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OVERVIEW OF NIGHTTIME SOLAR CELL

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Abstract: A nighttime solar cell is a clean passive solid state device which is developed to produce the electric power at day and night from a renewable energy source. Such as waste thermal power source and energy from deep space i.e. nighttime skyAs the conventional solar cell has some disadvantages such as high cost, problem for storage of power, no output at night.Thus using TEG Thermo-Electric Generators we can generates electrical energy from the temperature difference between temperature of deep space at 4°k and the surface of earth is normally 290°k thus using this The Nighttime Solar Cell will produce electrical power at night similar to photovoltaic cell.

The Infrared energy of the atmosphere is most influential parameter for the system operation. System works on both Nighttime and Daytime conditions by reversing the cold junction and hot junction plates. Use of vacuum tubes increases the efficiency of the system.

For the future reference the use of nanotechnology become an effective tool for increasing the output of nighttime solar cell.

I. INTRODUCTION

WHAT IS NIGHTTIME SOLAR CELL

The Nighttime Solar Cell is a clean, silent, passive, solid-state device that has been developed to produce electric power at day and night from a renewable energy source.

The device produces electric energy by utilizing a Thermo-Electric Generator (TEG) as a heat engine in the temperature difference that exists between the temperature of deep space at about 4° K and the surface of the earth, nominally at 290° K.The Nighttime Solar Cell will produce electric power at night similar to PV's.[6]

NECESSITY OF NIGHT TIME SOLAR CELL.

- Solar doesn't works at night.

Obviously the biggest disadvantages of solar energy production revolve around the fact that it's not constant. To produce solar electricity there must be sunlight. So energy must be stored or sourced elsewhere at night.

Beyond daily fluctuations, solar production decreases over winter months when there are less sunlight hours and sun radiation is less intense.

- Solar Inefficiency

A very common criticism is that solar energy production is relatively in Storing Solar Power

- Solar panels are bulky

Solar panels are bulky. This is particularly true of the higher-efficiency, traditional silicon crystalline wafer solar modules. These are the large solar panels that are covered in glass.

- One of the biggest disadvantages of solar energy – <u>COST</u>

II. LITERATURE SURVEY

BASIC WORKING PRINCIPLE

Seebeck Effect:-

The Seebeck effect is used in the thermoelectric generator, which functions like a heat engine, but is less bulky, has no moving parts, and is typically more expensive and less efficient. These have a use in power plants for converting waste heat into additional power (a form of energy recycling), and in automobiles as automotive thermoelectric generators (ATGs) for increasing fuel efficiency. Space probes often use radioisotope thermoelectric generators with the same mechanism but using radioisotopes to generate the required heat difference.

The thermoelectric effect is the direct conversion of temperature differences to electric

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voltage and vice-versa. A thermoelectric device creates a voltage when there is a different temperature on each side. Conversely, when a voltage is applied to it, it creates a temperature difference. At the atomic scale, an applied temperature gradient causes charge carriers in the material to diffuse from the hot side to the cold side.[8] [10]

Photovoltaic Effect:-Photo means light in Greek and Volt is the name of a pioneer in the study of electricity named Alessandro Volta. Photo electric effect emphasizes the effect of solar radiations (photon) on semiconductor material.

Albert Einstein was awarded the 1921 Nobel Prize in physics for his research on the photoelectric effect a phenomenon central to the generation of electricity through solar cells. In those early stages, the solar cell was developed only with 4 to 6 % efficiency only because of inadequate materials and problems in focusing the solar radiations. But, after 1989, the solar cells with more than 50% efficiency were developed. And new era of solar will starts emerging.[11]

Solar Cell:-

A solar cell (also called a photovoltaic cell) is a device that converts the energy of light directly into electricity by the photovoltaic effect. Its electrical characteristics e.g. current, voltage, or resistance vary when light is incident upon it. Which, when exposed to light, can generate and support an electric current without being attached to any external voltage source.[7]

