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MAPPING OF KINETIC AND POTENTIAL ENERGIES FOR DIFFERENT RENEWABLE SOURCES

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Abstract — Energy resources, prominently, are non-renewable worldwide and power system managers all over the globe are concerned in this matter. Urbanization and the population explosion have added to the woes of Power System Stake holders. Savior in this regard could be Renewable sources and its rampant usage. Kinetic energy can be a major source of energy if harnessed in a efficient manner. The same thing can be said about potential energy too. In this paper, kinetic and potential energies associated with various renewable sources are discussed**.**

Index terms—Potential energy, Kinetic energy, Current Electricity, Static Electricity, Renewable, Solar, Wind, Hydro

I. INTRODUCTION

The transformation of the world to a global home is rapid on the virtue of ever rising demand of energy. The world has seen a boom in the consumption of energy in its various forms to satisfy social and economical development needs of humans. The rise in the demand has led to the several harsh implications on the sustenance of the world environment and hence a different approach has to be adopted on the larger scale to fulfill the energy demands as well as mitigate the climatic adversities. In particular, the catastrophe of Fukushima Daiichi was a threshold in the call for alternative energy sources. Non conventional sources are now considered more reliable and desirable sources of fuel due to the least probabilities of disasters. The following graphs show the comparative rise in the non conventional technologies and the decline in the conventional ones. [2] [3]

Comparison of Utilization of Energy resources across the globe over the time [9]

TABLE I. COMPARISON OF THE RESOURCES [1]

Comparison on several aspects	*Conventional Resources*	*Non - conventional Resources*
Availability	Limited reserves	Abundant in nature
Carbon footprint	Extreme	Zero emission
Environmental implications	Harmful repurcussions	No apparent adversities on the environment
Distribution	Unevenly distributed	Mostly evenly distributed
Transportation	Has to be transported from its extraction source to the processing facility.	Used at the place itself where it is available.

Regeneration	Once drained, then takes billions of years to regenerate.	Regenerates at an extreme rate and hence is inexhaustible.

A. Physics of energy: According to Newtonian mechanics for translational motion, the energy which is present in the object with the mass by rectitude of the motion of the possible mass is known by the term defined by kinetic energy. Also presence of energy which is possessed by the object with mass on the rectitude which is present because of its position (height from a reference point or a surface) is known as potential energy. The general equation to describe the KE or the kinetic energy of an object with the presence effect of mass m and which is moving with a velocity vis K.E. = $\frac{1}{2}mv^2$ and if object is placed at a height which is 'h' from a given reference point then its potential energy is given by P.E. = mgh, where g is acceleration present due to gravity (g = 9.8 $\frac{m}{s^2}$). When the case is for the rigid body performing rotational motion, the mechanics is changed up to an extent, although the form of dynamics remains the same. Considering both the physical quantities, the kinetic energy falls in the category of scalar quantities and can be described for electric current, light, and projectiles. Whereas the potential energy is a vector quantity as it is the energy possessed by an object in a force field of any type as gravitational force field, electric force field, magnetic force field etc. In a nutshell, kinetic energy is doing work and the potential energy is the work which has been done. Now considering electric charge, electric current is the movement (motion) of free electrons and hence electrons have kinetic energy. Although the energy per electron is microscopically small. Also, when the charge is in stationary state (Static Electricity), the energy they possess is potential energy. When the charges of both the polarities are accumulated on the electrodes separated a small distance, the difference in the potential energies of both the electrodes is known as potential difference. When both the electrodes are connected across an electrical circuit, the electrons start drifting through the metal circuit at the drift velocity of about 1 mm per minute and hence they possess kinetic energy then. In different words, the difference between the total energy and the potential energy is kinetic energy. Kinetic energy can never be fully known as it is the work in progress. The movement of charged particles through a conductor is called Current Electricity. Current electricity is a form of Kinetic Energy. The extent of the work to be done and the amount of the total work done entirely depends upon the amount of charge stored on the electrodes. Building up of the adequate charge causes the electrical energy to be discharged in the form of a spark, or it may be in the form of a lightening which has electrical kinetic energy. The presence of the electrica energy goes to travel as waveforms in the medium. These waves are comprised of both kinetic and potential energy moving back and forth in the medium such as transmission lines. The waves can also be considered as a long cascade of swinging pendulums continuously transferring kinetic energy to potential energy and vice versa. Power plants produce kinetic energy by a number of means, mostly in the form of alternating current.

