International Journal of Engineering and Technical Research (IJETR)
ISSN: 2321-0869, Volume-2, Issue-10, October 2014

Static Wind Energy Converter

Ashish Sharma, Vishu Gupta, Meghana Solanki

***Abstract*— Wind energy has had a imensible impact on the way our world has taken form, from the first sailing ships that discovered new world to the wind mills that were used to create dry land in the Netherlands. With every new era, an innovative way was found to make use of the wind energy. In this thesis, we will introduce an innovative method of extracting wind energy. While wind energy is often viewed as an energy source on its own, technically speaking, wind energy is mainly a form of solar energy, because air flow is generated due to the uneven heating of the Earth's surface by the sun. About 1.0% of the energy reaching the earth surface, is transformed into energy of wind .Due to the uneven heating of the Earth's surface, there are few locations which are more suitable for the exploitation of wind energy, like at sea or oceans, on wide open plains , deserts or along coastal lines.**

The main purpose of this dissertation is to focused about the wind energy and its various effects, which shows the how does the wind energy produced electricity and how does the electric and magnetic field is produced, and its affect in various regions.

***Index Terms*— Include at least 5 keywords or phrases**

I. Introduction

Firstly, we will briefly explain the status of current use of wind energy, its capabilities, its drawbacks and what can be expected of wind energy. Then, we will introduce a different concepts , to convert wind energy into electrical ,in order to address some of the drawbacks which currently associated with its production.

Usually, when it comes to alternative source to generate energy, several terms are used to label these sources using adjectives like "sustainable" or "renewable" .Therefore, for the sake of transparency, the following definitions, are commonly accepted, and will be used throughout this thesis:

Sustainable energy

A type of energy generation, can be maintained economically efficient without depleting the resources.

Renewable energy A type of energy generation, where the required resources are normally replenished through natural processes. Usually, it means, the form of renewable energy are also sustainable if they manage economically.

Out of all forms of sustainable energy generation methods, wind energy is one of the best and most utilised forms, together with hydro energy. It is a emerging source of sustainable energy which has the potential to ease up the pressure on fossil based energy sources. The fact is, there is virtually no CO2 emission when generating the energy from wind which means that this form of power generation could play a giant role in global energy supply, especially in the issue of global warming.

Manuscript received October 13, 2014.

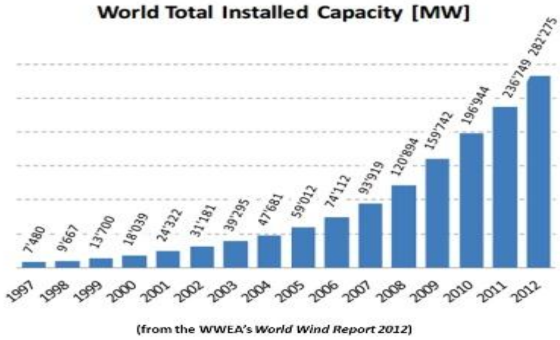


Figure 1 Total installed wind power capacity in the world (MW) until 2012

II. II. DATA PROVIDED BY THE WORLD WIND ENERGY ASSOCIATION

Globally, in 2007, the total installed capacity is roughly estimated 93919 MW and, as seen in Figure 1, the prediction for the next years is almost double of that capacity. In Netherlands, the installed wind power capacity currently is approximately 1527 MW. The goal of the government is to increase this capacity to 3054 MW in the next few years. In 2020, the target is to have 20.08% of the total output power be generated by means of sustainable energy ,in which wind Energy play significant role. This will mean , by then, total installed wind power capacity is of 6213 MW.

A. Conventional/Customary Methods

The most common method of converting wind energy to electrical is through the use of wind turbines of the horizontal axis design, see Figure 2

Figure 2. Wind turbines of the farming landscape

Their current efficiency is of 50.02% at their rated speeds, which means it convert 50.02 % of the available power associated with wind. Currently, small turbines have power capacities around 250 kw, while the large turbines are capable of delivering several megawatts .

B. Drawbacks/Flaw of Wind Turbines

Wind turbines still ,the main devices to convert wind energy into electrical energy, but there is number of drawbacks which limited the widespread use of wind energy. The main drawback its high cost of maintenance. This need for maintenance arises primarily from the conversion of wind energy to electrical energy via mechanical energy, especially the rotational movement drives the wind turbine. Gear box driven wind turbines are more prone to wear and tear losses , and it needs to be maintained once in a year. Added to the cost of maintenance , amongst other things, construction, land lease and permits which makes government subsidies a requisite to enabling wind energy projects. Thus, at this point of choice, the wind energy is a costliest one .