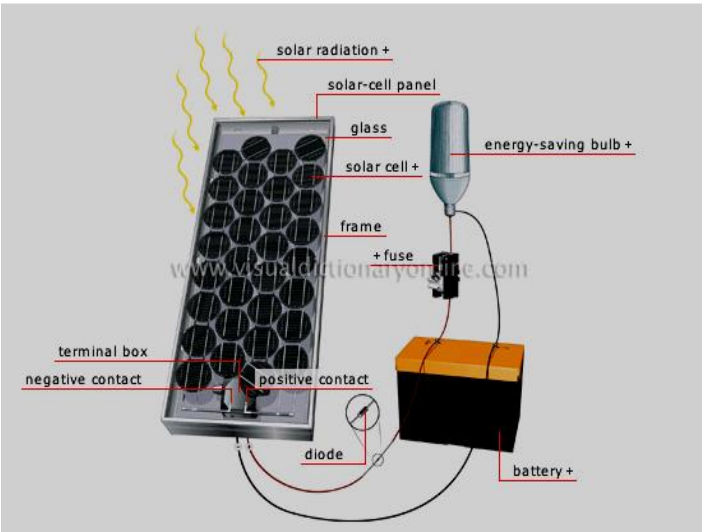

Fig.1. Basic Arrangement Of Solar Cell

III. MODEL OPERATION

The prototypes are single cells that will be built as arrays in large flat panels for commercial and domestic applications. The device operates similarly to daytime PVs The device operates similarly to daytime PVs in that this is a pollution-free, inexhaustible source of electric power, utilizing panel arrays of cells .However, the Nighttime Solar Cell produces electric power utilizing TEG's. For nighttime electrical energy production the TEG's operate in the continuous temperature difference that exists between the earth's surface and the nighttime sky (deep space) and capitalizes on the laws of nature that allow infrared (IR) energy to pass unattenuated through the atmosphere into deep space. That provides the thermal energy to operate the cell while the ambient air can be the thermal sink. Thus nighttime solar cell will operate for day as well as night. The night time solar cell panel arrays will provide about one-sixth the electric power at night that PVs can produce during the day typically when electrical energy requirements are less, using the same array surface area.[3]

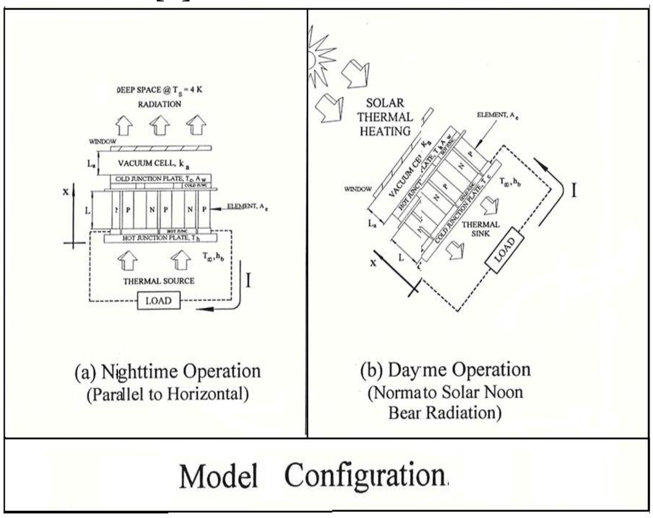

Fig.2 Model Configuration

Thermal model was developed from fundamental principle for this work.[3] The model determines the temperature difference between the HJP and CJP of TEG's. Fig.2(a)shows the physical configuration and parameters utilized in the model when using deep space as the thermal sink during nighttime operation. The orientation of the cell is such that the cold junction plate (CJP) is parallel to the horizontal. The thermal source, the ambient supplies energy to the module at T∞.

Fig.2 (a) shows the height of TEG element is to be L and the distance of cold junction plate to the window will La. The TEG junction is copper and the cold junction plate is aluminum is sufficiently large so the temperature gradients are small with the thickness for each.

