ISSN 2047-3338

Reduction of Global Warming By Using Renewable Energy Resources: A Mathematic Approach

Munish Kumar Jangra, K. P. S. Parmar and N. K. Yadav

***Abstract*— Global warming is the recent challenge to world. Governments of various countries in the world, at this time, are concentrating on the methods of reducing it. Both developed and developing countries are using fossil fuels in large quantity to meet their energy demands. The burning of fossil fuel produces CO_2. Man-made emission of CO_2 in atmosphere is highly responsible for global warming. In this paper, it is proved mathematically that how can global warming be reduced by using renewable energy resources (especially, by Wind Energy Conversion Systems & solar PV cells). This paper focuses on the importance of renewable energy resources with the help of EDFFQT curve. A new idea of directly and indirectly affecting renewable energy resources on global warming is also discussed.**

***Index Terms*— Global Warming, Renewable Energy Resources, Solar PV Cells, Wind Energy Conversion System (WECS)**

I. NOMENCLATURE

E	Total energy entering into the earth's atmosphere in any time interval, t, from sun.
E_{heat}	Heat energy formed from E.
E_{light}	Light energy formed from E.
E_{other}	Other forms of energy, also containing back reflected energy from earth's surface to space, formed from E.
E'_{heat}	Remaining heat energy after separation of air energy from E_{heat} .
E_{air}	Air energy formed from E_{heat}.
E'_{air}	Remaining air energy after separation of electrical energy from E_{air} .
$E_{electrical}$	Electrical energy.
x	Fraction of air energy converted into electrical energy.
E'_{light}	Combined energy of light and associated heat.
Tc	Time, when electrical demand curve cuts fossil fuel curve.

Munish Kumar Jangra is pursuing M. Tech. from D.C.R.U.S.T., Murthal, India (E-mail: munish.knl@gmail.com).

K. P. Singh Parmar is an Assistant Director with CAMPS, National Power Training Institute, Faridabad, India, (E-mail: kpsingh_jss@rediffmaill.com).

Naresh Kumar Yadav is with the Department of Electrical Engineering, at Deenbandhu Chhotu Ram University of Science and Technology, Sonepat, India, (E-mail: nkyadav76@gmail.com).

II. INTRODUCTION

GLOBAL warming is the recent problem to the whole world. Governments and various organizations of all developed and developing countries are trying to reduce it. Global warming is the unusually rapid increase in Earth's average surface temperature over the past century primarily due to the greenhouse gases released by people burning fossil fuels [6]. The global average surface temperature rose between 0.6 to 1.0 degrees Celsius for last 100 years [2], [6]. This is caused by green house effect. Near about 30% of incoming sun radiations are reflected back to space from the outer side of earth's atmosphere and remaining 70% enters the earth's atmosphere, from these radiations (visible light spectrum) a fraction is absorbed by earth, and earth re-radiate this absorbed energy in form of heat, i.e., infrared radiations. Green house gases such as carbon dioxide, nitrogen oxide, methane, fluorinated gases and water vapours [7], [4] absorb heat caused by these infrared radiations and slow its escape from the atmosphere. Thus infrared radiations remain in the earth's atmosphere for long time and because of this earth's surface temperature increases [1], [8]. Carbon dioxide emission is highly responsible for global warming [1], [3]. By various studies it is predicted that earth's average surface temperature could rise between 2°C and 5°C by the end of the 21st century [2], [6].

In this era human life is highly dependent upon electrical energy, even we can't think about life without electricity. But today most of electrical demand is met by conventional energy sources. One of the reasons for the global warming is increasing population and hence increasing industrialization. It is expected by many scientists that if global warming will continue in the same way then it may deteriorate the life on earth and will lead to bad weather conditions [2, 6]. Whole world is engaged in searching the solution for global warming. In this paper we introduced a very useful concept for reduction of Global Warming: use of renewable energy resources, which will not only reduce the global warming but will also give us electrical (or mechanical) energy.

In this paper we will also introduce the concept of directly and indirectly affecting renewable energy resources, on global warming. In this paper we will study the basic mechanism of wind, which will help us for proving that how we can reduce global warming by using wind turbines.

