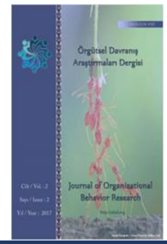
Örgütsel Davranış Araştırmaları Dergisi
Journal Of Organizational Behavior Research
Cilt / Vol.: 7, Sayı / Is.: S, Yıl/Year: 2022, Kod/ID: 22S0-886
2528-9705



Use of Solar Energy

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ABSTRACT

Currently, electrical energy generation in the world relies heavily on coal, oil and natural gas. Fossil fuels are not renewables as they are derived from limited resources which are being gradually used up. In contrast, renewable energies, such as wind and solar energies are being used as alternatives that never dry up. Most renewable energies are obtained from the sun, both directly and indirectly. Sunlight or solar energy can be utilized to warm and light houses and other buildings, generate electricity, heat water, and for solar heaters. This type of energy has also economic and industrial usages. Not all renewable energy resources are derived from the sun. Geothermal energy is the gateway for the internal heat of the earth for various applications including generating electrical power and heating and cooling buildings. Also, oceanic tidal energies are derived from the gravitational pull of the moon and the sun on the earth. This study now investigates the usages of solar energy.

Keywords: *Solar energy, Solar constant, Solar thermal systems, Photovoltaic devices*

INTRODUCTION

There are also some questions about the energy sources: "How will the energy situation look like in the next few decades?" "What are the most economical sources of energy?" and "Will the solar energy be introduced as a source of energy or economic profession?". It is clear that energy for all is a necessity and this is more noticeable with the growing technological advancements and rising world's population. Available data suggest that the world's energy consumption is increasingly growing and see demand levels double every 14 years, though this level for electrical energy has almost doubled every 10 years; in the meantime, this level has been an upward trend in developing countries, doubling every 7 years (Fardin, 2003). The rising population and technological advancements that have improved quality of life have caused demands for electricity to grow. Looking at demands for electricity supply from world's existing resources from 1960 to 1990, it is concluded that these resources have utilized fossil fuels to supply electrical energy.

Fossil fuels greatly contribute to many of the environmental problems we are faced with, e.g., greenhouse gases, air, water and soil pollution; however, renewable sources have little impacts on these problems and related pollutions. Greenhouse gases, carbon dioxide, methane, nitrous oxide, hydrocarbons and chlorofluorocarbons have surrounded the earth's atmosphere like a warm and transparent blanket, allowing warm solar radiation to come in to entrap the heat in proximity of the earth's surface. The impacts of these natural greenhouse gases keep the average earth's temperature around 60° F (33°C). However, increasing fossil fuels have significantly increased greenhouse gas emissions.

Considering climate changes within a year, it will not be economical to utilize systems that use solar heat, and it is best to use some secondary energy like fossil fuel alongside these systems; thus, the system will be able to operate under bad air conditions and situations where there is no sun. In other words, the solar system functions along the day (sunny hours), while the fossil energy is used when the sun is gone. The cost of energy generation or the ratio of energy and consumption cost to the energy generated is lower than the system whose total energy is supplied by the sun. The costs from making and maintaining a solar thermal system fall under costs of making and installation equipment, fuel, maintenance, and system design. System equipment includes various parts such as collectors, support system, and energy transfer systems including pumps, tubes or ducts as well as energy storage system. As stated, this study now investigates the usages of solar energy.

Solar constant

The following is a solar constant equation which specifies the solar constant spectrum:

$$\times B_{\lambda}(T) \text{ constant } S_{\lambda} =$$

Here, a fraction of energy (F), transmitted by wavelengths ranging from 0 to λ, is proportional to the area under curve of the blackbody that lies between these two boundaries. This value can be calculated from the solving the following integrals:

(1)

$$f_{\lambda}(T)=\frac{\int_{\circ}^{\lambda} B_{\lambda}(T)d\lambda}{\int_{\circ}^{\infty} B_{\lambda}(T)d\lambda}=\frac{\int_{\circ}^{\lambda} ad\lambda/\left[\lambda^{5}\left(e^{b\lambda I}-1\right)\right]}{\int_{\circ}^{\infty} ad\lambda/\left[\lambda^{5}\left(e^{b/\lambda T}-1\right)\right]}$$

Equation (1) reveals that the integrals can be solved and examined for types of temperature with no exception. However, this is not the case by changing the integrals and replacing the $X=\lambda T$. Using Equation (1), the following Equation (2) can be written as follows:

(2)

$$f_{\lambda}(T)=f(\lambda T)=f(X)=\int\frac{adx}{\delta x^{5}\left(e^{b/x}-1\right)}$$

Thus, if the integral is solved and f(x) can be tabulated, a fraction of energy lying between 0 to λ can be calculated for the black body curves at every temperature.