Fig.2(b) illustrates the daytime operation of the cell, where the CJP now becomes the hot junction plate (HJP). The HJP is now oriented normal to the solar beam radiation when the sun is at solar non, and the model accounts for the movement of the sun from horizon to horizon assuming the usual periodic motion of the sun.[8]

The CJP (or HJP) is 20cm and the aperture opening is slightly larger to avoid physical or thermal interference. The thickness of the CJP is 5mm to reduce the temperature gradients associated with the fin effect which results from the TEG module being smaller than the CJP.

The surface of the CJP is assumed to be a gray. Diffuse surface with (€c=αc) at temperature Tc. The surface facing the nighttime sky is assumed to have an emissivity (€c), of 0.90

Deep space is modeled as a black body at temperature Ts= 4° K. the model utilizes 12 transmission bands for radiative transfer through the atmosphere, although less than 1% of the energy occurs below 5 at 300° K or less. The view factor between the CJP and space is assumed to be unity. The exterior of the window is exposed to the ambient temperature, Tα, through a specified heat transfer coefficient, hw=10XW/(mXmXk) corresponding to weak free convection of air at the surface. Temperature variations through the windows are neglected.[3]

The TEG elements are bismuth telluride. The specific designs configuration for the TEG elements and module are based on standard sizes available from industry. The CJP and cell size are based on the size availability of the ZnSe widow (nomial size: 2"X 2") .With solar heating of the CJP during the day, three values of normally incident solar radiation are used in the model; 200 W/sq. m, 500 W/sq.m and 800 W/sq.m. Only the local ambient temperature, of values 300° K and 275° K as specified in the model, provides the thermal sink for this mode of operation.[3]

As done in the past (parise and jones, 2000) TEG model includes the effect of not having a full vacuum in the cell. That is there will now be a slight trace of air at the low pressure of about 25 torr. With this air, the only effect that will be considered in the model is between in the model is between the CJP and the ZnSe window, reefed to as the air gap.Free convection does not occur because the low density of the air results in a Reyleigh number for the air gap less than the critical value (Earton and Blum, 1975). The air gap is 1cm.The thermoelectric properties of the seebeck coefficients (αn,αp) , thermal conductivity (£n,£p), and the electrical resistivity are assumed to be constant. The length of the thermoelectric elements in the direction of heat flow is L.[3],[13]

IV. DEVICE DESSERTATION

Solar cells are the most commonly used devices in customer products to achieve power autonomy. This paper discusses a complementary approach to provide power autonomy to devices on a human body, i.e., thermoelectric conversion of human heat. In indoor applications, thermoelectric converters on the skin can provide more power per square centimeter than solar cells, particularly in adverse illumination conditions. Moreover, they work day and night. The first sensor nodes powered by human heat have been demonstrated and tested on people in 2004-2005. They used the state-of-the-art 100-muW watch-size thermoelectric wrist generators fabricated at IMEC and based on custom-design small-size BiTe thermopiles. The sensor node is completed with a power conditioning module, a microcontroller, and a wireless transceiver mounted on a watchstrap.[15]

The performance of the Nighttime Solar Cell tracks the atmospheric and meteorological conditions as the sun sets in the evening; the upper plate atmosphere is still heated by the sun and is comparatively warmer than the lower plate atmosphere which is starts to cool radiatively to deep space, no longer influenced by the sun's rays. After sunset (approximately 5:20pm), the upper atmosphere is still radiating back to earth at a higher temperature, and as incident solar radiation decreases, the Nighttime Solar Cell does not experience the full cooling effect of deep space; hence the cell output has not reached full potential at this time.

