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ATMOSPHERIC WATER GENERATION USING PELTIER EFFECT– A REVIEW

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ABSTRACT

In many nations, the availability of sustainable freshwater has become a major issue. Droughts, hurricanes and floods are becoming more common as the globe's population grows, the world becomes more industrialized, and global warming temperatures change. As a result, water scarcity issues may be seen all over the planet. The biggest stores of water are available in the air, contrary to common perception. As a result, various systems for producing drinking water from humid air have been created in research studies. Among the methods for obtaining clean water from humid air that are currently available, the use of thermo-electric cooling equipment for the creation of clean water is an environmentally friendly option. Based on the current review study, the technology's performance is assessed, and further research for atmospheric water collecting in humid or dry climate zones is suggested.

Keywords: Thermo-Electric Cooler, Dehumidifier, Water Condensation, Solar Energy.

I. INTRODUCTION

Water shortages are a global catastrophic problem. A shortage of water is closely bound up with human rights and adequate access to safe water is a worldwide development concern. But many nations confronted a rising water shortage during the 21st century, given the problems of population development, profuse consumption, expanding pollution and changes in global warming climatic conditions. It is projected that two thirds of the world's people would suffer water scarcity until 2025 at present rates of water usage. A lack of humidity in the air (producing minimal precipitation) or human activity that disturbs the water cycle are typically the reasons for water shortages.

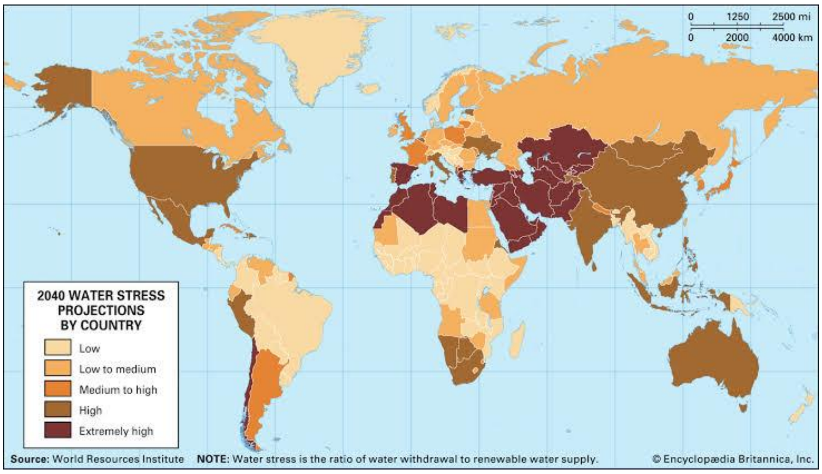

Figure 1: 2040 Water stress projections by country

Some regions where the water stress is considerable consume current water resources faster than refilled, and majority is utilized for agriculture. For irrigation purposes, 70 percent of global freshwater should be used. Africa, Middle East and Asia are hit hardest, however there is yearly water scarcity as close as the Midwest USA. In order to address this problem, we need a new technique for water supplying sensitive areas and an atmospheric water generator to help (AWG). It makes water vapour an usable form of water. It was predicted that the atmosphere contained renewable water over 12.9 to 1012 m^3 and that obtaining water from the air was desirable and possible. Apply a current to generate a temperature differential by the Peltier-based water generator concept to cool down and condense the surrounding air.

Thermoelectric cooler

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Thermoelectric technology (TE) has attracted attention all around the world in recent decades. When using direct current (DC) TECs employ the Peltier effect to create a temperature differential. TECs are silent, dependable and environmentally benign without moving components, refrigerants and gas emissions. The TECs are likewise tiny, lightweight and photovoltaic (PV) panels may be directly powered. Researchers have investigated and enhanced material performance, system structure, technique of heat dissipation etc. Integration of TECs into the collection of atmospheric steam is an interesting means for the construction of a portable generator. Many publications examined the performance of TECs for vapour extraction.