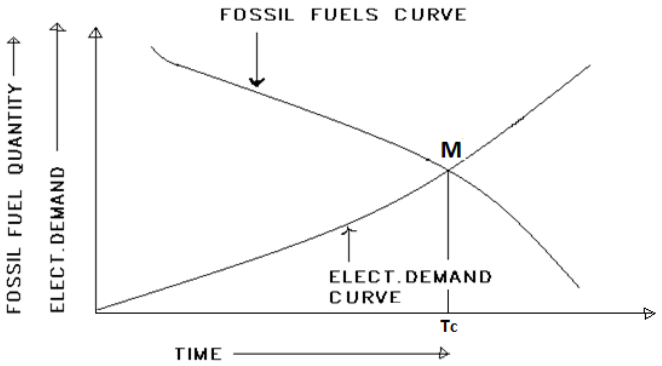

Fig. 1. EDFFQT curve

III. EDFFQT CURVE

Electrical Demand and Fossil Fuel Quantity v/s Time (EDFFQT) curve shows: there is need of renewable energy resources. As per the data of world for consumption of fossil fuel and electrical demand, a curve is drawn as shown in Fig. 1.

Curve shown in Fig. 1, is an approximate curve which is only drawn to show that for meeting the future electrical demand, we should now go for renewable energy sources. In Fig. 1, it can be seen that electrical demand curve is increasing, while the fossil fuel quantity curve is decreasing. There is a point of crossing of two curves, M. Up to point, M, electrical demand curve is below fossil fuel curve, and hence electrical demand can be met by fossil fuels alone. After point, M, fossil fuel curve is below the electrical demand curve, and hence electrical demand cannot be met by fossil fuels alone. The time corresponding to point, M, is T_C. This time, T_C, is expected in next 200 years [2], here problem is how to meet electrical demand after point, T_C. To meet this demand we should go for renewable energy sources, which will meet our electrical demand as well as will save us from global warming and pollution.

IV. MECHANISM OF AIR FLOW

Basically air is of two types:

A) Global Air
B) Local Air

A. Global Air

Global air is that air which flows globally. We will explain global air mechanism for two cases; one is when earth is assumed stationary and other when earth is included with its rotation. When earth is stationary (shown in Fig. 2) solar radiation heats the air near the equator, in this way density of the heated air becomes lower and this low density air moves in upward direction. The vacant space (at equator) of the heated and upward moved air is occupied by more dense higher pressure cool air, which came from poles of the earth. which will also be heated by solar radiation at equator and this air will also move in upward direction, and will forces the upper present air to move toward poles. Thus at surface air flows from poles to equator and in upper atmosphere it is from equator to poles. At surface air flows from Poles to equator,

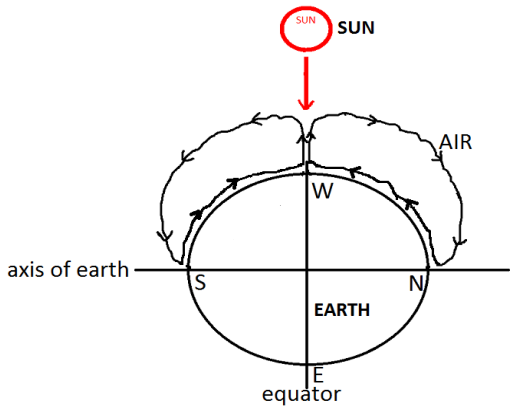

Fig. 2. Global air, with earth assumed stationary

because at poles there is presence of snow, and air above this surface will obviously cold. In Fig. 2, it is shown that the direction of the air is from poles toward equator (at surface) and in upper space the direction is reverse. The direction of air felt in northern hemisphere is from north to south while in southern hemisphere it is from south to north.

In above discussion we assumed that earth is stationary now we will discuss air flow mechanism when earth's rotation is also included. It is shown in Fig. 3, when a person is at the top (i.e., near equator in northern hemisphere and direct to sun) at that time the air near this person will be heated up and its density will become lesser so it will move in upward direction, at the same time earth is rotating (direction shown in Fig. 3), so the person will experience two components of air one is toward west and other is toward south (in northern hemisphere) (shown in Fig. 3).

The net resultant of both the components of air is the air direction felt by the person. One thing we must keep in mind is that, the direction of the global air felt by a person may not necessarily be from north to south (in northern hemisphere) because the surface is not plain but it is rough. It is because of the presence of the trees, buildings, mountains, etc., on the earth.

B. Local Air

Local Air is that air which flows locally. Land and water have unequal solar absorptivities and thermal time constants. Earth surface is surrounded by 71% water and 29% land.

