected together by complex processes to form what is known as the hydrological or water cycle. Hydrology is therefore a very broad and interdisciplinary science. Hydrology can be viewed as the scientific study of the water cycle. It is a discipline that studies the properties, occurrence, distribution and movement of water on and beneath the land surface.

Wisler and Brater (1959) defined hydrology as the science that deals with the processes governing the depletion and replenishment of the water resources of the land areas of the world. The *ad hoc* panel on hydrology of the Federal Council for Science and Technology in the United States recommended the following definition of hydrology in 1962:

> "The science that treats of the waters of the earth, their occurrence, circulation and distribution, their chemical and physical properties and their reaction with their environment including their

relation to living things. The domain of hydrology embraces the full life history of water on the earth".

The above definition has practically been adopted world-wide.

Also, the Qur'an told us about the source of springs in the earth; God says: (*See you not that Allah sends down water (rain) from the sky, and causes it to penetrate the earth, [and then makes it to spring up] as water-springs)* (Sûrat Az-Zumar - verse 21). This verse tells us that the source of springs is the water of rain and that is the opposite to the belief of some people who believed that the source of these springs is the sea.

It is quite clear from the above that the scope of hydrology is very wide. What professional hydrologists study is, however, more restricted than the scope of the above and other definitions of the subject. The International Association for Scientific Hydrology recognizes four distinct branches of the subject, of which surface and groundwater have received the greatest attention.

These four branches are:

- surface water
- groundwater
- snow and ice
- limnology – the study of lakes.

Because water, the focus of the study of hydrology, is an ubiquitous element of the natural environment, hydrology traverses the domains of several environmental science subjects such as meteorology, geology, glaciology, oceanography and ecology. Also, scientific hydrology underlies the development, utilization and control of water resources. It therefore has some relationship with social science subjects like economics, political science and sociology. Applications of hydrology are numerous and varied. Hydrology has practical applications in water resources development and management, flood prediction and forecasting, watershed management, design of water control structures and drainage systems, salinity control and pollution abatement among others. These areas make up applied hydrology, although it is often difficult to distinguish between the principles of hydrology and the applications of such principles in the real world (Ayoade, 1988).

2.1.1 Hydrological cycle

As illustrated in Figure 1, the annual average hydrological cycle for the Earth as a whole, together with an alternative set of estimates of water stored made by combining observations with model-calculated data. It is clear that the simple concept of a hydrological cycle that merely involves water evaporating from the ocean, falling as precipitation over land then running back to the ocean is a poor representation of the truth. There are also substantial hydrological cycles over the oceans which cover about 70% of the globe, and over the continents which cover the remainder, as well as water exchanged in atmospheric and river flows between these two.

On average, there is a net transfer from oceanic to continental surfaces because the oceans evaporate about $413 \times 10^3 \text{ km}^3 \text{ yr}^{-1}$ of water, which is equivalent to about 1200 mm of evaporation, but they receive back only about 90% of this as precipitation. Some of the water evaporated from the ocean is therefore transported over land and falls as precipitation, but on average about 65% of this terrestrial precipitation is then re-evaporated and this provides some of the water subsequently falling as precipitation elsewhere over land. On average, about 35% of terrestrial precipitation returns to the ocean as surface runoff, but the proportion of terrestrial precipitation that is re-evaporated and the proportion leaving as surface runoff.