Vol. 5, No. 2, October 2024, page 241-249
JTTM: Jurnal Terapan Teknik Mesin
p ISSN 2721-5377| e ISSN 2721-7825
http://jurnal.sttmcileungsi.ac.id/index.php/jttm

Arduino performance in control systems for converting air-to-water

Triwahyudin Rohman*, Naufal Waliy Ishlah, Salvatore Johanes Rega, Subekti Subekti

*Department of Mechanical Engineering, Faculty of Engineering, Mercu Buana University, Jakarta, Indonesia
Meruya Selatan No. 1, West Jakarta, Indonesia

* triwahyudinrohman10@gmail.com

Submitted: 23/03/2024 Revised: 07/06/2024 Accepted: 15/06/2024

Abstract: Humans are unable to function without water. Water is therefore necessary for living. This study will address the advantages of converting air into drinkable water based on this premise. Regarding the condensation process itself, it is not the best option to use it in remote locations because it needs a lot of energy and equipment. Consequently, thermoelectric technology was used in this study to replace the condensation process. This tool's easier thermoelectric operation makes it suitable for usage in remote locations. The design of an effective Arduino program control system should take into account the effects of temperature and humidity condition parameters on the environment to maximize water production. This will allow the performance between supporting sensors and the main components to be automatically optimized under a variety of environmental conditions and produce water without wasting excessive energy. As a result, the trial where the average temperature was 30°C and the average humidity was 81% produced the highest results for the researchers when they calculated the environmental condition factors that were already known. Within the hour-long study session, 6 milliliters of water were created. In addition to the efficiency with which the Arduino program is commanded, from all sensors to the primary thermoelectric components, it can execute commands automatically and optimally. It can also resolve issues that affect the air-to-water converter controller's performance in a way that ensures proper operation of all controllers by taking into account the relevant factors. to the fullest without squandering too much energy.

Keywords: Arduino; thermoelectric; water condensation; dehumidifier; atmospheric water generator.

1. INTRODUCTION

Humans depend on water to do a variety of tasks since it is essential to life as we know it on Earth [1]. Water is the source of life and is required for nearly all human activities. It is essential for life processes and without it, there would be no life at all [2]. According to Law No. 7 of 2004, water includes all liquid substances found on land, whether above or below the surface, such as rainwater, ocean, groundwater, and surface water. Without water, society would cease to exist [3]. The study of national history reveals that the loss of a nation's water supply, which is essential for life, can have catastrophic consequences. As a result, the UN states that access to water is a human right. For everyone to have the equal basic right to utilize water on Earth. According to a 2015 World Resource Institute research, Indonesia is very likely to face a water catastrophe by 2040 [4]. According to Bappenas, the region facing a water crisis, the island of Java, will see a rise in water shortage as well, going from 6% in 2000 to 9.6%. 2045.

Solving this issue requires effort, and one way to do so is by getting water from the air rather than the ground. Since water vapor is present in the air around us, we can use the air as a substitute supply of water [5]. It is feasible to extract water from the air endlessly because the volume of air is infinite [6]. When airborne water vapor crosses over a surface that is colder than the water vapor's dew point, condensation may take place [7][8]. An essential factor in the condensation process is air temperature [9]. Therefore, a calculated move to solve this issue is to search for novel ways to extract water from humid air. The application of air condensation process technology is primarily responsible for the innovation in the form of a method for producing water from humid air. When the air cools down, the water vapor in the very humid air evaporates from the sun's rays and turns into liquid water. This process is known as condensation, which is the conversion of gaseous energy into liquid [10]. The SeeBeck effect, which occurs when a direct current is supplied to a thermoelectric, allows the thermoelectric principle to be employed as a cooler by creating a temperature differential on both sides of the semiconductor chip [11]. Aside from that, Mercu Buana University researchers are working to create new renewable energy. The purpose of this paper is to design a control system that makes use of an Arduino controller to ensure that the air-to-water device operates as efficiently as possible by monitoring the air's temperature and humidity levels.

2. METHOD

The air-to-water converter will first be tested in the field, and data will be gathered and analyzed to derive trial results and conclusions. The flow diagram, as displayed in Figure 1, illustrates the steps used in conducting this research.

