Hybrid Energy System Based On Solar Cell and Self-Healing/Self-Cleaning Triboelectric Nanogenerator with Rain Drop Simulation

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ABSTRACT
Solar cells act as sustainable energy harvest are quickly spread across the world wide. However, the output performance of solar cells is dramatically reduced in rainy day and the Potential mechanical damages to the surface solar cell may also suppress its output capability. Herein, we propose a hybrid energy system consisted of a solar cell and a self-healing/self-cleaning triboelectric nanogenerator (TENG) for harvesting both solar and Raindrop energies.The application of self-healable TENG for hybrid energy system has been a challenging task, since it is difficult to maintain both the super-hydrophobicity and healable Capability for the electrification surface of TENG. This self-healable and transparent TENG Shows an excellent output performance under rainy day with a peak short-circuit current of 0.8 μA and a peak open-circuit voltage of 6 V, respectively, while it can work very well with solar cell under sunny days. Solar cell under sunny days.it consists of 15 sensors for a panel of 1 square feet producing 5-6 watts of energy.
Keywords: solar,triboelectric nanogenerators, TENG, Peak short-circuit current,Charger controller.

I. INTRODUCTION

Due to its high ease of access, high energy conversion efficiency, cost-effectiveness, and pollution-free nature, solar energy has been well-considered as one of the most prominent solutions to the ongoing global energy shortage. Despite appearances, A transparent covering protects a solar cell from the elements. This layer, unfortunately, has the potential to reduce solar cell efficiency.Renewable energy technology has progressed as a result of developments and subsequencies, hybrid renewable energy systems are becoming popular as stand-alone power systems for providing electricity in remote places. Due to advancements in renewable energy technologies and consequent rises in petroleum prices, hybrid renewable energy systems are becoming attractive as stand-alone power systems for providing electricity in remote places. A hybrid energy system, also known as hybrid power, is made up of two or more renewable energy sources that are combined to improve system efficiency and supply balance.

➤ Biomass-wind-fuel cell is an a hybrid energy system is an example.
➤ Photovoltaic (PV) and wind energy.
➤ Photovoltaic (PV) and Hydraulic (Hydraulic).
➤ Wind and Hydraulic.
➤ Biomass and solar thermal.

Hybrid energy has the following advantages:
➤ Consistent power supply
➤ Make the most of renewable resources.
➤ Low-cost maintenance • High-efficiency
➤ Maintain a high level of load management.
Let's have a look at some of the disadvantages of hybrid energy systems.
➤ Complicated control mechanism
➤ Expensive installation
➤ Limited number of devices connectable

II. OVERVIEW OF THE PROJECT:-

The project "Hybrid energy based on solar ell self-cleaning/self-healing triboeletric nano generators" employs triboelectric nano generators in the sense of creating electricity for rain drops falling in the TENG using a solar cell and TENG combo. Hybrid energy is made up of a variety of components that work together to generate electricity that may be used for household and commercial purposes. TENG's broad application allows it to capture a variety of mechanical energies such as raindrops, water waves, wind, vibrations, and human motions. This hybrid energy system can harvest energy from both sunlight and raindrops because the liquid-solid type TENG can be installed on the surface of the solar cell. The triboelectric materials used in this liquid-solid electrification are mainly polymers with high electron-withdrawing capability, and their transparency can be as high as 95%, indicating that they have negligible effects on solar cell operation.

Triboeletric Nano Generatos Specfications:-
➤ E-textiles (multifunctional electronic textiles) with tiny electronic devices will pave the way for a new generation of wearable devices and human–machine interfaces.

➤ Unfortunately, significant issues such as battery reliance, breathability, adequate washability, and compatibility with mass production techniques impede the development of e-textiles.

➤ This paper explains how to turn ordinary clothing and textiles into waterproof, breathable, and antibacterial e-textiles for self-powered human–machine interfaces in a simple and cost-effective way.