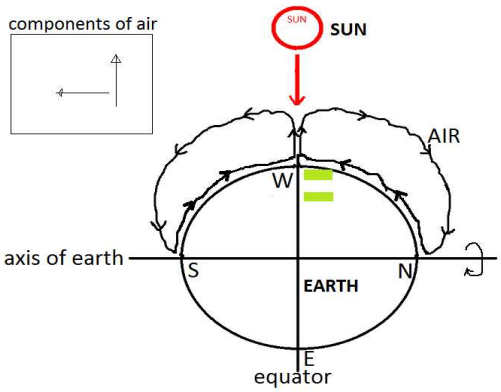

Fig. 3. Global air, with including the rotation of earth

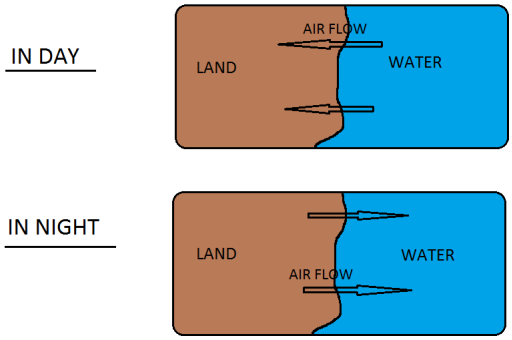

Fig. 4. Local air

During day light the land heats up more rapidly as compare to nearby sea or water bodies, and due to this air above the land becomes warmer as compare to the air above the water. The warmed air becomes lighter and moves in upward direction. Vacant space of this upward moved warmed air is occupied by the high density cool air which came from above water. Thus in day wind flows from water to land. At the night the wind direction reverses, because the land surface cools more rapidly than the water. Local winds are caused by two mechanisms. The first is differential heating of land & water (shown in Fig. 4). As explained above. The second mechanism of local winds is caused by hills & mountain sides. During day the air above the slopes heats up more rapidly as compare to air above low land and at night, cools down more rapidly than the air above the low lands. This causes heated lighter air in day to rise along the slopes and relatively cool heavy air to flow down in night.

The net air felt by us is the resultant of both global & local air. The direction of the air changes time to time, this is locally and because of the temperature difference of two or more regions. So we have seen that the reason for flow of air is the temperature difference on earth's surface.

V. GLOBAL WARMING REDUCTION CONCEPT

A. Reduction of Global Warming by Using Wind Turbines

In this section we will mathematically prove that how global warming can be reduced by using wind turbines.

Let in any time interval, t, energy, E, enters into the earth's atmosphere, from sun, where,

$$E = E_{heat} + E_{light} + E_{other} \quad (1)$$

Where,

$$E_{heat} = E_{air} + E'_{heat} \quad (2)$$

Put equation (2) in equation (1).

We get,

$$E = E_{air} + E'_{heat} + E_{light} + E_{other} \quad (3)$$

Where E_{air} is proportional to E_{heat}, because as heat energy will large then due to presence of land and water, and temperature difference on earth's surface, air production will also be large.

$$E_{air} \alpha E_{heat} \quad (4)$$

So if we convert some fraction, x, of E_{air} into electrical energy then E_{air} will be reduced from its previous value, i.e.,

$$E_{electrical} = x * E_{air} \quad (5)$$

Where:

$0 < x < 1$.

Now energy in air is:

$$E'_{air} = E_{air} - E_{electrical} \quad (6)$$

$$E'_{air} = E_{air}(1 - x) \quad (7)$$

Now, higher the value of x, lesser will be the left behind energy of air, E'_{air}. From equation (3) & (6), we get,

$$E = E_{electrical} + E'_{air} + E'_{heat} + E_{light} + E_{other} \quad (8)$$

From equation (8), we can see that we have converted some amount of sun energy into electrical energy, and because of this the heat energy scattered in earth's atmosphere is not E_{heat}, but it is E'_{heat}.

Where, $E_{heat} > E'_{heat}$

Now E'_{air} will try to increase its value to E_{air} by extracting energy out of E'_{heat}. Thus further heat energy is transferred to air energy, which will further be converted into electrical energy. In this way heat energy (coming from sun) is not being scattered in atmosphere of earth, but is converted into electrical energy as well (double benefit of the concept used). So global warming can be reduced if sufficient amount of wind farms are installed.

Case: when we are not using wind turbines

In this section we will concentrate on the fact that what will happen if we do not use wind turbines. Recall eq. (1) & (3).

$$E = E_{heat} + E_{light} + E_{other}$$

$$E = E_{air} + E'_{heat} + E_{light} + E_{other}$$

Now if we are not converting this air energy, E_{air}, into any other form (either mechanical or electrical) then decrease in E'_{heat} will not be at the same rate as it was in the case when we were converting air energy into electrical energy, but it will be at a negligible rate. Thus temperature of earth will increase in this case as compare to the case when we were using wind turbines.

From discussion, we conclude, if we convert air energy into electrical energy then remaining air energy, E'_{air}, will try to diminish E'_{heat} for getting increase in itself value. Thus as E'_{heat} will decrease so naturally the earth's temperature will decrease.