Other drawbacks include the facts, the customary wind turbines is bound to circular surface area, because of its rotational movement. This movement is also the cause of noise and intermittent shadow nuisance. Another often heard complaint is that these wind turbines are responsible for what is called "visual pollution", especially in case of large wind turbine farms in rural and their settings are involved. A solution for this problem is to build wind turbine farms at sea and its shores. This, of course, introduces problems such as increased construction and maintenance costs.

C. Surrogate Methods of Wind Energy

There have been developments in the field of surrogate wind energy conversion. One example is "ladder mill" [2] consists of, a series of kites having rotator moment while driving a generator , all of these developments are still in an experimental stage and have not been yet proven commercially successful. Although, they have common elements like mechanical moving parts, which will lead to wear and tear cost, similar to wind turbines.

D. Wind Energy Uses

As many countries have stated their long-term energy goals and they wish to increase their wind energy output, a question is often arises! When , any form of surrogate energy production is avail? Is it can replace current energy production processes or not? With due respect to wind energy, it can be said, its intermittent nature and the limited means of energy storage will not be able to fully replace fossil and nuclear based energy production. Also, some computational research models used which described and [3] suggest the local and global climate could be surrogate by the use of large scale of wind energy, for e.g 1/15th demand of global electricity, by extracting kinetic energy and changing turbulent transport in the atmospheric boundary layer.

III. NEW CONCEPT AND THE SYSTEM WITH VERY LITTLE MOVEMENT

As stated before, all the methods, used to convert wind into electrical energy, due to some form of mechanical movement, which only the reason of maintenance and the cause of failure. Therefore, a concept of little mechanical movement would be ideal with respect to system complexity and maintenance costs.

The static wind energy converter which is based on the principle, the wind carries or transports electrically charged particles in an electric field. Without going into great detail on how we will create these charge carriers ,for now, we will discuss about the principles of the method and its possible implementations into an actual system. In principle, an object can hold or store a charge and, could be used as charge carrier. At the end of this chapter, we will discuss in more detail what's this, in practice, will come down.

It is important to mention the concept of converting wind energy into electrical by having the wind move charge carriers in an electric field .There have been several patents which propose a similar ideas, however, most of it do not have an energy efficient solution to create charge carriers.

Principle

When a force acts on a body which undergoes a displacement, force does work on the body. In the case of energy system, the body is a charged particle with charge q and the force F is the electric force on the charged particle due to an field of electric field E, is given by

$$F = q E$$

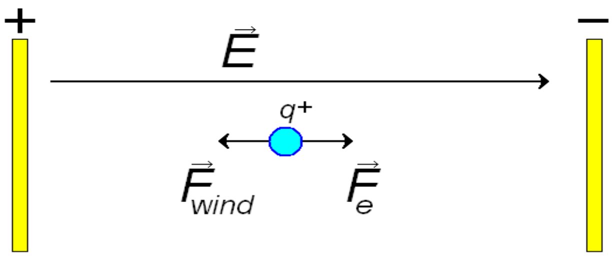


Figure 3. A positively charged particle is pushed towards the positive(+) electrode by the wind opposite to the direction of the electric field, thereby increasing the potential energy of the charged particle

By allowing the wind , to force the charged particles against the direction of this electric force, the potential energy of charged particles will increase, similarly, pushing a rock up a mountain against gravity.

$Dw = -du$

B. Implementation of the method

Currently, we used two methods of collecting the charged particles, both will be explained together with their respective advantages and disadvantages:

C. Type A: Implementation Of The Static Wind Energy System With An Insulated Collector

As we can see in Figure 4, this implementation of system, the charged particles created by the system, which consists of number of nozzles and electrodes, with ground. A stream of charged particles, can be considered as an electric current, then transported by wind to a separate insulated collector, which is initially neutral. When the charged particles reach to the collector, they will deliver their charge to it. This cause, the rise in potential of the collector. This potential ,will have the same polarity as of charged particles cloud, therefore, they creating an electric field. Due to this, an electric force push the charged particles away from the collector. Initially, the force of wind energy is larger than applied electric force and therefore the charged particles continuously arrive at the collector. As long as the process occurs, the electric field generated by the collector will continuously increase, causing the charged particles cloud either move back against the wind or around the collector. When it comes in contact with the charging system the charge is lost and the net current decreases. Therefore, the wind has to overcome repelling electric force and depending on their speed , the size of collector and the load, the collector attains maximum potential which further depends on possible leakage currents to earth via insulator surface. If, all produced charged particles are captured by the collector, then, the maximum power of the system has been attained.