III. LITERATURE REVIEW

The introduction of power generation with raindrop vibration energy by combining solar and triboelectric nano generators Solar cells may not appear to be the ideal option for energy production in locations where it rains frequently. The sky darkens and the sun's rays are blocked from reaching the cell. Researchers have been working on systems that can create energy even while it's raining.Previous research has combined a pseudocapacitor or triboelectric nanogenerator (TENG) with a solar cell to create a device that can generate energy from raindrop motion. However, these gadgets are typically difficult to make and bulky.
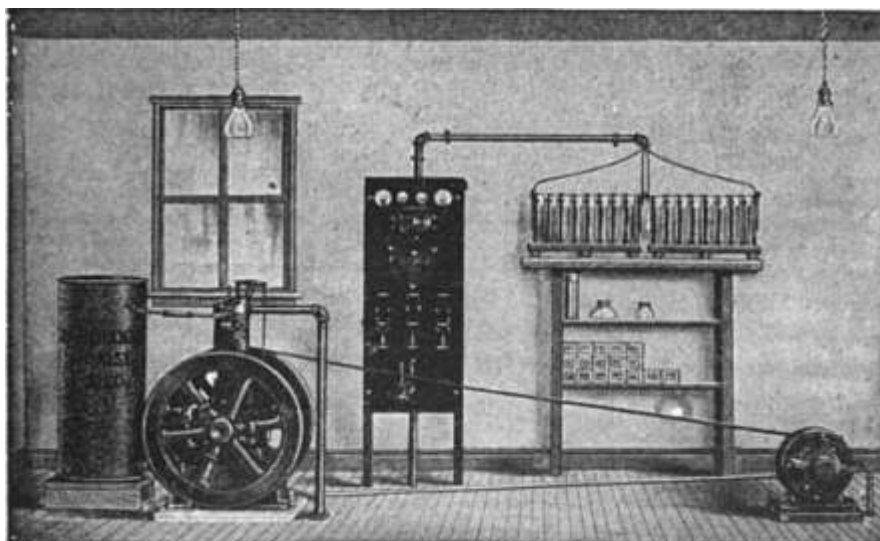

FIG.1: Hybrid energy organization

When water drops touched this material and then fell off, it had a TENG performance. The textured electrode serves as a common electrode for the TENG and the solar cell. It was put in the middle of the two devices and was used to transfer energy from the TENG to the cell. The solar cell could still generate electricity from sunlight as well as rains because the polymers are transparent. This basic design, according to the scientists, displays a novel concept in energy harvesting under a variety of weather circumstances.

IV. THEORY
Solar module:- Solar energy has the full

capability of all renewable energy sources, and even if only a tiny portion of it could be used, it would be one of the most essential energy sources in the country, especially when other sources have been depleted. The sun provides energy to the earth. This energy keeps the earth's temperature above that of colder space, drives circulation in the atmosphere and oceans, controls the water cycle, and allows plants to photosynthesise. The solar power at the point where the sun meets the atmosphere is 1017 watts, while the solar power at the surface of the planet is 1016 watts. The entire global energy demand of all needs The power required for civilisation is 1013 watts. As a result, the sun provides us with 10^3 times high energy than we require. If we can only use 5 percent of this energy, the world will require 50 times as much. On a bright sunny day, the sun's energy radiated is around 1 kw/m^2, and There have been efforts to utilise this energy to raise steam that can be utilized to drive prime movers for the creation of electrical energy. because to the vast amount of area required and the uncertainty of energy availability at a consistent rate due to clouds, winds, haze, and other factors, this source is It's just used to generate electricity to a limited extent.

Triboelectric effect: The triboelectric effect is a type of contact with electrification in which one substance becomes electrically charged after rubbing against another. By touching a glass with fur or combing a comb through one's hair, triboelectricity can be formed.Most static electricity is triboelectric on a daily basis. The triboelectric effect is a sort of contact electrification in which a material becomes electrically charged when it comes into contact with another material via friction.A common example is rubbing a plastic pen on a sleeve made of practically any common fabric used in modern clothes, such as Fabrics made of cotton, wool, polyester, or a combination of these materials are available. When the pen gets close enough, it will readily attract and pick up bits of paper that are less than a square millimetre in size. An electric pen will also repel another electrified pen. This aversion is revealed by the delicate setup of hanging both pens on threads and positioning them near one another. Such research soon leads to the notion of two forms of measurable electric charge, one of which is almost the inverse of the other, with the overall charge determined by a simple sign addition. Provisional charge partition (electric polarisation or dipole moment) of electric charges inside the paper causes the stimulating plastic pen's electrostatic attraction to neutral, uncharged parts of paper (for example) (or perhaps alignments of permanent molecular or atomic electric dipoles).