II. POTENTIAL ENERGY AND KINETIC ENERGY IN HYDRO POWER

Availability of water source for the generation of Hydro Electricity is easily accountable as compared to Wind or Solar Energy. The water in the reservoir of the Hydro Power dam is source of the stored potential energy. When water from the reservoir is freed to flow down through the penstock towards the turbine, potential energy is converted to kinetic energy. Turbine in the HE power plant converts kinetic energy of the flowing-falling water into the electrical energy by spinning the alternator connected to it. The entire process follows as this: The running water rushes across turbine and hits the blades of it and consequently spinning the turbine. This converts KE of the running water to the mechanical energy of the spinning wheel. Only a partial amount of running water can be utilized for the generation of Electricity and a huge amount of the energy is released wasted as the water falls. This is noteworthy that higher the altitude of the water reservoir higher will be the potential energy stored in it because of the gravitational force and the altitude velocity of the flowing water is also very much dependent on the mass of the stored water of the reservoir.

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III. MEASUREMENT OF HYDRO ENERGIES

For the measurement of the Hydro Energies, the following parameters are measured:

1. The Electrical Potential Energy

Amount/Voltage of electrical PE or the potential energy is measured at varied heights and with discrete velocities of water, non identical or disparate blade sizes, and the incompatible and inconsistent sized water streams are considered.

2. Power from Dams (Potential Energy)

As mentioned the hydroelectric dam has a reservoir with a massive amount of water stored in it. Therefore the available or stored energy depends on potential head of water which is above the turbine and also the volume of the water falling upon the turbine. In the hydroelectric plants the turbines are generally of reaction type with their blades entirely submerged in the flow of water. Dam reservoir on the other hand provides the facility to control the water flow volume and hence the output of the generator can be controlled.

IV. AVAILABLE POWER (DUE TO POTENTIAL ENERGY OF THE STORED WATER)

Potential energy per unit volume of the stored water is given by:

$$PE = \rho g h \quad (1)$$

Where ρ density of the water (in$\frac{kg}{m^3}$), g = 9.8$\frac{m}{s^2}$ is acceleration due to gravity, h is the altitude at which the volume of the water is stored.

Power P which is from the dam:

$$P = \rho \eta g h Q \quad (2)$$

Q is the volume of water flowing per unit time, this rate of the flow is preferably estimated in$\frac{m}{s^2}$; η is the efficiency of the turbine. It has been apparent from the studies that when conversion efficiency is assumed to be a 100%, an equivalent power of 10 kW is generated for water flowing at the rate of 1$\frac{m^3}{s}$ from a head of 1 metre. It is just over 9 kW with a turbine with efficiency between 90% and 95%.

Power of the Potential is studied mathematically:

1. Power or W = (net head in metre) x flow/second x 9.81x 0.5 (turbine generator efficiency)
2. Potential power or PE is approximated as, Power o/p = (height in metre) x (water flow/ second) x 5 (3)

V. RUN OF RIVER POWER (KINETIC ENERGY)

It is not that the 'Run - of – river' installations require on the flooding of large expanses of land mass to construct. In fact the required constant water supply can also be extracted out from the natural water bodies like lakes, rivers, or other reservoirs. The upstream lakes and reservoirs are typically utilized for the plants which are a tad bit of small scale generating up to 10 MW output power. Whereas the fast flowing water from the river or a steam is taken through the penstock to a turbine, often a Pelton wheel which drives a heavy duty alternator to generate the electrical power of far greater magnitude. Design of the wheel of the turbine is designated in such a manner so as to convert the kinetic energy of the flowing water into the rotational kinetic energy and this rotational kinetic energy which moves the generator and hence the available energy is dependent upon the amount of flowing water through the turbine and is directly proportional to the square of its velocity. The Power can be calculated as:

Power = Height of the Dam x Flow rate of River x (Efficiency)/11.8

A. *Maximum Available P, Power*: More the kinetic energy ($\frac{1}{2}mv^2$) of the water impinging the blades of the turbine the maximum will be the power output from the turbine used in run of the river application.