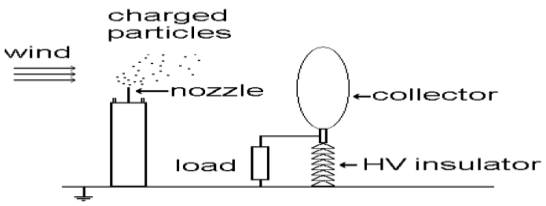


Figure 4. Type A implementation of the static wind converter system with an insulated collector. The charged particles through the charging system consisting of nozzles and electrodes .Wind transports these particles to the collector
Currently, research on it is also carried out in Japan by Sato et al.This work is only limited to implementations with a separate collector.

IV. EXPECTED ADVANTAGES AND DISADVANTAGES

This principle is expected to have several advantages over the standard conventional wind turbine systems. First of all , apart from the floating charged particles, there is no moving/rotating parts present in the system. This means there is no wear and tear losses commonly found in the gearbox systems of wind turbines. This will have a positive impact on maintenance and investments factors. Secondly, due to the lack of moving/rotating parts, there is less noise generating from the system.. Thirdly, since there are no blades is present ,so, no intermittent shadows will be present. And, this is especially important for the systems placed in the urban or rural areas. Finally, since there is no rotational movement in the system, increasing the wind surface area does not necessarily have to go hand in hand with an increased circular wind area which illustrated in the Figure 5

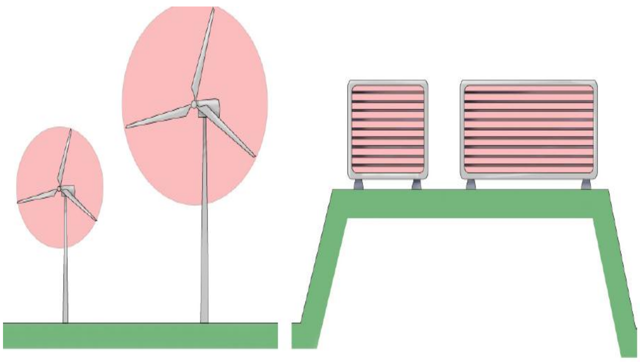


Figure 5 Using conventional wind turbines (left), increasing the wind surface area means the diameter of the circular area needs to be increased

Due to the systems nature, it is possible , to extend the wind surface in one of the two dimensions, making this a modular approach possible. This way, one could think of building long strips of system modules along roof tops or dams, as illustrated in Figure 5. These long strips would help to make static construction of the system and thus, less adaptable to the direction of wind.
We will see in the next chapter design and construction of the system.

V. DESIGN AND CONSTRUCTION

A. Constructed Hammered Iron Bar

A wire is wound over hammered piece of iron having specific no.of turns explained later in detail.

Fig 6-Hammered Iron Bar

B. The Produce Electric Field

The below diagram shows the effect of electric field through key, which get magnetised through applied electric field

.

Fig 7 Electric field magnetised the key shows surface charge Density.

The field of electricity produced by a surface charge :-
E = ρs/2έo * an

VI. TESTING & RESULTS

The experiment reveals the various results based on true testing of model in real environment. Here , the below table suggest the results of voltage & current producing capacity of setup used for static wind energy converter.
These results shown on below given tables based on real time testing environment containing the dimensions of hammered bar & its effects on voltage and current as well.

Here we are discussed about the generation of current and it behaviour into various materials, and how does it creates effects into hammered bar.

A. Electric Field in Material Space

As we discussed about the electric field in free space or field without any physical medium ,here we studied about electric field through materials, its effects & limitations.
Firstly we discussed about the current and its behaviour
Current through conductor & its convection property :-
The current through given area is the electric charge passing through the area in per unit time.