Rain drop simulator: Simulators of Rainfall Rainfall modelling has long been used to investigate the impacts of rain-induced erosion. Researchers discovered that simulated rainfall gave more uniform control over experiments than genuine rainfall, necessitating the development of rainfall simulators. While genuine rainfall is preferred for erosion control practise testing, simulated rainfall provides for faster data collection and repeatable testing. Drop generating mechanisms (such as hypodermic needles and thread) were utilised in the first rainfall simulation.

FIG.2: Raindrop simulation

Components Required: Mainly the Triboelectric nanogenerators required components are constantly following below.

➢ Polycrystallin solar cell
➢ Triboelectric nanogenerators
➢ Charger controler
➢ Battery 12v
➢ Dc to ac convertor

➢ Mobile charger module
➢ Triboelectric nano generetors ,rain simulator

Polycrystallin solar cell:-

polycrystalline type solar panel is used to capture sunlight and use the photovoltaic effect to transform it into electrical energy.This electrical energy is then used to charge the battery via a charge controller. The charge controller is used to avoid overcharging the battery by cutting off the connection between the solar module and the battery when the battery is full.

FIG.3:solar module

Specification of solar panel:

S.no	Specification name	Nomenclature	Range
1.	Maximum power	Pmax	10 Wp
2.	Maximum power voltage	Vmp	20V
3.	Maximum power current	Imp	0.50A
4.	Short Circuit	Isc	0.60A
5.	Open circuit voltage	Voc	24.8V
6.	Maximum system Voltage	Vmax	600V
7.	Irradiance	Ir	1000 W/m^2
8.	Cell temperature	T	25^oC

Table.1: Specification of solar panel

Triboelectric nanogenerators :-

The working mechanism of the triboelectric nanogenerator may be characterised as the periodic change in the potential difference caused by the cyclic separation and re-contact of the opposing triboelectric charges on the inner surfaces of the two sheets. The inner surfaces of the two sheets come into close contact when the device is bent or pushed mechanically, and charge transfer commences, leaving one side of the surface with positive charges and the other with negative charges.
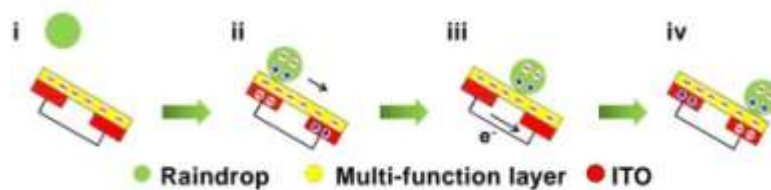

FIG.4:Flow of electrons in triboelectric sensors

Specifications Of Triboelectric NanogeneratorsIt have self-healing/self-cleaning priorities

S.no	Specification name	Nomenclature	Range
1.	Voltage output	Vout	1-10 KV[97]
2.	Current output	Cout	1.5 mA[97]
3.	Power density output	Pd out	500 W m^{-2}
4.	Power characteristic		AC

Table.2: Specifications Of Triboelectric Nanogenerators

Charger controller :-

A solar charge controller is a voltage and current regulator that protects a battery bank from becoming overcharged by solar panels. The voltage and current from the solar panel are regulated before travelling to the batteries to avoid a deep cycle battery from overcharging during the day. Furthermore, no power is returned to the panels, leading the battery to be depleted at night when the solar panel is not charging. Additional features including as load control and illumination are available on a number of charge regulators.

Fig.5: Charger controller

Function of the device:
➢ Using the MPPT algorithm
➢ Charge status is indicated by an LED.
➢ Voltages, current, and power are displayed on an LCD monitor.
➢ Automatic battery voltage identification (12 V/24 V)
➢ USB charging port 5 V Technical specifications for the device

Battery :-

Batteries are used to store extra energy, with chemical energy being converted to electrical energy during recharging. In this project, lead acid rechargeable batteries are employed. In solar power plants, rechargeable batteries are commonly utilised to store extra electrical energy generated by photovoltaic cells or solar panels during sunny day hours. Excess electrical energy stored in batteries is fed into the grid during off-peak hours, when the sun isn't shining brightly enough to provide continuous electricity to the grid.

Fig.6: Secondary battery

➢ Time required to fully recharge a 2.5Ah battery at 12V.,
➢ We can generate electricity with the solar anel we're utilising. 5 watts of power output 305mA is the current output. 16.4V output voltage.
➢ The voltage output of the solar panels must be higher than the voltage of thebatteries.
➢ Battery current/solar panel output current =2.5A/0.305A =8.19h Recharge time
➢ It takes 8.19 hours to fully recharge the battery.