The value of this fraction for

$x_{1}=\lambda_{1}T=(0.4\mu m)(5760k)=2304\mu m-k$

Is equal to:

$f(x_{1})=f(2304\mu m-k)=.121=\%12.1$

Note:

This fraction will be for the similar wavelengths at temperature lower than 3000K.

$[x_{1}=(0.4)(3000)=1200\mu m-k]\quad f(1200)_{\mu m-k}=0.002=0.2$

A fraction of energy for the wavelength between λ_1 and λ_2 is calculated as follows:

$f_{\lambda_1,\lambda_2} = f_{\lambda_2} - f_{\lambda_1}$

For example, to determine the fraction of energy for the wavelengths between $\lambda_1 = 0.4$ and $\lambda_2 = 0.7$, µm is used, while to determine k = 5760 T, the following is used:

367 = 37%. = 00.121488 – .) = 0k –m μ (2304 f) – k -m μ (4032 f

The residual fraction that is determined by wavelengths longer than λ_2 - 0.7 m μ is calculated as follows:

51 = 51%.488 ≅ 0. 1 - f_{λ_2} =1 - 0

To approximate the solar spectrum by the distribution of a blackbody at 5760 K, almost 12% of the energy will be transmitted at wavelengths shorter than 0.4 m μ. This will mainly take the form of ultraviolet radiation, as the visible part of the solar spectrum includes 37% energy, while wavelengths longer than 0.7 m μ (mostly infrared) involve 51% energy. Therefore, almost two-thirds of the solar energy received will be invisible to the human eyes.

To sum up, solar flux that reaches the upper parts of the earth's atmosphere has basically electromagnetic property. Its spectral distribution is fully similar to the spectrum that is emitted by a surface of a blackbody at 5760K. Almost, half of this energy will reach the earth in the form of infrared rays, while 1/3 of which lays on the visible region of the spectrum. This ray-like flux takes a unidirectional radiation form whose divergence angle is almost 1/2°. The total flux (average seasons of the year) that radiates over a surface facing the sun is called solar constant which is numerically as follows:

$$S = 1352 w/m^2 = \frac{1.94 Ly}{\min} = \frac{429 Btu}{hr - ft^2}$$

Where 1 -252 cal - 2.929 $\times 10^{-4}$ kwhr is the British thermal unit (BTU) and 1 - 1cal / cm^2 is Langley (Ly).

To predict the abundance and accessibility of the solar energy on earth, it is required to consider the apparent solar motion of the sun on a celestial sphere. The subject of the sun throughout the day and also the length of the day itself will both determine the amount of solar energy, provided to solar collectors.

Solar Thermal Systems

Unlike concentrators which usually require daily tracking systems, flat panels operate at fixed directions. Although the tracking system improves the efficiency of a flat panel, the resulting efficiency will increase by increasing expenses spent on making and maintaining the tracking system. A fixed array of flat panels should be arranged in a way that the received flux will have the highest daily efficiency during the working period (seasonally adjusted). The size of an array of the panels is determined by ambient conditions, need for heating, array and sunlight-capturing levels. Suppose, for example, the daily thermal need of a house in a cold season is 100kw-hr/day (or approximately 3.4×10^5 BTU/day) and the daily sunlight-capturing level on the panel set is 4kw-hr/m^2-day. Also, suppose the area of each panel is 1.5 square meters; thus, the total efficiency will be 50%, while one-third of which comes from secondary heaters.

Therefore, the solar thermal amount needed will be 66.7kw-hr/day, because the array efficiency is 50%. Areas needed is thus equivalent to:

$A = \frac{P(daily)}{F(daily)\times\eta} = \frac{66.7}{4\times0.5} = 33.3$ Square meters

And since the area of each panel is 1.5 square meters, the number of panels required amounts to 22.

Every solar panel array includes thermal panels which are positioned in series and parallel forms or combined. The temperature generated by each large array is not higher than that produced by a single collector; however, an array with an n number of panels to collect an n times as much thermal power as produced by a single panel, is more powerful. To collect this volume of heat, the level of fluid flux applied to the set must be an n times as many. In a series array, a panel's outlet is directly connected to the inlet of the next panel.