I = dq/ dt (in amperes)

This current, change into the density when pass through the volume & become current density i.e the current ΔI flow through the surface ΔS ,the current density is

$$J_n = \Delta I / \Delta S$$
$$\Delta I = J_n \Delta S$$
$$\Delta I = \int J_n \cdot \Delta S$$

It depends how I is produced , there are different kinds of current densities : convection current , displacement current ,conduction current density , here we discussed about convection current density
Convection current is different , it does not involve conductors & not satisfy Ohm's law . It occurs when current flow through insulating medium like vacuum, rarefied gases , liquid . A beam of electron in vacuum is convection current .

B. Conductor

A conductor possess excess of charges ,which is free to move. When an external electric field Ee is applied ,the positive charge is moves along applied field , while the opposite of it .The free charge do two things . Firstly accumulated on the surface make the induced one. Secondly, induced charge set up the induced electric field which cancel the external field. It leads to important conductor property i.e equipotential surface cannot contain any electrostatic field

$$E = 0 , \rho v = 0 \quad V_{ab} = 0 \text{ inside a conductor}$$

C. Polarization in Dielectrics

In conductor the charges are free to move in the shell of atom, hence it possess current effectively but in the case of dielectric , they are not free to move ,bound by the nuclear force & we may assumed the displacement current produced due to external electric field.
We know , the electric field consist of +Q & -Q charges which produced F+ = QE & F- = QE due to applied electric field respectively .A dipole results from the displacement of charges & hence the field is said to be polarised .
In polarised state , the charge cloud is distorted by external electric field E ,

$$P = Qd$$

D - distance vector from +Q to –Q of the dipole.

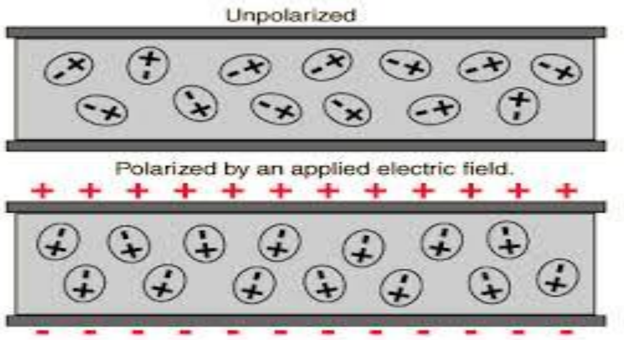


Figure 8 Polarization In Dielectric

D. Testing Equipments

1) Dimension of Hammered Bar-1: The hammered bar consist of following dimensions Length = 220mm, Width = 20mm. Height = 5mm using the wire length of 10 meter considering the cost constraints of wire.

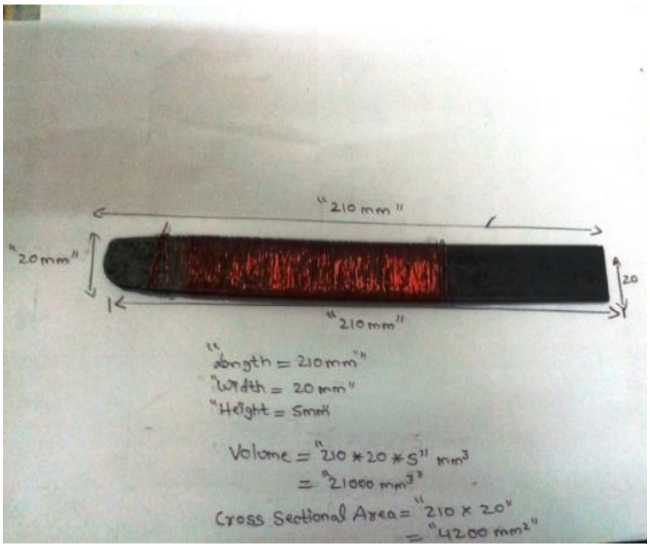


Figure 9 Hammered Bar (210*20*5) mm3

Depend on above dimension , it produced the a certain level of voltage and current, of different values, it shown in table I

S.No	Number of Turns	Output in Volts	Output in Ampere
1	40	17.4	1.09
2	50	21.3	1.12
3	60	24.5	2.11
4	70	29.3	3.18

Volume = (210 *20*5) mm3
= 21000 mm3
Cross Sectional Area = (210*20) mm2
= 4200 mm2

TABLE I

S.No	Number of Turns	Output in Volts	Output in Ampere
1	45	13.25	1.01
2	50	14.33	1.04
3	60	24.55	2.01
4	65	26.66	2.97

Showing the effect of voltage and current due to number of turns

2) Discussion :The table I &figure 9 reveals the generation of level of voltages which depends on wire turned around across the hammered bar of specific dimensions. As the number of turns changes the value of voltage and current get change, which ensured the change in flux produced change in voltage. So the bar of different dimensions does effects the voltage & current.