Dc to ac convertor :-
Converting DC power to AC voltage is a common problem in most small electrical installations. Every circuit may be seen if we design a circuit that accepts AC input and produces DC. On the other hand, a DC to AC converter circuitis used to convert the circuit from DC to AC. In circuits where DC to AC conversion is not practicable, an inverter (converter) is usually used. Inverter circuits are used to convert the DC to AC converter as a result.
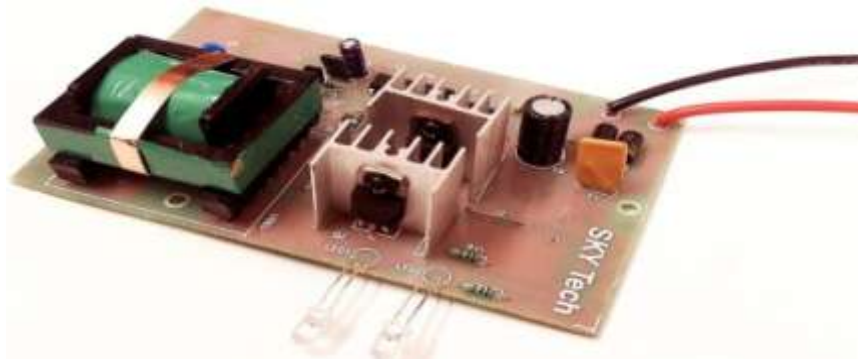

Fig.7: DC to AC convertor

Between DC and AC conversion is feasible. 12V, 24V, 48V and 110V, 120V. , 24V, 48V to 110V, 120V, 220V, 230V, 240V with 50Hz/60Hz supply. Here is a basic 12V DC to 220V AC Converter circuit that is meant to convert DC to AC for a better understanding of this topic.

V. METHODOLOGY

Working process of hybrid energy system :- The hybrid energy based on solar cell self- healing self-cleaning triboelectric nanogenerator in getting so many components to assemble to make hybrid

energy system mainly consists of solar panels and battery solar charge controller triboelectric nano generator and DC to AC converter accomplished for that system. Solar panel is fixed at the one of the energy source of the system during normal daylight conditions and it is received the sun light from Sun and it is convert the energy into electrical energy by using a solar charger controller. The Solar Charger controller is mainly to purify the energy from solar cell it is abnormal energy like a direct current voltage it is stabilize the energy.

Fig.8: hybrid energy system model

Another energy generation devices is a triboelectric nanogenerator by using triboelectric effect the raindrop energy harvesting technology is working with kinetic energy into the form of vibrations or shock into electrical energy.The rain water contains positively charged ions like ammonium calcium and sodium when water binds to tribelectric panel surface and double layer of positive ions and negative charge electrons is

created which ends up producing voltage and current and it is power to store by the storage devices like batteries.Then DC power useful to only DC power operated devices but DC power will be useful to AC power by using DC to AC converter. The DC power 12 volt it and it is converts to to 220 volts by using of DC to AC inverter to the batteries to get DC to AC.
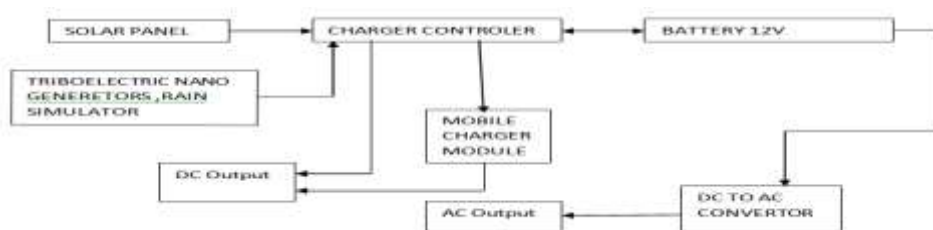