Equation for calculating maximum output power is:

$$P_{max} = \frac{1}{2}\eta\rho Q v^2 \quad (4)$$

Here v - velocity of the flowing water
Q- volume of water through turbine/ sec.

Q = Av, where A is area swept of the turbine blades.
Thus,

$$P_{max} = \frac{1}{2}\eta\rho A v^3 \quad (5)$$

The above equation clearly states maximum o/p power is directly proportional to velocity of the running water's cube. Taking inefficacies of the system in account it can be drawn to the conclusion that the water flowing at the rate of one cubic metre per second through a turbine with 100% efficiency (ideal) will generate the power slightly less than or equal to 0.5kW. This accounts to $1/20^{th}$ part of the power which is generated by same volume of water flowing from over dam.

Now generation of same amount of the power having same volume of water from run of the river, the velocity of the flow should have to be $\sqrt{20}$ metre/sec.

VI. An Example of Power Generation Calculation for Hydro – Electric Plants

Considering a turbine with an efficiency of 80% and the height of the dam to be 20 feet and the rate of flow to be 500 cubic feet per second. The power generated will be:

P = (20 feet) x (500 cubic feet per second) x 0.80/11.8 = 677.96 kW ~ 678 kW

Now the energy generated in a year will be:

Annually Generated Electrical Energy = (678 kW) x (24 hours per day) x (365 days in the year) = 5,939,280 kWh

In India, the annual residential consumption per person per year is about 3,000 kWh. So the number of persons the mentioned dam can serve a year can be determined as follows: Number of persons served = (5,939,280 kWh)/(3,000 kWh per person per year) = 1979.76 ~ 1980 persons

VII. Wind Energy's Potential Energy and Kinetic Energy

Wind energy is nothing but a form of sun or solar energy. Wind energy/ power outlines procedure by in which the wind is consumed for the production of the electricity. Turbines of the Wheel change the k.e. in the wind into m.e.. A generator can convert mechanical power into electricity. Wind has both k.e and p.e. Wind moving higher up in the atmosphere has more potential energy than wind moving lower in the atmosphere. Wind that is moving down in the atmosphere will gain kinetic energy from the potential energy it loses. Sun light, Earth light and Cosmic or Galactic light combine in various ways to generate an atmosphere. Energy units [photons] mass in various ways in the atmosphere to become the foundations of all articulated energy centres within the atmosphere and on the surface of Earth. Farmers have used the kinetic energy of the wind to drive wind mills which can also stuff up directions for the migrating bird life. Science defines energy as the strength and vitality to do work and in this case calculating kinetic and potential energy is helpful in making machines. Dark-light energy is infinite and creates infinite possibilities and probabilities that people can tune too. The wind cannot be bound to just potential and kinetic applications. The origin of the wind is potential energy due to changes in atmospheric pressure but it is converted in kinetic energy, when air hit a blade it changes velocity direction and magnitude applying lateral impulse mechanical energy to the blade. But since gravitational force on gas molecules is negligible so it may not be considered that it has potential energy and about kinetic energy is surely there as every moving object has kinetic energy.