S.No	Number of Turns	Output in Volts	Output in Ampere
1	30	11.22	0.99
2	40	11.99	1.00
3	45	17.55	1.99
4	50	20.66	2.05

3) Dimension of Hammered Bar-2:The hammered bar consist of following dimensions Length = 75mm, Width = 20mm. Height = 5mm using the wire of 8meter considering the cost constraints of wire.

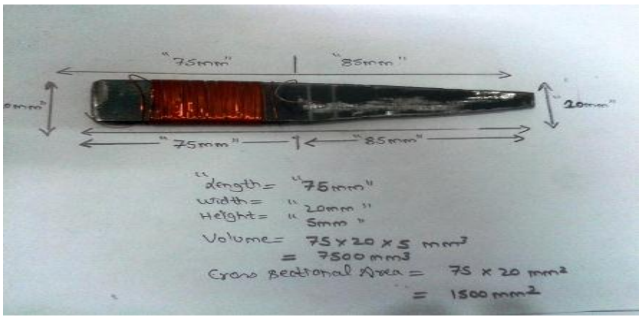


Fig 10 Hammered Bar (75*20*5) mm3

Depend on above dimension , it produced the a certain level of voltage and current, of different values, it shown in table II

Volume = (75* 20* 5) mm3
= 7500 mm3
Cross Sectional Area = (75*20) mm2
=1500 mm2

TABLE II

Showing the effect of voltage and current due to number of turns.

4) Discussion: The table II &figure 10 reveals the generation of level of voltages which depends on wire turned around across the hammered bar of specific dimensions. As the number of turns changes the value of voltage and current get change, which ensured the change in flux produced change in voltage. So the bar of different dimensions does effects the voltage & current.

5) Dimension of Hammered Bar-3:The hammered bar consist of following dimensions Length = 85mm, Width = 10mm. Height = 5mm using the wire of 6meter considering the cost constraints of wire.

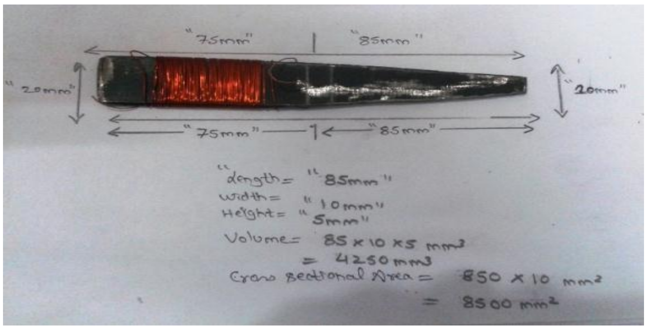


Fig 11 Hammered Bar (85*10*5) mm3

Depend on it, produced the level of voltage and current of different values, it shown in table III

Volume = (85* 10* 5) mm3
= 4250 mm3
Cross Sec Sectional Area = (85*10) mm2
= 850 mm2

TABLE III

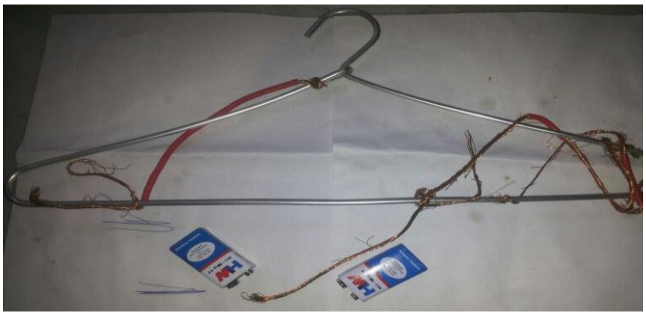
Showing the effect of voltage and current due to number of turns.

6) Discussion: The table III &figure 11 reveals the generation of level of voltages which depends on wire turned around across the hammered bar of specific dimensions. As the number of turns changes the value of voltage and current get change, which ensured the change in flux produced change in voltage. So the bar of different dimensions does effects the voltage & current.