As a result, the increased flux must pass through all the panels of an array. As the fluid rate increases, its resistance against the flux will increase. Moreover, the longer the total length of a tube through which the fluid passes, the more the flux will be. Thus, a series and long array of panels could exhibit higher resistance against the transmitting fluid flow. To keep the fluid flowing, the pumps must produce much pressure so that at the inlet, it is much more than the pressure at the outlet. This will create strain at the pump and panels of an array. Furthermore, not all panels of a series array will yield a similar efficiency rate. The panels that are closer to the inlet operate at a lower temperature and have thus greater yield, while those close to the fluid's outlet will have lower efficiency.

In a solar thermal system, some measures are usually adopted to store heat. The energy received at times when the sunlight is high can be stored, while it can be used at times when the sun is gone. When heat is stored in a medium, the medium's energy increases and this increase can take the form of a potential where the molecular structure changes, like a chemical change; a phase change (e.g., melting or evaporation). When the added heat only increases the ambient temperature, the thermal energy is said to be stored as tangible heat. Unless there is a phase change, the increase in temperature will be almost proportional to the stored heat, but disproportional to the mass.

Capturing sunlight on the earth's surface

The amount of solar energy on the earth's surface will be considerably lower than the energy that reaches upper layers of the earth's atmosphere. The reduction in solar energy by the time it enters the earth's surface is basically determined by the light state of the earth's atmosphere. The combined components of the atmosphere affect the sunlight by two processes of absorption and scattering. The amounts of absorption and scattering that occur in a definite component of a solar spectrum depend on combining the atmosphere and its wavelength. In certain regions of the spectrum, solar energy is mainly scattered, while major parts of which are absorbed in other regions. Thus, the spectral combination of sunlight-capturing on the earth's surface significantly varies from the features of the blackbody curve of solar constant at 5760 K. It is also important to note that sunlight-capturing at the earth's surface cannot be considered equivalent to a unidirectional ray. This subject also held true of the radiation reaching the upper layers of the atmosphere. An amount of scattered radiation reaches the earth in the form of scattered radiation. Scattered radiation refers to components that travel at different directions; thus, the total solar radiation over the earth's surface includes a direct unidirectional component that causes atmospheric scattering.

The constituting components of the atmosphere, including such molecules as N_2, O_2, Co_2 and H_2o, ozone and larger particles such as fog droplets, soot or dust can affect the radiation by the two processes of absorption and scattering. In the absorption process, the radiated energy converts to another form of energy which is usually heat. Part of the absorbed energy is, to some extent, determined by the cross-section of the mass absorption $\sigma^a(\lambda)$. This parameter varies from one molecule to the other. It also depends on the wavelength of the radiation received. As noted, N_2 and O_2 molecules cannot be considerably absorbed into the solar spectrum. On the other hand, Co_2 and H_2o can be greatly absorbed into selected areas of the infrared regions of the solar spectrum. These regions are called absorption bands. Scattering is more complicated than absorption. Like absorption, a fraction of energy radiated is also dissipated in scattering. This amount is calculated by the cross-section of the mass scattering $\sigma^a(\lambda)$ which is an ingredient component. Unlike absorption, scattering does not convert radiation energy into heat; rather it emits it again into other directions. Atmospheric scattering of the solar energy within a clear day is basically created by oxygen and hydrogen. Some particles cause scattering which take back and forth directions (e.g., Rayleigh scattering), while other particles of radiation are scattered more homogenously. Particle matter inside the atmosphere such as dusts, soot and fog scatter the radiation in a more complicated form, than predicted by the Rayleigh law. The red color of the sky by the sunset is a result of the radiation scattered by dust particles around the earth's surface. The radiation that is not affected by the absorption and scattering processes is called direct or attenuated component which is calculated for a simple and relatively layered atmosphere. This component is demonstrated to be calculated by a singular atmospheric parameter which is a function of wavelength, called optical thickness, T_λ. This parameter and the way it affects the radiation direction will be discussed in detail in the next section.

Scattered flux

The total solar flux that radiates over the sea surface includes a direct unidirectional ray and a component pf scattered flux. A scattered component composed of radiation is either a reflection of the constituting components of the atmosphere or radiation reflected from the earth below it. A formula for the behavior and reaction of the scattered component is intricate, and a simple formula similar to Equation (3) for a flat-layer atmosphere is lacking. Thus, rather than trying to find accurate solutions to the scattered flux, an analysis is provided here to estimate it and also to demonstrate how factors affect the environment.