As per the explanation of Prof. Friedrich Aumayr of Institute of Applied Physics at the gathering of TU Wien, "The solar wind consists of charged particles -- mainly hydrogen and helium ions, but heavier atoms up to iron also play a role,". The heavier particles like these smash rocks of the surface at very high speed of 400-800 kilometer/ sec and the further effect emit various other atoms. These massive particles rose enormously before mainly falling back to the exterior area. This will create exosphere around the Mercury or Moon. Also an extremely thin atmosphere of atoms sputters from the surface rocks by the bombardment of solar wind. The exosphere is of great interest for space research because its composition allows scientists to find out the chemical composition of surface of rock. A research scholar Paul Szabo from Friedrich Aumayr's team has said that Up to now it was assumed that the kinetic energy of the fast particles is primarily responsible for atomization of the rock surface, but this is only half the truth: we were able to show that the high electrical charge of the particles plays a decisive role. It is the reason that the particles on the surface can do much more damage than previously thought." When the particles of the solar wind are multiply charged, i.e. when they lack several electrons, they carry a large amount of energy which is released in a flash on impact. Protons make up by far the largest part of the solar wind. [10]

VIII. CALCULATING ENERGIES (WIND POWER GENERATION)

Wind energy is calculated as follows: 1/2 x mass x velocity x velocity
Mass times velocity equals momentum in the wind.
Power per unit area is KE times momentum, or mv2 times mv.
Therefore, the amount of power that may be collected from the wind is equal to velocity cubed (v3).
A wind blowing at 60 mph has 27 times more strength than one blowing at 20 mph.Power per square metre equals 0.0006 v3 for typical air conditions with density and moisture constant. metres per second, which represents speed. Kilowatts were then used to measure power. A speed of 2 mph is equal to 1 metre per second. 10 m/s of wind at 20 mph. Power generated is equal to 600 watts per square metre (0.6 Kilowatts per square metre) or 0.0006 x 103 (0.0006 x 1000).

IX. POTENTIAL AND KINETIC ENERGY IN RELATION TO SOLAR ENERGY

All time, solar, the sun energy is being converted into kinetic energy that is available in winds, clouds, ocean waves, and rainfall. This happens by initially converting the radiations from sunshine into thermal energy that raises the temperature of the receiving medium creating a weight/ density unbalance. This unbalance causes the resulting movement of the objects / medium carrying kinetic energy.

In recent years, organic and inorganic halide perovskites-based solar cells have demonstrated rapidly increased power conversion efficiencies. They exhibit and demonstrate behaviours including voltage and current hysteresis as well as a low-frequency large dielectric response. Ion transport has been found to be a significant contributor to these results. Fundamentally, activation energies for ion migration in methylammonium lead iodide (CH3NH3PbI3) are derived from the very beginning. These are contrasted with kinetic information obtained from a perovskite-based solar cell's current and voltage response. The foundations of microscopic transport were identified, and it was discovered that iodide ion migration was easily facilitated by vacancies with an activation energy of 0.6 eV, in good agreement with kinetic studies. When combined with kinetic practicals and experiments that would be performed for the monitoring of the photo-current relaxation of devices,

the initial basic basics and principle approaches were used to investigate the major key point issues linked to intrinsic defect migration in CH3NH3PbI3. [4]
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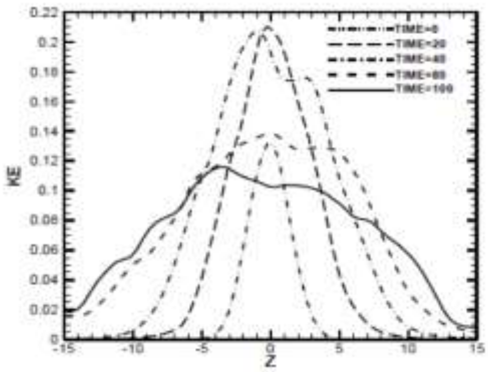
Mexico has a lot of potential for using renewable energy sources. With regard to solar energy, as an illustration, the nation of Mexico has extremely exceptional superb conditions with a vast geographical extension and ideal climatic conditions, with the average of the sun or solar radiation adding up to and equating to roughly 5.0 kWh/m2/d. For each class of end-use points, the technological, economic, and commercial potential are estimated. To determine the potential of SWH for homes in Mexico, various and end-use potentials are combined and extrapolated. Energy savings range from 29% to 56% of consumption for water heating during the winter, with the built-up area of the Gulf of Mexico having the highest and greatest potential for energy savings. Savings in rural households were 1.3 PJ and in urban households 10.4 PJ for the use of SWH. Given the possibilities assessed in this article, it is obvious that the SWH can play a key part in resolving Mexico's energy issues. The SWH is not just the near future; it is the present of the energy use for heating water. [5]