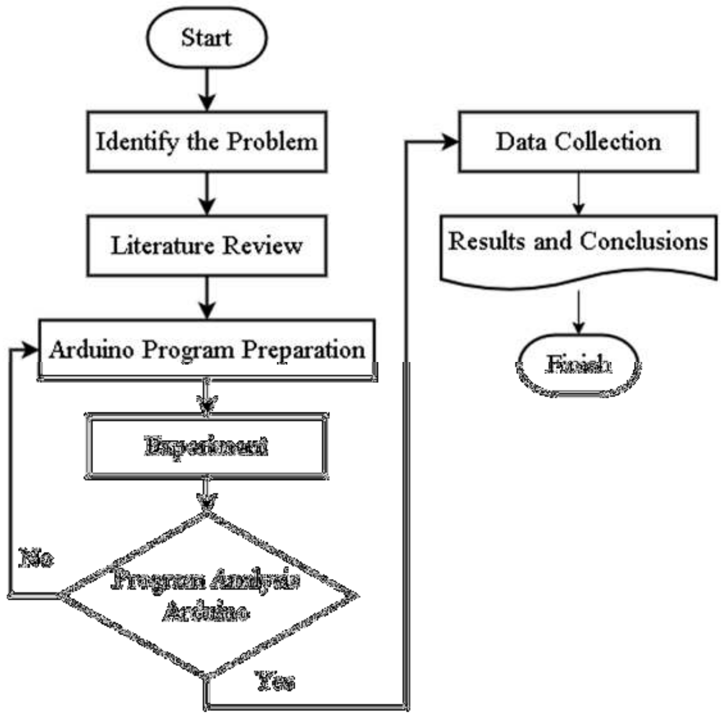


Figure 1. Flow diagram.

The condensation process approach, in which a substance transitions from one phase of the item to another, is used in this study. If the substance's form is altered by the emission and absorption of heat, then this will transpire. For instance, gas must reach its dew point to become water, and water must reach its freezing point to become a solid [12]. The condensation process, which is the transition from gas to liquid, happens when the air in the environment reaches the dew point. This means that when the relative humidity hits 100% and the air can no longer hold on to more water vapor, a condensation process will take place. turn liquable. Understanding the dew point at the test site is crucial for equipment testing since it will impact the water findings the equipment produces. Using the equation (1).

$$T = T - \left(\frac{100-RH}{5}\right) \tag{1}$$

Information:
T : Air temperature in °C
Rh : Relative humidity determined in volume fraction (from 0.01 to 1.00).

The researcher used the Arduino Uno microcontroller control system in this study, one of several microcontroller control systems where the microcontroller is the central component of the automatic control project [13]. With the implementation of a processing language, the Arduino Uno is an open-source physical computing platform built on a basic input/output circuit [14]. All of the parts employed in the air-to-water converter are anticipated to function at their best when programmed commands are followed by an Arduino control system. Controlling the primary component and other auxiliary components is the goal of circuit design. The Arduino circuit shown in Figure 2 is as follows.