E. Application of Static Wind Converter

Here , we used hollow frame consist of solution having small holes of .002mm ,through which p the solution is poured down the other end of the frame via grid of wire having electric field,

As we know the wind intensity is high on height , so as we placed our object at rise building flow of solution could get high due to high speed of wind, hence it shows various level of high of current and voltages.



Hollow frame (140*320)mm

Figure 12 Hollow frame consist of gauge of conductive wires

In order to model the movement or trajectories of a number of the charged droplets as described at the beginning of this section, these droplets will be positioned in a simple electrode configuration, which means that the electric field will be modelled as a uniform field decreasing in the wind direction with. The droplets will be assigned a polarity such, that the electric force they will experience, will be directed in the opposite direction of the wind, as shown in the fig 13

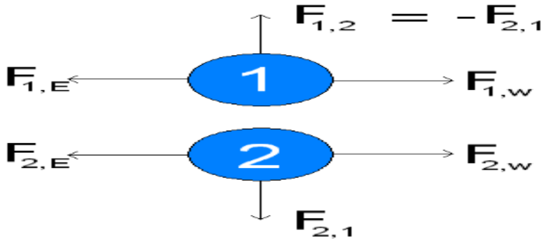


Figure 13 The schematic representation of charged particles under uniform electric field along with the air flow, showing the repelling property due to of alike polarity

There are several natural forces acting on the droplets like gravity which obviously acts on all droplets,

$$\vec{F}_{i,g} = m_i \cdot \vec{g} \quad [4]$$

In which mi is the mass of the ith droplet and g is the gravity due to acceleration. In this model, the mass of the droplet, mi is keep constant, thus disregarding evaporation effects. After droplet flight times have been calculated, the buoyancy force can compare them to because evaporation is a critical factor.

$$\vec{F}_{i,B} = -\rho_a \cdot V_d \cdot \vec{g} \quad [5]$$

In which Vd is the volume of the droplet and ρa is the air density. The drag force due to the wind which initially causes the droplets to move,

$$\vec{F}_{i,w} = \frac{\pi}{8} \cdot C_D \cdot \rho_a \cdot d^2 \cdot |\vec{v}_w - \vec{v}_d|^2 \cdot \frac{\vec{v}_w - \vec{v}_d}{|\vec{v}_w - \vec{v}_d|} \quad [6]$$

CD - drag coefficient,
Vw - wind speed
Vd - speed of the droplet.

This drag force will be zero if droplet speed is equal to the wind speed. In specific cases, we can take out CD and simplify by looking at the Reynolds number. The dimensionless Reynolds number is an important in fluid mechanics and used to find our whether a flow process is turbulent or laminar, by the ratio of inertial and viscous forces. If it is lower than 1, which means the viscous forces are dominant, & it said to be laminar,

$$Re = \frac{\rho_a \cdot d \cdot |\vec{v}_w - \vec{v}_d|}{\eta_a} < 1 \quad [7]$$

In which ηa is the dynamic/absolute viscosity of air. Laminar flow is always associated with smooth flow of patterns as opposed to turbulent flow . When this happens, it comes under the Stokes region ,where it can be be shown that, in that case, Stokes' law can be used for the drag force,

$$\vec{F}_{i,w} = \frac{3\pi \cdot \eta_a \cdot d \cdot (\vec{v}_w - \vec{v}_d)}{C_c} \quad [8]$$

In which Cc is the slip correction factor by Cunningham, which is relevant for particles smaller than 1 μm. For particles d >> 1 μm, we can assume Cc = 1, The forces which act on the droplets is electric , & can be divided into two parts. The first part of electric force is external electric which created by one or more electrodes present in the system, which will be represented by Eext ,

$$\vec{F}_{i,E} = q_i \cdot \vec{E}_{ext} \quad [9]$$

In which qi is the charge present on the ith droplet. The electric field, Eext, is decreased in the direction of wind, with 1/r2 and is pointed in the opposite direction of the wind. In this modeling , part of Eext represents the field created by the charging system of the and, it is responsible for the creation of the droplets.
The second part of the force of electric is due to the field created by the other charged droplets & it is,

$$\vec{F}_{i,j} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_i q_j}{r_{i,j}^2} \cdot \hat{r}_{ij}$$