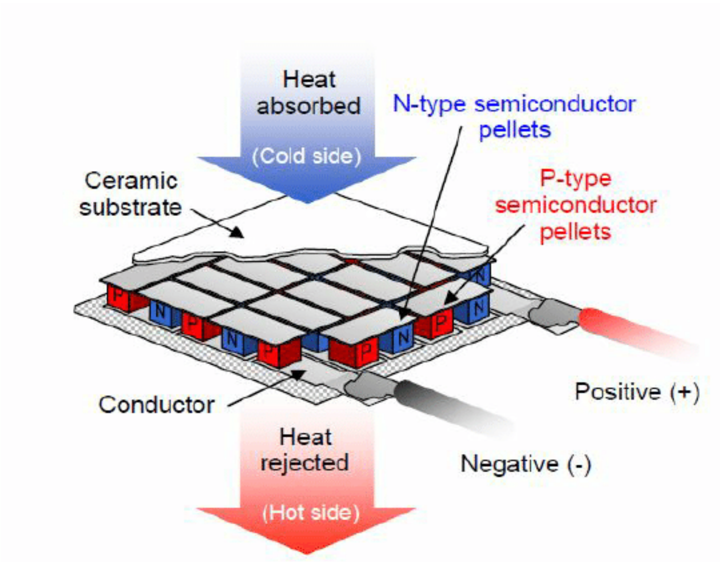

Figure 2: Thermoelectric cooler (TEC)

II. LITERATURE SURVEY

1. **M.Eslami et al.** presented an experimental study of Thermal analysis and optimization of a system for water harvesting from humid air using thermoelectric coolers. They have used sensitivity analysis to find the optimum number of TECs. The resulting system is capable of producing 26 ml of water within 1 h from the air with 75% relative humidity and the temperature of 318 K by consuming only 20 W of electrical power.

2. **Shanshan liua et al.** presented an experimental analysis of portable atmospheric water generator by thermoelectric cooling method. The experimental system contained a humidifier, a mixing chamber, an air channel and a TE water generator with 2 TECs. The resulting system can able to generate 25.1 g per hour with the usage of 58.2 W input. This system is suitable for outdoor use.

3. **Jatin Patel et al.** presented an experimental investigations of atmospheric water extraction device under different climatic conditions. This system works on vapour compression refrigeration cycle. This system can capable of extracting 0.28 L/h in mild and dry condition and up to 1.78 L/h in humid and warm condition. According to this study AWE devices are most effective in hot and humid regions.

4. **Kashif Irshad et al.** presented an experimental study of a thermoelectric air duct dehumidification system for tropical climate. This system consists of 24 TEMs connected with airduct dehumidifier and it is called TE-ADD system. TE-ADD system is connected to an air-conditioning test chamber under tropical conditions of Perak, Malaysia and investigated. According to numerical method analysis with ±6% error the optimal production is achieved for an input current of 3 A to 4 A at an airflow rate of 0.012 kg/s, while that for an input current of 5A to 6 A is achieved at 0.011 kg/s.

5. **Lauren Sharpe et al.** presented a study of how to increase the efficiency of a peltier device by assessing the thermal performance of liquid cooled microchannel heat sinks. Liquid cooled heat sinks were used in this system so that it can provide highest thermal efficiency. They investigated for suitable coolant for the microchannel heat sinks with water, Al2O3 nanofluid, TiO3/H2O nanofluid, Nanofluid, Trans critical CO2, Supercritical CO2 and Galinstan. At the end they selected Galinstan as it requires low pumping power to achieve its minimal thermal resistance and due to its great cooling ability.

6. **Dr.G.Satish Pandian et al.** proposed a review on design and fabrication of atmospheric water generator using peltier effect. Their main aim is to build a AWG to produce fresh drinking water with high coefficient of performance. After obtaining dew point temperature they calculated COP of peltier, so that they can estimate time required to generate water droplet.

7. **Vivek Patel et al.** presented an experimental and theoretical study on the influence of thermo-electric cooling dehumidifier on humidification-dehumidification water desalination system. Theoretically it was explained as (Energy at dehumidifier inlet) = (Energy absorbed by TEC modules) + (Energy carried away by distilled water) + (Energy at dehumidifier outlet air) and experimentally it was done in 3 set by varying mass flow rate, air temperature and relative humidity.

8. **Chana Uttasilp et al.** presented a study on optimal solar energy on thermoelectric cooler of water generator in case study on flood crisis. The prototype was built and tested at temperature around 30 degree C and humidity was in the range of 60-80%. The results shows that 0.2-0.3L of drinking water per day with power consumption of 2.5-3.6 W.

9. **Ali Akbar Salehi et al.** presented a review on the water-energy nexus for drinking water production from humid air. They proposed that use of renewable energy is the solution for reduction of energy costs. And they proposed that water can be harvested with the technologies like nature structure, fog collection, underground selection, atmospheric water generators and absorption method.