NOTE: Energy, E, entering the atmosphere of earth (in any time interval, t) is very high, i.e., $E \gg E_{electrical}$

Although the effect of wind turbines all over the earth is small with present installed capacity of the wind farms, but we can make this effect significant and enough for taking over the global warming by increasing the installed capacity of wind farms in world.

B. Reduction of global warming by using solar systems

For Solar systems, we mean to PV cells, solar collectors, solar furnaces, solar cookers, solar refrigerators, etc. Let we first talk about solar PV cells in which the energy of light photons is converted into electrical energy. Recall eq. (1)

$$E = E_{heat} + E_{light} + E_{other} \quad (9)$$

As we know solar radiations are in the range from UV to infrared (0.1 μ_m to 4.0 μ_m). Around 99% of solar radiations reaching the earth's surface are generally in region 0.3 μ_m to 3.0 μ_m. Now radiations of proper wavelength (generally, 0.20 μ_m to 1.15 μ_m) is converted into electrical energy by solar PV cells, and remaining radiations are not converted into electrical energy. Sun radiations have maximum energy intensity in that range which could be converted into electrical energy by solar PV cells. Photons of light (of each wavelength) have associated heat energy, so equation (9) can be written as:

$$E = E'_{light} + E_{other} \quad (10)$$

Where E'_{light} is combined energy of light and associated heat for whole range of wavelength of sun radiations reaching the surface of earth? Now if we use solar PV cells then energy (light & associated heat) of photons of proper wavelength will be converted into electrical energy. In this way the heat energy of those photons, which are converted into electrical energy, is prevented from being absorbed by earth and its re-radiation in form of infrared radiations.

But in the case if we are not using solar PV cells, the heat energy of photons (which was converted into electrical energy) will be absorbed by earth and will be re-radiated in form of infrared radiations, which will contribute to global warming because of green house gases.

Now if we use other solar systems like, solar collectors, solar furnaces, solar cookers, etc., even then we can reduce global warming, because if we are not using these solar systems then we will use any fossil fuel for getting heat energy. Where burning of fossil fuel will lead to global warming and heat energy coming from sun will be useless and will be absorbed by earth, and this absorbed energy will be re-radiated in form of infrared radiations. These infrared radiations will be trapped by green house gases to form global warming. But by using above said solar systems we will utilize incoming sun radiation's heat energy without using fossil fuel. Above said solar systems (other than solar PV cells) reduce the global warming only in the sense that we are avoiding the use of fossil fuel.

Similar to WECS, the effect of solar systems on global warming is very small with present scenario, but it can be made significant and enough for taking over the global warming by using solar systems in large extent.

C. Combined effect of wind turbines and solar PV cells for reducing global warming

As we have seen that solar PV cells works on the direct conversion of sun light (of proper wavelength) into electrical energy, so energy conversion is instantaneous. Solar PV cells do not convert heat energy into electrical energy but convert light (consisting of associated heat) of proper wavelength into electrical energy. In this way solar PV cells will control the rate by which earth's mean temperature is increasing. Solar PV cells can make this rate of increasing of earth's temperature very small, if they are used in large scale. A solar PV cell has no relation with the present or past temperature of earth and also has no relation with the green house gases present in the atmosphere. Thus by using solar PV cells, we can decrease the rate of increase of earth's temperature.

We have seen that wind turbines reduce global warming because of the temperature difference on the earth (most of temperature difference is created by the presence of water and land on the earth) and hence most of the heat energy is converted into electrical energy via air energy. Thus unlike solar PV cell, wind turbines has relation with the temperature of earth's atmosphere and with green house gases. As we know green house gases absorb heat in the atmosphere and thus will create a temperature difference, which will produce flow of air.

Thus we can control global warming effectively and can reduce the effect of presence of green house gases present in atmosphere, by installing enough wind farms.

From above discussion we can infer that by allocating both wind turbines and solar systems, with enough capacities, at proper positions in the world, we can control global warming.

VI. DIRECTLY AND INDIRECTLY AFFECTING RENEWABLE ENERGY RESOURCES ON GLOBAL WARMING

Directly affecting renewable energy resources on global warming are those, which converts some part of heat energy (present at earth or coming from sun) into electrical energy and decrease the rate of increasing of earth's mean temperature. Wind turbines, solar PV cells, ocean thermal plants are example of directly affecting renewable energy resources on global warming, because wind turbine converts air energy (which is produced by temperature difference on earth) into electrical energy, solar PV cells convert light (of proper wavelength and associated heat with that light photons) energy into electrical energy, and ocean thermal generation works on the temperature difference in the top and bottom layers of sea.