In which ri,j is the distance between droplet i and droplet j. The charge created by droplets having same polarity and, thus, they will repel each other. In reality, the sum of the electric fields generated by all the charged droplets affects the electric field at the charging system, represented by Eext, which means the charging and spraying process is changed. Therefore created charge droplets could have different sizes, initial velocities and charges.. Summing all contributing forces, we find for the law of motion

$$\vec{F}_i = \vec{F}_{i,g} + \vec{F}_{i,B} + \vec{F}_{i,w} + \vec{F}_{i,E} + \sum_{j \neq i}^{j} \vec{F}_{i,j} = m_i \cdot \vec{a}_i$$

In which Fi is the total force on the ith droplet and ai is the acceleration of the charged droplet. Above Equation can be solved, and giving us the velocity and position of every droplet at each point in time. In this equation, the total force is mainly dominated by the drag force and the electric force.
Using above equation, the work done on the ith droplet, Wi, by the wind can be found by using

$$W_i = \int \left(\vec{F}_i - \vec{F}_{i,w}\right) \cdot d\vec{\ell}$$

In which dℓ is the displacement which follows the path of the droplet. From this, the difference of potential energy for the droplet can be calculated and, we can taking the sum of all the droplets, the total energy gained from the wind.

F. Various Forms of water droplet having different in diameters with their respective maximum charge:-

The above table shows the various solution droplets of different diameters along with their charge .Hence with the assumption of droplet mass we calculate the acting force on it drops.
And with help of it , we calculate acting electric field
F = q.E

The following table shows force produced due to mass of droplets.

TABLE IV

Shows the force acting on droplets having different mass

S.no	Force acting on droplet(N)	Q charge(C)	Electric field(V/M)
1	$3.92 *10^{-3}$	$1.02 *10^{-03}$	3.9984
2	$5.88*10^{-3}$	$1.07*10^{-03}$	5.49
3	$7.84*10^{-3}$	$1.09*10^{-03}$	7.19
4	$9.8*10^{-3}$	$1.12*10-^{03}$	8.75

TABLE V

S.no	Mass of droplets(mg)	Gravitational force(g) (m/s2)	Force act on droplet(newton)
1	.0004	9.8	$3.92 *10^{-3}$
2	.0006	9.8	$5.88*10^{-3}$
3	.0008	9.8	$7.84*10^{-3}$
4	.0010	9.8	$9.8*10^{-3}$

Shows the electric field produced due to force and charge acting on droplets having different mass.

VII.CONCLUSION

Here ,a number of assumptions we have been made for the movement of charged droplets by wind in an electric field. Firstly, we assumed there is no evaporation of the droplets. If the charged droplet do evaporate, then ions will be formed and create ionic space charge field. If this would occurs close to the charging system then its effect will have to taken into account. Therefore, the evaporation times calculated in the previous section must be compared to the flight time of the charged droplets in order to verify whether the omission of evaporation effects is justified. However, estimations show that in wet conditions the evaporation times are in the order of nine seconds. With a wind speed of e.g. 9 m/s, the ionic space charge field will be formed at distances of a hundred metres and its effect can be neglected.

REFERENCES

[1] International Energy Agency, World Energy Outlook 2012, pp.66-67, 2012
[2] International Energy Agency, World Energy Outlook 2012, pp.72-73, 2012
[3] International Energy Agency, World Energy Outlook 2012, pp.378-382, 2012
[4] Gerald James Holton and Stephen G. Brush (2001). Physics, the human adventure: from Copernicus to Einstein and beyond (3rd ed.). Rutgers University Press. P. 113. ISBN 978-0-8135-2908-0.
[5] Acott, Chris (1999). "The diving "Law-ers": A brief resume of their lives.". South pacificunderwatermedicine Society journal 29 (1). ISSN 0813-1988.OCLC 16986801. Retrieved 2009-06-13..
[6] Clancy, L.J. (1975) Aerodynamics Fig 5.24. Pitman Publishing Limited, London. ISBN 0-273-01120-0
[7] Ojovan, M.I. and Lee, W.E. (2004). "Viscosity of network liquids within Doremus approach". J. Appl. Phys. 95 (7): 3803–3810
[8] Stokes, Sir G. G. (1891). Natural Theology. Adam and Charles Black, Edinburgh.
[9] Huray, Paul G. (2009), Maxwell's Equations, Wiley-IEEE, p. 205, ISBN 0-470-54276-4, Chapter 7, p 205