10. **Du Runze et al.** presented an experimental investigation on a portable atmospheric water generator for maritime rescue. The system composed of a water generating module, a water purifying module, a power supply and control module and a buoyancy module. The results showed that the best water production rate of 460 mL/h was achieved when Tin =27 and RHin=92%.

11. **Atul Ekad et al.** presented a study on solar powered atmospheric water generator and overview on AWG technologies. They compared two different technologies, like vapour compression system which can only produce 72.1 ml of water per KW-hr and AWG with peltier effect can produce 1L of water per hour at high humid conditions.

12. **Rang Tu et al.** presented a study on reviews of atmospheric water harvesting technologies. They are condensation technology, sorption technology and other technologies. And compared among each of the technologies to choose the best one. They concluded that condensation technology with TEC can produce the average of 1.71 kg/hr.

13. **Rohan Gupta et al.** presented a study on Water through air using peltier elements. This conventional cooling system contains three fundamental parts- the evaporator, compressor and condenser. The TE couples are combined in a module and connected electrically in series and thermally in parallel to obtain a promising output. The resultant system can generate 1L of water per hour in humid regions at daytime.

14. **Hasila Jarimi et al.** presented a study on review of sustainable methods for atmospheric water harvesting. They proposed reviews about atmospheric fog harvesting and dew water harvesting including different varieties. They concluded that desiccant based water collection systems are sophisticated than radiation-based systems but can collect more water.

15. **Kiara Pontious et al.** presented an experimental study on design of an atmospheric water generator harvesting water out of thin air. They built two prototypes, one with cross flow heat exchanger and another with thermoelectric cooler. These prototypes were built to operate under dry bulb temperature range of 55–130-degree F and RH range between 52%-100%. As performance wise both the protypes were performed well. They proposed that these technologies can be used for agricultural irrigation instead of desalination technology.

16. **Du Runze et al.** Authors here are using AWG to help people in distress in seas (south China sea). People in distress who may need rescue must hold onto their lives as long as possible before the search party arrives, there the use of portable seawater desalinations device proves effective. The researchers designed a AWG which had a water generating module, water purifying module, power supply and a buoyancy module which gave them 5.52L/d with temperature being 27C and RH being 92% and desalination rate above 96% which is proved as a feasible solution for the people in distress.

17. **Thualfaqir J. et al.** The researchers built a prototype of AWG. The prototype was solar powered and portable with a peltier module which was attached with fans on both ends of the module. They wanted to increase the generation of water from the proposed AWG. They experimented this by increasing the air flow rate at the hotter side of the peltier module. The prototype was generating about 9.5ml/hr. at airflow velocity of 1m/s, but after increasing the air flow rate at the hotter side the peltier module the water generated was increased to 20ml/hr. at the same airflow velocity i.e., 1m/s.

18. **Soroush Moradi et al.** The author gave almost prominence in understanding the existing active and passive type of AWG's and their advantages and disadvantages, and from that data he is designing a new model which deals with some obstacles these existing AWGs are facing. He compared the model which works with the help of external power supply(active) which generates good amount of water but has a problem while installing in remote areas or forests where regular service isn't available and a model which collects water from dew and fog(passive) where in this case service isn't needed often but collection of water collected is very much lesser. Thus, the author proposing a new design where the funnel shaped condenser tilted at 60 degree with additional edges at the bottom will be more efficient than the existing models.

III. WATER PRODUCTION FROM HUMID AIR

Water production using peltier effect

Air-Air water generators are instruments that collect water molecules from the air and the transformation phase takes place from vapour to fluid. These instruments are split into three groups. Cooling in the first group is below the ambient air dew point, which may be supplied by the gas compression or the Peltier effect. The Peltier thermoelectric device contains two sides (a p-type and an N-type semi-conductor), so that heat is brought from both sides when the DC current runs through it and the Peltier effect is termed the hotter side. The peltier effect is the reverse of See beck effect and shows that heat is absorbed by welding of two different metals at a single intersection and that heat is absorbed at the other junction.