As the upper atmosphere cools, the voltage output of the cell increases as shown in fig until about 8:00pm.However, around 8:00pm, another phenomenon takes place, Due to very low temperature small crystals of moisture (ice) formed on the glass, slightly obscuring (disturbing) a clear view of deep space. Hence, the output decreases

due to an obstruction on the window. While In arid(dry) climates the formation of ice on the window would not occur. This demonstrates the increased performance of the Nighttime Solar Cell.[6]
The analysis shows that the previous presumed design of an HTS in the 6mm to 8mm thickness range is not necessary. In fact cell performance will be affected only slightly by making the HTS thin (1mm to 2mm). This also leaves the door open for a copper HTS with a higher thermal conductivity, although a heavier material. However, more research is needed to determine a spectral radiative coating for the HTS surface that will be facing deep space, and will function well in a vacuum.[4]

The increased "overhang" and added surface area of the larger HTS will improve cell output considerably. The radiative link between the cell and the thermal sink has already been demonstrated to be a strong function of HTS (CJP) surface area.3 This analysis shows that the HTS "fin" effectiveness remains quite high (>96%) for a 2mm thick (thin) HTS with a 5cm overhang (large surface area HTS). Therefore many small junctions with large HTSs will increase voltage output of the cell significantly. This puts nanotechnology at the forefront of making high-density modules, that is, many very small junctions in close proximity, extremely promising for future Nighttime Solar Cell performance.[4]
The performance of the prototype was coupled to the ambient air temperature only, if the TEG hot junctions could be thermally connected to the heat source of low-grade thermal waste stream, the performance of the device would be improved substantially. Thus, other thermal sources for the device can be used to improve the electrical output.[4]

Data Collection and Parameters Measured
Data collection took place over a nine-month period, October 2003 to June 2004, covering ambient temperatures from 35°C to –16°C. The open circuit voltage output of the cell was measured. Local conditions of dry bulb temperature and sky condition (clear, partly cloudy, cloudy, rain, snow, etc.) were recorded, along with the date and time of day. Local relative humidity readings were recorded until the meter stopped functioning. However, the US Weather Bureau (USWB) maintains a full weather monitoring station (Bradley International Airport, Hartford, CT) less than 3.5miles from the prototype site, with no extreme topographical or geographical changes in between. In addition, the dry bulb temperature and relative humidity readings between the two sites corresponded almost exactly. Therefore relative humidity and wet bulb temperature readings were used from the USWB site as needed, and the performance of the prototype Nighttime Solar Cell was correlated with local weather conditions. The open circuit voltage produced by the cell is measured as the output. The voltage potential is considered a good measure of the energy output of the cell –obviously the higher the potential, the higher the available energy.[2]

V. Results

Here element of size 1mmX1mmX25mm has been taken and power output will be calculated for the different combinations of TEG Elements Figure 3 shows the power output of the cell is the function of the numbers of pairs used.
For the 6elements with 3 TEG junctions the designed cell produces the 4 mW of output power If we increases the no. of elements to 44 corresponds to the 22 TEG junctions with this cell will produce nearly 7mW of output power. Which only requires 48 °k temperature difference between CJP and HJP. Figure shows that if we provide low thermal waste source to hot junction plate to increase its temperature above normal. Then for only 10 °K rise in temperature of thermal source it will results in 22% rise in the output power.

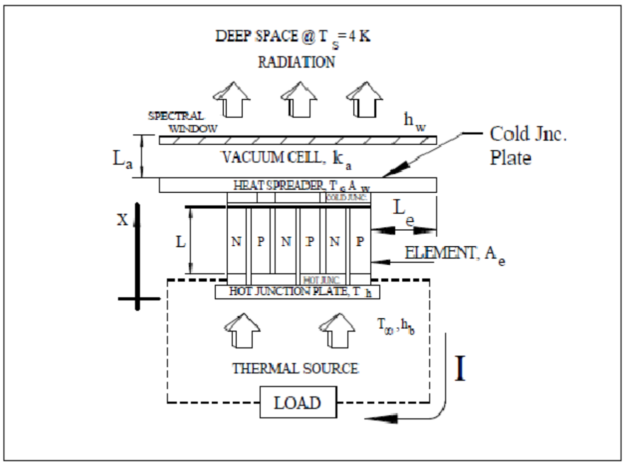

Fig.3Model Configuration Of Nighttime Solar Cell [7]