Fig.9: schematic diagram

VI.   RESULT AND DISCUSSION

The hybrid energy solar system based solar cell and tribo electric nano generators conducting experimental reading on the solar and rain drop energy at the different times variables and it taken by reading on voltage(V),current(I) and power. The solar energy taken by the every 1hour up to 10 hours time frame and raindrop energy taken by the every 10 mints up to 100 mints time frame by using multi meter.
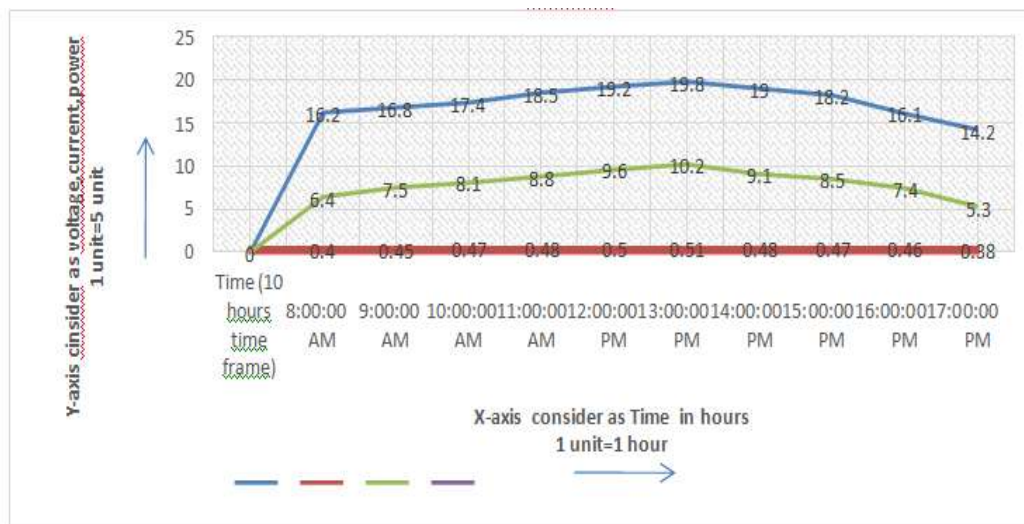
The solar energy taken by load conditions in intrevels of time Experimental Readings are taken in coordinates: 14.6587° N, 78.7533° E and the location is : Kadapa,Khajipet.

The solar energy taken taken by load conditions

S.no	Time (10 hours time frame)	Voltage (V)	Current(I)	Power(P=V×I)watts
1.	8:00:00 AM	16.2	0.4	6.4
2.	9:00:00 AM	16.8	0.45	7.5
3.	10:00:00 AM	17.4	0.47	8.1
4.	11:00:00 AM	18.5	0.48	8.8
5.	12:00:00 PM	19.2	0.5	9.6
6.	13:00:00 PM	19.8	0.51	10.2
7.	14:00:00 PM	19	0.48	9.1
8.	15:00:00 PM	18.2	0.47	8.5
9.	16:00:00 PM	16.1	0.46	7.4
10.	17:00:00 PM	14.2	0.38	5.3

Table.1: The solar energy taken taken by load conditions

The solar energy taken by load conditions in intrevels of time

Graph.1: The solar energy taken by load conditions in intrevels of time

The solar energy taken in load condition,The graph represent in X-axis consider as 10 Hours time frame,and each unit consider as a 1 hour. Upto 8:00:00 Am to 17:00:00 Pm time span. Then Y-axis consider each unit in 5 units and include the voltage (V),Current (I),Power (P=V×I) in Watts. And collaboration of Voltage and current its outcomes the Power. In that Ten Readings taken as a each specific time and voltage,current like a in the cur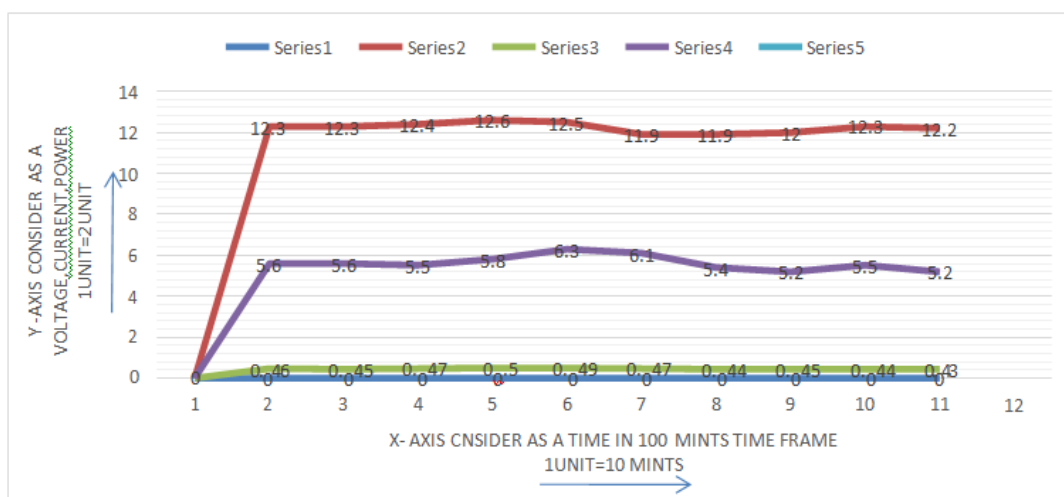rent 0.4A get it the voltage is 6.4V and Power is 16.2 Watts. And second ,third ,forth upto tenth readings In the same ratio we get Ten readings results as well as.