Peltier cooler device is a peltier component and a strong combination of heat sink / fan. In different sizes and shapes the peltier components come. They are usually made of a higher number of rectangular-shaped thermocouples packed between two thin slabs of ceramic. This kind of gadget is so strong that in several minutes it can freeze good quantities of water. Virtually TE pairs are joined together in a module, which is electrically and thermally linked to achieve a promising output. But using such a gadget with less favorable work at power ratio will be problematic. The greater temperature on the hot side causes heat to grow from the warm to the cold and the cooling effect of TECs might be unfavorable. When this instrument is maintained in a comparatively humid atmosphere and air is pushed to the cool side of the TEC device, the water vapour gaining its latent heat, which is required for the dew points' temperature and thus water condensation, can be strengthened by passing the same hot air through the cold side of TEC. The Module Peltier comprises of multiple parallelly and electrically linked thermocouples and integrated between two ceramic panels.

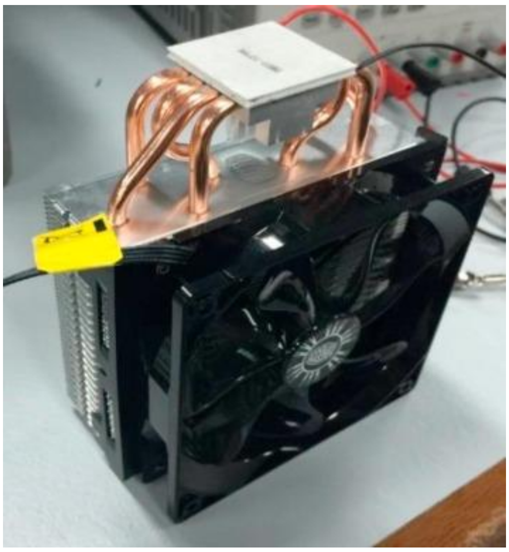

Figure 3: Peltier cooler device

Solar driven TEC

The thermoelectric pair is used to generate the condensing temperature environment or the dew point. Solar energy has the good feature of minimal demand during its use phase, making it perfect for installation when the freshwater supply is highly degraded. However, if the energy crisis in the 1970s did not affect modern thinking, research into Peltier cooling effect and photovoltaic effect was developed in the same period, mainly for the World Health Organization's and the International Health Organizations Cold Chain project, specifically for rural areas. The application of solar cooling was still excluded. Cells, as well as the (Photo Voltaic) PV array, storage battery, and controller, are the major components of the solar battery.

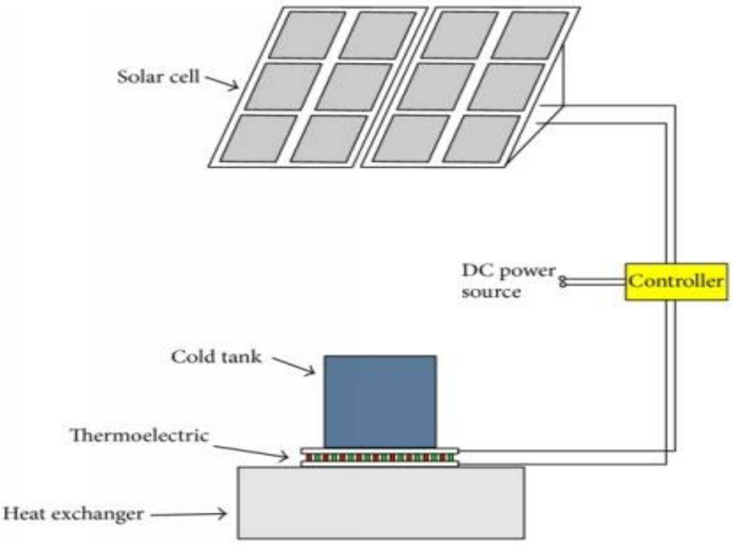

Figure 4: Solar driven TEC

To regulate the system and keep the temperature of the circulating air above the freezing point of water, a TC1046 sensor and a PIC16F872 or AT mega series microcontroller are used. When the switching frequency is, the boost converter is designed to function in continuous conduction mode (CCM). As soon as the device is turned on, the hot side begins to heat up and the cold side cools down, reaching dew point temperature. Water vapors begin to condense when the cold side of TEC cools the air flowing through its heat sink region, similar to how water condenses outside a glass of ice.