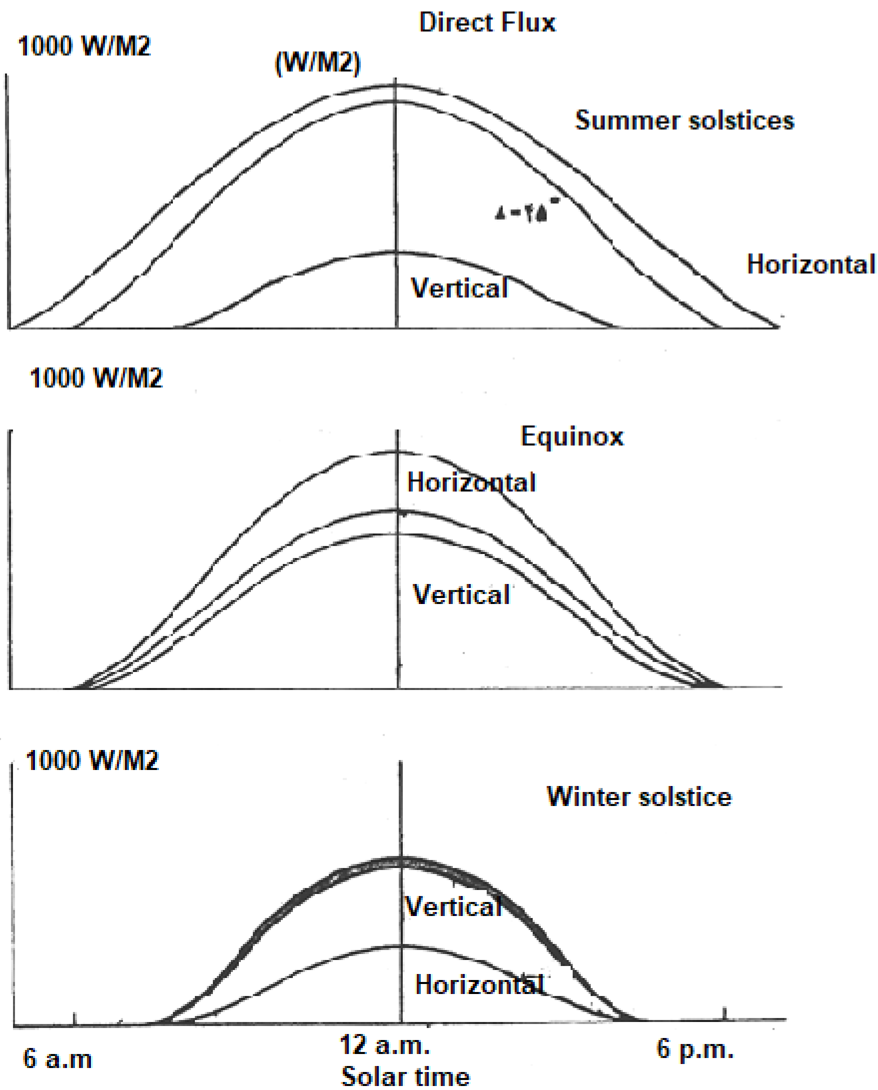

Figure 1: Direct hourly flux on surfaces with different angles of skewness in different seasons, all these cases have been calculated for the observer at colatitude -49 and optical thickness J = 0.3.

The term intensity is used to describe directional radiation distribution. It also reveals how much radiation power is emitted at a surface unit in different respects around a point in space. Here, a specific direction is determined as a unit vector Ω . For a layered flat atmosphere, the spectral intensity is written as $I_{\lambda}(Z,\Omega)$ or

$\frac{\text{Radiation power}}{\text{Length-Angle-Area}}$ ...l intensity is both a function of height and the direction used. as follows:

$$=\frac{dp}{dA-d\Omega-d\lambda} \qquad I_\lambda(Z,\Omega)=$$

Where $d\Omega$ is the differential spatial angle around the direction Ω.
If $I_\lambda = I_\lambda(Z)$, i.e., if the intensity does not depend on Ω, the radiation is thus said to be uniform (all directions are uniform). In this case, the radiated energy is equally emitted in all directions. On the other hand, if the function $I_\lambda = (Z,\Omega)$ is found to be very intense along a single direction, such as $\Omega_\circ$, and zero in other directions, that radiation is said to be ray-like and unidirectional. Although the direct solar component is basically unidirectional, the scattered component is not simply made of homogenous radiations. The spectral flux received by this surface is as follows:
(4)

$$F_\lambda(Z,\hat{n})=\int_{(n,\hat{\Omega}\geq 0)} I_\lambda(Z.\Omega)\hat{n}.\Omega d\Omega$$