The solar energy taken by load conditions in intrevels of time Experimental Readings are taken in coordinates: 14.6587^o N, 78.7533^o E and the location is : Kadapa,Khajipet.

The Rain drop energy reading taken in load condition

S.no	Time(100mints time frame)	Voltage (V)	Current(I)	Power(P=V×I)watts
1.	10:00 MINTS	12.3	0.46	5.6
2.	20:00 MINTS	12.3	0.45	5.6
3.	30:00 MINTS	12.4	0.47	5.5
4.	40:00 MINTS	12.6	0.5	5.8
5.	50:00 MINTS	12.5	0.49	6.3
6.	60:00 MINTS	11.9	0.47	6.1
7.	70:00 MINTS	11.9	0.44	5.4
8.	80:00 MINTS	12.0	0.45	5.2
9.	90:00 MINTS	12.3	0.44	5.5
10.	100:00 MINTS	12.2	0.43	5.2

Table.2: The Rain drop energy reading taken in load condition

Graph.2: The Rain drop energy reading taken in load condition in 100 mins time frame

Rain drop energy in load condition,The graph represent in X-axis consider as 100 Mints time frame,and each unit consider as a 10 mints. Upto 10:00 Mints to 100:00 Mints time span. Then Y-axis consider each unit in 2 units and include the voltage (V),Current (I),Power (P=V×I) in Watts. And collaboration of Voltage and current its outcomes the Power. In that Ten Readings taken as a each specific time and voltage,current like a in the current 0.46A get it the voltage is 5.6V and Power is 12.3 Watts. second ,third ,forth upto tenth readings In the same ratio we get Ten readings results as well as.

VII.   CONCLUSION

The place in India with the most rainfall also has the most rainfall in the globe. India is a diverse country. From cultural to linguistic to geographical diversity, one can find a wide range of Climates and temperatures in different sections of the subcontinent. So you have dry places like the Thar desert in the west and rainy areas like Mawsynram in the east.India's wettest place, in the east. In the north, you'll find areas as frigid as Leh, while in the south, you'll find places as humid as Chennai. It's a fantastic combination of everything. India is so amazingThe rainiest states in India include Arunachal Pradesh, Sikkim, West Bengal, Odisha, Uttarakhand, Uttar Pradesh, Karnataka, and Kerala.

The Indian monsoon has an impact on the Indian subcontinent and its water bodies. The monsoon winds blow from the north east in the cooler months and then from the During the summer, head to the southwest. India receives a lot of rain throughout this cycle, especially in the months of June and July. The Western Ghats of India are experiencing early monsoons, with an average rainfall of 2,000 to 5,000 mm (80 to 200 inches) on the region's windward slopes.So that introduced the triboelectric nano technology in the rainy places and getting best results for the producing electricity.

Most rainy places in india is
➢ Mawsynram of Khasi Hills in Meghalaya, North East India, has the title of being the wettest place of India and of the world It has a recorded 11, 872 mm. of rainfall during peak monsoons in India.
➢ Cherrapunji is located on the Khasi Hills' slopes and receives rainfall similar to Mawsynram. The greatest rainfall ever recorded in Cherrapunji was 11,619 mm.
➢ Agumbe is a tiny town in Karnataka's Shimoga district. It receives 7,691 mm of rain on average.
➢ Mahabaleshwar, Maharashtra, is in second place in terms of yearly rainfall. The reported level is 5,618 mm.
➢ The yearly rainfall in Pasighat is 4,388 mm.
➢ The capital of Sikkim, Gangtok, is next in line, with 3,737 mm of annual rainfall.