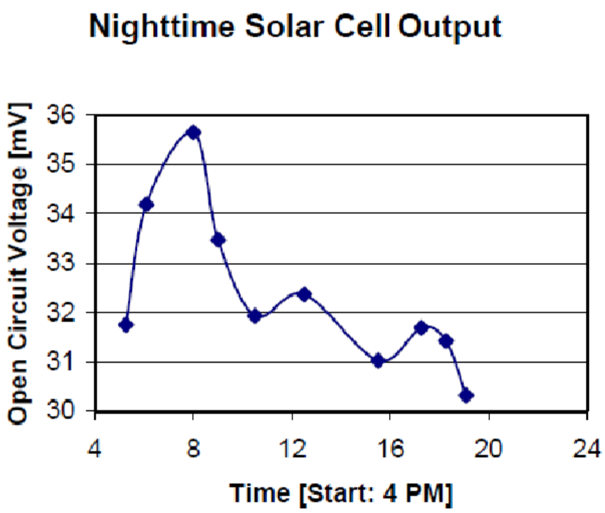

Fig.4 Output Of Nighttime Solar Cell For Whole Day(5 Pm To 7am) [7]

Fig.4shows the performance of nighttime solar cell for cloudless night from 4pm to whole night. In early evening i.e. 4pm the output of cell increases rapidly up to certain time i.e. mid night, after then output decreases quickly and continue to decreases at slower but constant rate. Yet there is no cloud in the night the output still decreases as shown.[6]
Also with the physical condition such cloudy sky the performance of the cell is changes with the change in atmospheric changes such as change in humidity & moisture contain will greatly influenced output of solar cell as shown in fig.5
As the relative humidity changes the open circuit voltage of the nighttime solar cell changes.

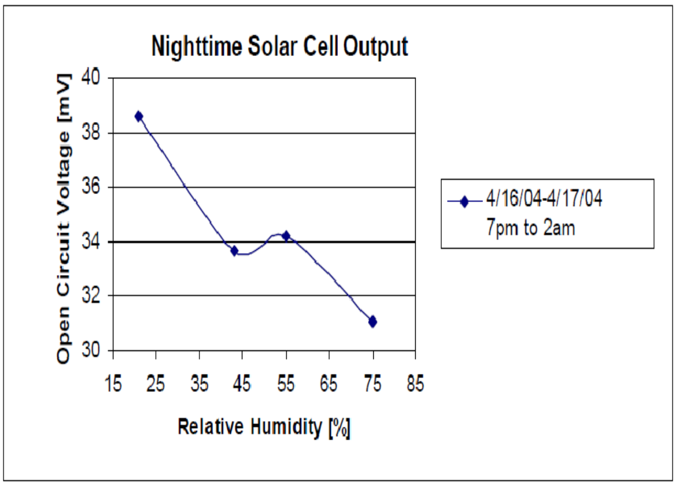

Fig.5Open Circuit Voltage Output Of Solar Cell With Relative Humidity Conditions. [6]

VI. CONCLUSION

In this paper, The prototype indicate the sensitivity of operation to high humidity conditions i.e. it's performance changes with change in humidity of atmosphere, as well as its performance during various weather conditions. The device produces the highest energy output at the lowest recorded relative humidity reading. Therefore, the arid regions[1] where the relative humidity is low are expected to be the prime locations for use of the device.
This prototype did not have all the attributes that were included in the thermal model. Therefore, the next generation prototype will have the benefit of the vacuum, which is expected to improve cell operation ten times.[6]
The prototype cell produced almost 40 mV. The device has been operating over an extended period of time, and has produced a steady voltage output with a turndown ratio of 30:1 from a clear low humidity sky with low turndown ratio significant output will be high.
The prototype Nighttime Solar Cell showed that the earth/deep space temperature difference can be used to produce electric power. In addition, the prototype cell demonstrated that the climatic conditions throughout affected its operation. Thus, the Nighttime Solar Cell could conceivably be used as a meteorological instrument to track and predict atmospheric conditions above the cell. When the direct path between the CJP and deep space is obscured in any way, the cell is very sensitive and registered the change. Therefore, the Nighttime Solar Cell can be a multi-use device for energy production or weather monitoring.[6]

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