Where the product of $\hat{n}.\Omega$ is the cosine of the angle between $\Omega,\hat{n}$. The integral index suggests that integration is performed on spatial angles where $\hat{n}.\Omega > 0$. This ensures that the only radiation that is transmitted in the hemisphere to the said surface is inserted in Equation 5-8. Equation (4) shows that the flux received by a surface, even for the scattering radiations, generally depends on the said surfaces and their positions in the atmosphere. With respect to ray-like radiations, Equation (4) is simplified as follows:
(4a)

$$F_\lambda^{Ray} = F_\lambda^{Perpendicular}\hat{n}.\Omega_\circ = F_\lambda^{Perpendicular} G\theta$$

Where θ represents the angle of inclination between the ray of the line perpendicular to the said surface. $F_\lambda^{Perpendicular}$ is a ray flux radiated over a surface whose direction is perpendicular to the ray. For homogenous radiation, Equation (4) can be integrated to derive the following formula:
(4b)

$$F_\lambda^{Homogenous} = I_\lambda^{Homogenous}\int_{(n.\hat{\Omega}\geq 0)} \hat{n}.\Omega d\Omega = \Pi I_\lambda^{Homogenous}$$

In this case, reception is independent from the surface direction. Scattered radiation is not generally homogenous, and received flux depends on the surface direction, to some extent. This dependency is not clear as was seen about the direct flux.

Measuring sunlight capturing on the earth's surface

Most energy measurement devices fall under one of the two following categories:

1. Photovoltaic devices
2. Radiometric devices

The first group includes means with receptor or sensor parts whose electrical features change by the solar radiation. As for example, when the sunlight radiates over photovoltaic means, such as s*ilicon* or *selenium cells,* voltage is generated. The short-circuit current of these devices are used to measure the intensity of the irradiated radiation. Optical conductive detectors, including cadmium sulfide or cadmium silica change resistance in response to the electro-magnetic radiation when the detectors are connected to batteries. They also convert into a criterion to measure the level of intensity in the circuit. In addition, there are devices with vacuum tubes, known as phototubes which are coated by specific elements, which, when radiated over by light, they emit electron. In the meantime, changing the tube's conductivity, performed by optical electrons, can be used to measure the intensity of radiation.

Despite the fact that photovoltaic transistor devices are durable, small and cheap to make, and are less affected by ambient conditions, they have disadvantages, also. These devices tend to be interrupted or saturated at high-intensity surfaces. More importantly, these photovoltaic devices do not provide a uniform response across solar spectrum. This is to suggest that the equal amounts of solar energy received in different spectral regions generate different signals. Also, if a device is sensitive to a visible spectrum, it will not detect the presence or changes of solar energy in the infrared.

The second group includes radiometric devices which absorb radiation in a black absorber and use heat generated to create a receptor. This change is measured and connected to sunlight capturing surfaces. One radiometric device used in the U.S. is the black and white pyranometry whose receptor part is made of two adjacent plane surfaces, a black one and a white (silver) one. To each of these parts is connected a thermal sensor (of a thermocouple). The sensors generate a voltage signal which is directly proportional to difference of heat between black and white surfaces. When the solar energy is radiated over this device, the black color surface will absorb the radiation and get warmer than the white surfaces which reflect the radiation and remain at around the ambient temperature. The greater sunlight capturing, the larger the difference of heat and the voltage signal.

Direct conversion of the solar energy into work; photovoltaic devices

Photovoltaic devices first use solar thermal devices to convert radiation into heat which parts of it get into work; although, theoretically speaking, all solar energy can be converted into work, heat cannot be fully converted into useful work, while some part of the heat must be returned to a colder source. In the meantime, the conversion efficiency is restricted by the ratio of cold source temperature to the warm source temperature, and the less this ratio, the greater the efficiency (Roger et al. 2000). In the direct conversion process, the solar energy is used without converting the electro-magnetic radiation into heat. This process does not need cold and warm sources. Although conversion efficiency may entail practical limitations, it is not limited by the Carnot formula. To demonstrate how a beam of radiation can be directly converted into mechanical energy, a Crookes radiometer is used.