Production of water by varying different parameters

System description

The TE-ADD system, as illustrated in Figure 4, is composed of 24 TEM (TEC1-12730) with Table 1, heat sinks, and fans in an aluminium sheet box. The 25 TEM, organized as an 8x3 grid, are fastened to an acrylic Perspex sheet put in the middle of the TE-ADD, which divides the Air Pipeline into two segments, the Cold air Pipeline and the Hot Air Pipeline. The thermal paste was applied to both the warm and cold sides of the TEMs to dissipate and absorb the heat properly. The hot and cold sides of the TEM's were attached to heat sink diameters of 65 mm 65 mm 20 mm and 65 mm 65 mm 10 mm. A small bucket for the collection of water condensate generated was also positioned on the cold side of the TE-ADD system as illustrated in Figure 1. On the hot side of the TE-ADD system was fitted an axial flow fan with the specifications 30 W, 50 60 Hz and 300 CFM, while a different axial fan was fitted with the requirements 56 W, 70~80 Hz and 600 CFM for adequate air circulation on the hot side of the TE-ADD system. The TE-ADD system was adequately insulated by means of aluminium isolating sheets to limit the air or heat leakage.

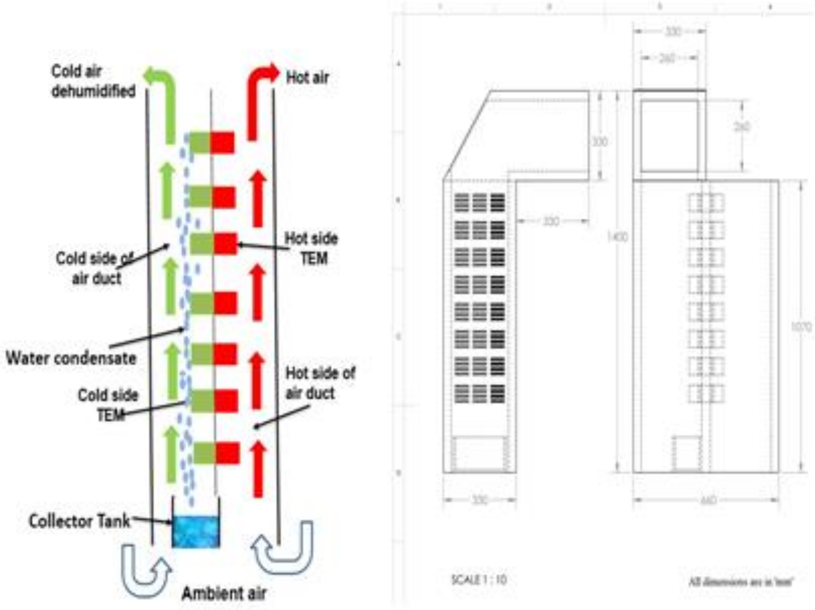

Figure 5: The schematic diagram of the thermoelectric air duct dehumidification (TE-ADD) system

Table 1: Specifications of thermoelectric module

Model	Dimension (mm)	*N*	*Umax* (V)	*Tmax* (°C)	*STE* (V/K)	*Imax* (A)	*Qcmax* (W)	R_{TE} (Ω)	K_{TE} (W/°C)
TEC 112730	62×62×4.8	127	15.4	68	0.051	30	*266.7*	0.27	0.5177

Variation of input current and airflow into the system

For the input current 3 A and 4 A with an airflow rate of 0.012 kg/s, the optimal water condensate generation is obtained whereas for the input current of 5 A and 6 A, the airflow rate is 0.011 kg/s. Further increase in input power lowers the cooling capacity of the TEM, and thus, with the ideal water generation at an airflow rate of 0.013 kg/s the water condensate is considerably reduced. There are two reasons for changing the optimum generation of water at various airflow speeds. Firstly: The velocity of airflow influences both side of the TEMs' rate of heat dissipation and absorption. Before exiting the conduit system, both lower and higher airflow speeds cannot disperse and absorb heat substantially from the two sides of the TEMs correspondingly. Thus, the buildup of heat lowers condensation and generation of water. Second, the use of air conditioning TEMs poses issues such as poor layer weight, metallised contact layer and diffusion among the materials. Frost forms when air comes into close contact with the ceramic plate of the TEMs. This is due to the chilly side of TEMs' lower surface temperature, which allows dew drops to condense from the air. Dew condensation raises the system's thermal resistance and blocks airflow over the TEMs.

IV. CONCLUSION

In this paper the, atmospheric water generation technologies using peltier effect are reviewed. And mainly focused on AWG using prltier cooler device, Solar driven AWG and variation in airflow and input current to the AWG system. By considering all the parameters and climatic conditions, the AWG should build to produce optimum yield.

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