REFERENCES

[1]   E.H. Jung, N.J. Jeon, E.Y. Park, C.S. Moon, T.J. Shin, T.Y. Yang, J.H. Noh, J. Seo, Efficient, stable and scalable perovskite solar cells using poly(3-hexylthiophene), Nature 567 (2019) 511-515.
[2]   Y. Cui, H.F. Yao, J.Q. Zhang, T. Zhang, Y.M. Wang, L. Hong, K.H. Xian, B.W. Xu,S.Q. Zhang, J. Peng, Z.X. Wei, F. Gao, J.H. Hou, Over 16% efficiency organic photovoltaic cells enabled by a chlorinated acceptor with increased open-circuit voltages, Nat. Commun. 10 (2019) 2515.
[3]   X.P. Xu, K. Feng, Z.Z. Bi, W. Ma, G.J. Zhang, Q. Peng, Single-Junction Polymer Solar Cells with 16.35% Efficiency Enabled by a Platinum(II) Complexation Strategy, Adv. Mater. 31 (2019) 1901872.
[4]   L.Y. Wang, Y. Wang, H. Wang, G.Q. Xu, A. Doring, W.A. Daoud, J.B. Xu, A.L. Rogach, Y. Xi,Y.L. Zi, Carbon Dot Based Composite Films for Simultaneously Harvesting Raindrop Energyand Boosting Solar Energy Conversion Efficiency in Hybrid Cells, ACS Nano 14 (2020) 10359-10369.
[5]   J.H. Nie, Z.M. Wang, Z.W. Ren, S.Y. Li, X.Y. Chen, Z.L. Wang, Power generation from the interaction of a liquid droplet and a liquid membrane, Nat. Commun. 10 (2019) 2264.
[6]   Y.Q. Liu, N. Sun, J.W. Liu, Z. Wen, X.H. Sun, S.T. Lee, B.Q. Sun, Integrating a Silicon Solar Cell with a Triboelectric Nanogenerator via a Mutual Electrode for Harvesting Energy from Sunlight and Raindrops, ACS Nano 12 (2018) 2893-2899.
[7]   Z.H. Lin, G. Cheng, S. Lee, K.C. Pradel, Z.L. Wang, Harvesting water drop energy by a sequential contact-electrification and electrostatic-induction process, Adv. Mater. 26 (2014) 4690-4696.
[8]   Z.H. Lin, G. Cheng, W.Z. Wu, K.C. Pradel, Z.L. Wang, Dual-Mode Triboelectric Nanogenerator for Harvesting Water Energy and as a Self-Powered Ethanol Nanosensor, ACS Nano 8 (2014) 6440-6448.
[9]   A. Ahmed, Z. Saadatnia, I. Hassan, Y.L. Zi, Y. Xi, X. He, J. Zu, Z.L. Wang, Self-

Powered Wireless Sensor Node Enabled by a Duck-Shaped Triboelectric Nanogenerator for Harvesting Water Wave Energy, Adv. Energy Mater. 7 (2017) 1601705.

[10] J. Chen, J. Yang, Z.L. Li, X. Fan, Y.L. Zi, Q.S. Jing, H.Y. Guo, Z. Wen, K.C. Pradel, S.M. Niu, Z.L. Wang, Networks of Triboelectric Nanogenerators for Harvesting Water Wave Energy: A Potential Approach toward Blue Energy, ACS Nano 9 (2015) 3324-3331.

[11] T. Jiang, L.M. Zhang, X.Y. Chen, C.B. Han, W. Tang, C. Zhang, L. Xu, Z.L. Wang, Structural Optimization of Triboelectric Nanogenerator for Harvesting Water Wave Energy, ACS Nano9 (2015) 12562-12572.

[12] J. Bae, J. Lee, S. Kim, J. Ha, B.S. Lee, Y. Park, C. Choong, J.B. Kim, Z.L. Wang, H.Y. Kim, J.J. Park, U.I. Chung, Flutter-driven triboelectrification for harvesting wind energy, Nat. Commun. 5 (2014) 4929.

[13] Y. Jie, X.T. Jia, J.D. Zou, Y.D. Chen, N. Wang, Z.L. Wang, X. Cao, Natural Leaf Made Triboelectric Nanogenerator for Harvesting Environmental Mechanical Energy, Adv. Energy Mater. 8 (2018) 1703133.

[14] L. Zheng, G. Cheng, J. Chen, L. Lin, J. Wang, Y.S. Liu, H.X. Li, Z.L. Wang, Hybridized Power Panel to Simultaneously Generate Electricity from Sunlight, Raindrops, and Wind around