There are processes that directly convert the solar energy into chemical energy. Green plants use soar energy to convert water carbon dioxide into complicated hydrocarbons. This is an incremental process where only a small fraction of sunlight radiated over the plant is converted into chemical energy. Chemical fuels are suggested to be obtained at lower costs from a living mass, i.e., from kinds of plants grown specifically for this purpose. The mass production of alcohol from corns and sugar for vehicle fuel is now being developed. One of the most promising methods to generate electricity is to use photovoltaic devices. A photovoltaic device is an instrument that generates voltage when irradiated by the sunlight. A common category of these devices, which are known as P-N junction devices, is being investigated. For example, tools made from silicon are capable of generating 0.5 V in each cell under intense sunlight, yielding 10-12% efficiency.

P-N junction photovoltaic devices

Suppose a single P-N junction, made of a silicon wafer of p type, on which a thin layer of silicon of n type is deposited. The wafer is called bottom and the deposited layer is surface layer which connect electrodes into the external layer of the device. Electrodes are made of very thin metal deposit for the surface layer. These electrodes must be transparent to allow the sunlight to reach the surface layer at the lowest attenuation. The surface layer is also thin; as a result, the sunlight can reach the junction. As the sunlight radiates over the photovoltaic device, some of the photons form electron-hole pair whose impacts are light current that transmits from matter type n to matter type p. To make photovoltaic terminals short-circuit, the whole photonic current returns through the external circuit, and the junction current reaches zero. Thus, as expected, the terminal voltage becomes zero (Yu et al. 198).

Manufacturing silicon photovoltaic devices

Currently, silicon photovoltaic devices are among the most effective solar cells. They are made at the purest degree of available silicon (solar degree). This silicon is taken from the more impure silicon (semiconductor degree) used to make electronic parts. The final stage is called regional melting where molten silicon regions move through the matter mass and take away with them small residual impurities. The residual solar degree purity in mass of matter is 990999.

This pure silicon is kept molten in a crucible by waves with radio frequencies similar to the waves used in a microwave oven. This causes the said matter to be uniformly heated. The molten matter is kept in a neutral gas medium. The impure matter is carefully added to the molten matter to obtain the matter type n or p. The molten matter is then crystallized. The commonly used crystallization technique is the Czochralski technique. A small crystal grain, connected to a special clip, is added to the molten matter. By removing the grain, a crystalline silicon made cylindrical ingot is formed which is gradually taken out of the molten matter. The diameter of the ingot depends on the rate of taking the grain out of the molten matter. Later, silicon ingots (type n or p) are made in the form of round wafers of approximate thickness of 0.075 cm at solar degrees. These wafers form the solar panels. Of the bottom matter is type p, photovoltaic devices can be produced at lower prices, as suggested by recent literature on V-shaped thin (uncrystallized) semiconductors. Another method under investigation is to use plastic prismatic concentrators that allow large amounts of the flux to radiate over low-area cells. If the costs of making cells can be reduced by a 100 factor, i.e., to 40 dollars per each square meters, the total efficiency of generating electrical power will be greater, especially because fossil fuel are costing more.

Conclusion

The significance of renewables is due to their advantages. Renewable energy technologies are clean sources of energy which are less affected by environmental pollutions, compared to conventional energies. Renewable energies never exhaust. However, other energy sources are limited and could dry up these days. Investment on renewable energies is mainly made on preparation of raw material (goods and appliance), consumer and structural goods to make and maintain devices, rather than on costly importation of energy. This denotes that the money you will pay for the energy will, instead of being transferred to a foreign nation, remain in our country, create employment and save fuel consumption. Compared to conventional energy sources which rely on fossil fuels, renewable energy technologies are more environmentally friendly. Renewable energy technologies generate heat and electricity by emitting (generating) small or zero amounts of carbon dioxide. Also, fossil fuel energies serve as major sources for air, water and soil pollution. Pollutants such as carbon monoxide, sulfur dioxide, nitrogen dioxide, particulate matter and lead are posing threats to the environment we are living in. In other words, most renewable technologies generate small or zero pollution. Earth warming and pollution both pose grave risks to the future human generation. The long-tern impacts of the earth warming may also be more severe. Fatalities are correlated with very warm air, i.e., as temperature climbs, diseases can produce stronger latent energy. Finally, renewable energy technologies can help us change conventional patterns of energy consumption in order to improve our environment.

Acknowledgment: None

Conflict of Interest: None

Funding: None

Ethical statements: None

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