It is demonstrated that solar wind standoff, an ion-electron kinetic interaction mechanism that locally inhibits weathering by solar wind ions, reproduces and yields the shape of the Reiner Gamma Albedo pattern by linking the completely kinetic simulations with a Surface Vector Mapping model. The importance of a kinetic technique to characterise the solar-wind interaction is expressed by the simultaneous qualitative agreement between optical remote observations and in situ particle measurements of the back-scattered ions. However, due to the fact that magnetic shielding on small scales is an ion-electron kinetic mechanism, it is not possible to assess the veracity of the solar wind standoff model solely by analysing the magnetic topology and the size of the crustal field. A fluid created utilising magnetohydrodynamic or hybrid technology. In order to shield the underlying surface, create Reiner Gamma's three bright lobes, and direct solar wind plasma into its dark lanes, the approach requires surface magnetic fields and/or spatial scales that are at least an order of magnitude larger than what is currently inferred from in-orbit observations. This indicates that even if many protons touch the surface of the moon, differential darkening could still occur owing to solar wind standoff if enough kinetic energy is lost due to the charge-separation electrostatic field before the protons reach the surface. We demonstrate qualitative agreement between in-person measurements of the back-scattered protons simultaneously coupled together by a fully kinetic simulation and optical remote observations for the first time. Up until then, fully kinetic simulation studies are the best option. [6]

Sometimes, the fluid flow in a solar system consists of two phases, including steam and liquid water. The Large Eddy Simulation (LES) technique has been used in this study to create a complete three-dimensional compressible fluid dynamics model of a compressible turbulent temporal mixing layer (steam flow). The primary goal of the current research is to compare the vortices that are produced during mixing at three distinct times. The Navier-Stokes equations have been filtered using a top-hat filtering function to separate the large and sub-grid scales, and the dynamic eddy viscosity model has been used to describe the sub-grid scales. Verman's direct numerical simulation (DNS) and (LES) results have been compared to the numerical result for the momentum thickness.



Comparison of kinetic energies at different temperatures

At five distinct intervals (steps), The numerical results showed that the turbulence spread resulting from the mixing of layers in the entire flow field, and its effects on the main flow properties. The sub-grid scale kinetic energy and the flow simulation results, such as vortices, pressure, density, and x-velocity component, have been presented. According to the model, eddy viscosity dissipates flow kinetic energy at sub-grid sizes. On the other hand, the dynamic coefficient, which regulates the degree of flow turbulence, has taken the position of the square of constant coefficient in Smagorinsky's basic model. The order of the eddy viscosity in the flow is determined by local variations in this coefficient. The dynamic coefficient is then continuously adjusted by achieving the new value at any location in the flow field after a time step or numerous time steps by evaluating the flow field. This makes it possible to calculate the precise rate of kinetic energy conversion to heat. In the dynamic eddy viscosity model, test filtering is employed for this purpose with a filter width that is twice that of the original filter. The turbulent stress tensor model at sub-grid scales and the strain field at large scales are related by eddy viscosity. [7]

Scientists at the Los Alamos National Laboratory have constructed magnetically-doped quantum dots that can absorb electron kinetic energy before it is lost as heat. A significant portion of the energy from sunshine is lost as heat in conventional solar cells. Due to the lack of efficient methods for harnessing the kinetic energy of "hot" electrons produced by photons in the green to ultraviolet region of the sun's light spectrum, this waste happens. In the past, hot-carrier energy has been harnessed by stimulating an immobile, low-energy electron to a current-conducting state by transferring kinetic energy from the hot, energetic electron to it. The number of electrons contributing to the photocurrent is doubled as a result of this phenomenon, known as carrier multiplication, which can be employed to improve the efficiency of solar cells.[9]