Indirectly affecting renewable energy resources on global warming are those which do not convert heat energy into electrical energy but convert any other form of energy into electrical energy. Thus these renewable energy sources will not reduce global warming in the direct sense but will reduce global warming in the sense that if we will use these renewable energy resources then some part of our electrical demand will be fulfilled by these renewable resources and for this much electric power (as supplied by indirectly affecting renewable energy sources) we will not use thermal power plants. Thus there will lesser emission of co_2 and hence reduction in global warming.

Thus WECS, Solar PV cells and ocean thermal energy conversion systems are both directly and indirectly affecting renewable energy resources on global warming, and other renewable energy resources like tidal plants, fuel cells, hydro plants, etc., are indirectly affecting renewable energy resources on global warming.

VII. CONCLUSION

EDFFQT curve is introduced to concentrate on the importance of renewable energy sources. A mathematic approach is presented to show that how can global warming be reduced by using renewable energy resources (especially, WECS and solar PV cells). It is inferred that if we allocate wind turbines and solar systems at proper locations in the world, with enough capacities, we can overcome the problem of global warming. A new idea of directly and indirectly affecting renewable energy resources on global warming is discussed. It is shown that WECS, Solar PV cells and ocean thermal energy conversion systems are both directly and indirectly affecting renewable energy resources on global warming, and other renewable energy resources like tidal plants, fuel cells, hydro plants, etc., are indirectly affecting renewable energy resources on global warming.

REFERENCES

[1] A. H. M. Sadrul Ula, "Global warming and electric power generation: what is the connection?," IEEE Transactions on Energy Conversion, vol. 6, no.4, December 1991.

[2] B. K. BOSE, "Global Warming: energy, environmental pollution, and the impact of power elecronics," IEEE Industrial Electronics. Magazine, vol. 4, no. 1, pp. 6-17, March 2009.

[3] J. Armstrong and H. Bailly, "Energy efficiency a strategy for delaying global warming," in Proc. of 25th Intersociety Energy Conversion Engineering Conference, 1990.IECEC-90, vol. 4, pp. 381-385, 1990.

[4] S. Pal, "Wind energy - An innovative solution to global warming?," in 1st international Conference on the development in renewable energy technology (ICDRET)- 2009, pp. 1-3, 2009.

[5] M. Amirthalingam, "A novel technology utilizing renewable energies to mitigate air pollution, global warming & climate change," in 1st international Conference on the development in renewable energy technology (ICDRET)- 2009, pp. 1-3, 2009.

[6] Global warming and its bad effects; http://earthobservatory.nasa.gov/Features/GlobalWarming/

[7] Green house gases; http://www.acoolerclimate.com/greenhouse-gas-emissions/

[8] Green House effect; http://environment.about.com/od/globalwarming/a/greenhouse.htm for about.com

Munish Kumar Jangra received the B. Tech. (Hons.) from Kurukshetra University, Kurukshetra, India, in 2009. He is pursuing M. Tech. in Electrical Engg. from DeenBandhu Chhotu Ram University of Science & Technology, Murthal (Sonepat)-Haryana, India.

K. P. Singh Parmar is an Assistant Director (Technical), Centre for Advanced Management and Power Studies, NPTI, Faridabad, India. He has worked as an Assistant Professor with the Electrical Engineering Department, JSS Academy Of Technical Education, NOIDA (UP), India. He obtained his BE(Hons) from Govt. Engineering College Rewa (MP) and M.Tech. from Indian Institute of Technology Delhi and has been involved in teaching, training, consultancy and research since 2001. He has taught various subjects of Electrical Engineering including Electric machines, Power systems, Electric drives, Control systems, Electric Networks and Systems, Basic System Engineering and Management in Transmission and Distribution System. Mr Parmar is a life member of ISTE, India and member of IETE, India. His research interests include AGC, Power quality, Energy conservation, Unit commitment, wind and solar energy.

Naresh Kumar Yadav obtained B.Tech. in electrical engineering from Maharshi Dayanand University, Rohtak (Haryana), India and M.Tech. in electrical engineering from National Institute of Technology, Kurukshetra, India, in 2000 and 2004, respectively. Since August-2006 he has been with Department of Electrical Engineering, Faculty of Engineering and Technology, DeenBandhu Chhotu Ram University of Science & Technology, Murthal (Sonepat)-Haryana, India, where he is currently Assistant Professor. Presently he is pursuing his Ph.D. research at Jamia Millia Islamia (Central University), New Delhi-110025. Mr. Yadav is a life time member of Indian Society for Technical Education. His research interests include power system deregulation, FACTS applications to power system restructuring, Automatic Generation Control etc.