The material's surface deflects the electrons, causing some of their energy to be lost. This energy loss can be quantified, making it possible to draw conclusions about the material's characteristics, such as its capacity to carry electricity or heat. It needs to be measured from several angles. The energy loss could only be measured for one angle at a time up until this point. As a result, measurements of a single sample took an entire day, often longer. A technique for measuring a sample in a matter of minutes has been developed by François Bocquet and his associates. Their HREELS device has two extra parts that make the measurements easier: The first, according to Bocquet, is a hemispherical electron analyzer that has been used successfully for ten years in angle-resolved photoelectron spectroscopy. The second is a modified electron source tailored to the institute-created electron analyzer. "The second is a modified electron source tailored to the electron analyzer, which was produced here at the institute." By using specifically created software, this is tuned to make sure the electrons in the beam have the correct kinetic energy and can be concentrated on a very tiny area of the sample. The analyzer can be utilised most effectively in this fashion, enabling the simultaneous monitoring of energy losses from various angles. [9]

Researchers from TU Delft have developed a novel method for quickly and precisely determining the solar energy potential of surfaces in non-rural urban settings. The most recent technique can significantly assist architects and urban planners in incorporating the technicalities of PVs or solar power into their architectural process. In metropolitan settings, buildings, trees, and various other structures shade solar panels, which has a significant impact on the efficiency of a PV system. The integration of PV systems into the urban environment will be made easier by an appropriate and accurate judgement and assessment of the specific performance, and the corresponding pricing or performance of PV systems.

The energy yield of PV systems can be simulated using a variety of techniques. All of these instruments essentially rely on mathematical models that calculate the incident sun radiation on solar PV modules. The tools that offer an annual irradiation that is received by the solar PV modules are used repeatedly to calculate the incident irradiance. But the truth is that determining with great accuracy how much electricity a PV system produces in a city environment is not at all straight forward. But the truth is that determining with great accuracy how much electricity a PV system produces in a city environment is not at all straightforward. The new method makes the numerical steps easier and allows for high end accuracy while allowing for speedy verification of the solar energy potential for vast urban areas. The association between the skyline profile and the annual irradiation at a specific urban location is very strong. The study shows that the two parameters that are generated from the skyline profile—the sky view factor and the sun coverage factor—can be used to quantify the total annual solar irradiation that is received by a chosen surface in an urban environment. The second value is indicative of the irradiation from the direct sunlight component, whilst the first parameter is utilised to estimate the irradiation from the diffuse sunlight component. The skyline profile makes it simple and quick to get these two elements. This study demonstrates that the computational complexity of the issue is greatly reduced when these two factors are used. The approach has already been incorporated by the Photovoltaic Materials and Devices department into a software toolkit that can precisely determine the energy yield of PV systems at any location. It will also assist investors in making choices on the installation of PV systems in buildings and other urban areas. [9]

X. MEASUREMENTS

A. Measuring Hydroenergies: This involves taking measurements of the voltage, which is also known as the amount of potential energy in electricity, and doing so at various heights, water speeds, blade sizes, and water stream sizes.

B. Measuring Solar Energies: From a basic solar cell placed in the sun, measure the voltage, which is the amount of potential energy in the electricity between cell connections. The next step would be to position mirrors close to and around the cell so that more and more light would reflect upon it. The measurement is affected by trying out different and multiple places as well as different foil shapes.

C. Measuring Wind Energy: A generator that is typically attached to the turbine shaft by gears that cause the generator to rotate at a different speed than the turbine shaft is used to measure wind energy. The electricity is transformed into the proper voltage and frequency to put into the power grid, which is likely 60 Hertz or 50 Hertz, using fancy power electronic controls.

XI. COMPARISON

1. A turbine modifies each of the portion of power of wind to the power in the form of mechanical it can be asserted that efficiency in that case is full or hundred percent. This is rather impractical concept to ponder. Achievement of as low as fifty percent is also very much questionable. A turbine which is possessing the productivity/efficiency of fifty percent would modify half of the power in the wind to mechanical power.

2. Hydropower depends a lot on landscapes and it is a costly affair to change its kinetic and potential energies.
3. By the cases studied in this paper, we can infer that kinetic energies and potential of Solar can be altered to achieve greater power.

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