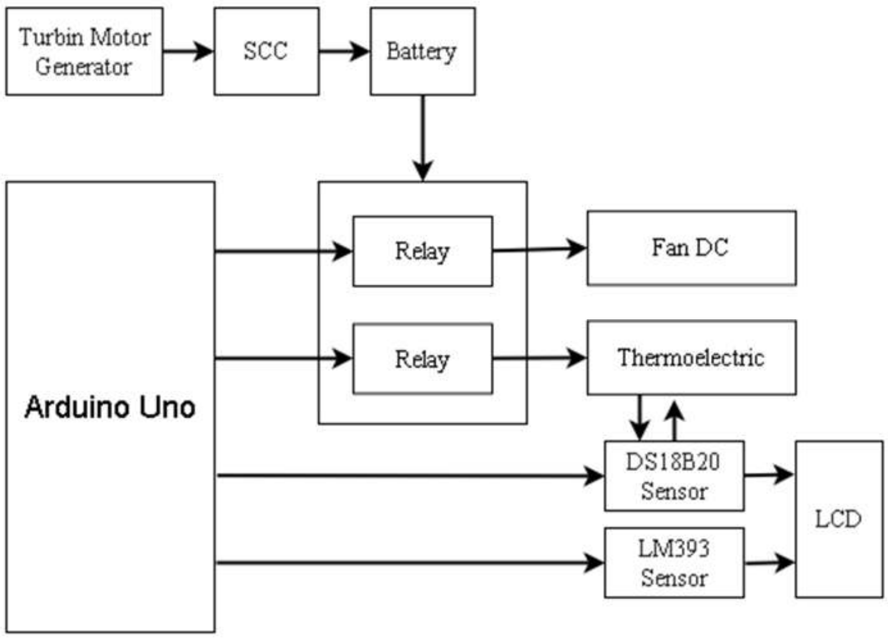
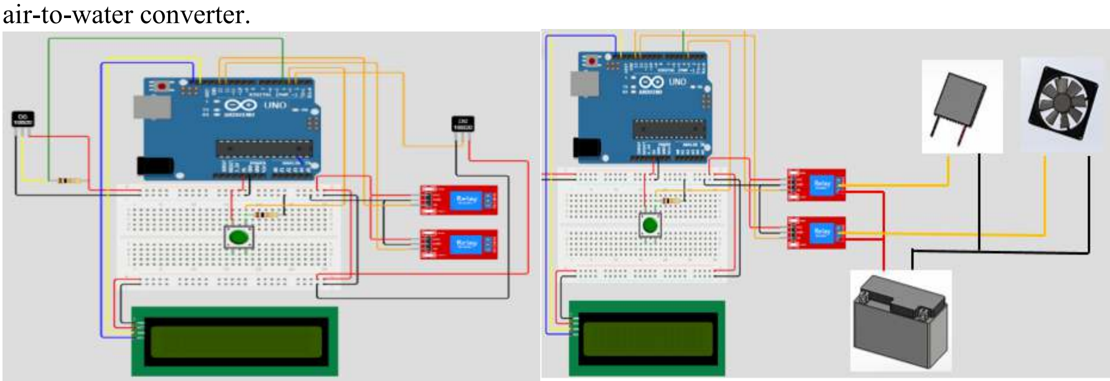


Figure 2. Arduino control system circuit.

At this point, the goal of the Arduino control system design is to arrange the supporting parts into several systems that should function by program instructions. The supporting components that use a thermoelectric module to create temperature variations to turn air into water through condensation will be integrated into the Arduino circuit that was developed. Upon receiving a direct electrical voltage for the module [15]. This thermoelectric component generates cold by converting electrical energy from heat energy or vice versa (thermoelectric cooling) [16].

The Peltier effect, which is caused by a voltage supply between the two electrodes attached to the semiconductor material, is the basis for the thermoelectric module's operation. This effect causes a temperature difference on both sides. When utilizing this module, the hot side heat dissipation mechanism is crucial. Thus, the cold side of the module will have a lower temperature if the hot temperature is the same as the surrounding environment [17]. This is because as the electrons from the hot side move faster, they will diffuse to the cold side, creating an electric field within the material [18].

Using a thermoelectric cooler component is a less complicated technological solution for cooling than utilizing a refrigerant-based vapor compression system, which is nevertheless highly difficult to operate [19]. All parts will come together to form the controller depicted in Figure 3 that operates the air-to-water converter.



(a) Sensor Circuit (b) Thermoelectric Circuit

Figure 3. Circuit of (a) Sensor Components and (b) Thermoelectric.

Building the sensor and thermoelectric circuits seen in Figure 3, together. This circuit contains a variety of components with a range of specifications, in addition to the tool and material characteristics shown in Table 1.

Table 1. Tools and materials.

No	Items	Description	Qty	Units
A.	**Ingredients**			
1	Generator Motors	Capacity 50-100W	1	units
2	SCC	10A 12V	1	units
3	Batteries	12V 7Ah	1	units
4	Controller	Arduino Uno	1	set
5	Temperature sensor	DS18B20	1	set
6	1 channel relay		2	units
7	LCD	16x2 I2C LCD	1	set
8	RPM sensors	LM393	1	set
9	Thermoelectric	TEC-12706 12V	1	units
10	DC Fan	12V 0.3A	1	set
B.	**Measuring Instrument**			
1	Anemometer	Digital UT363	1	set
2	Tachometer	Digital DT-2234L	1	set

The Arduino needs to be programmed to perform commands or operations that have been customized to your needs, just like other microcontrollers. To improve the thermoelectric performance, a cut-off program can be established on the relay that instructs it to connect or disconnect electricity based on temperature commands by the program's mode. This will be demonstrated in Figure 4.

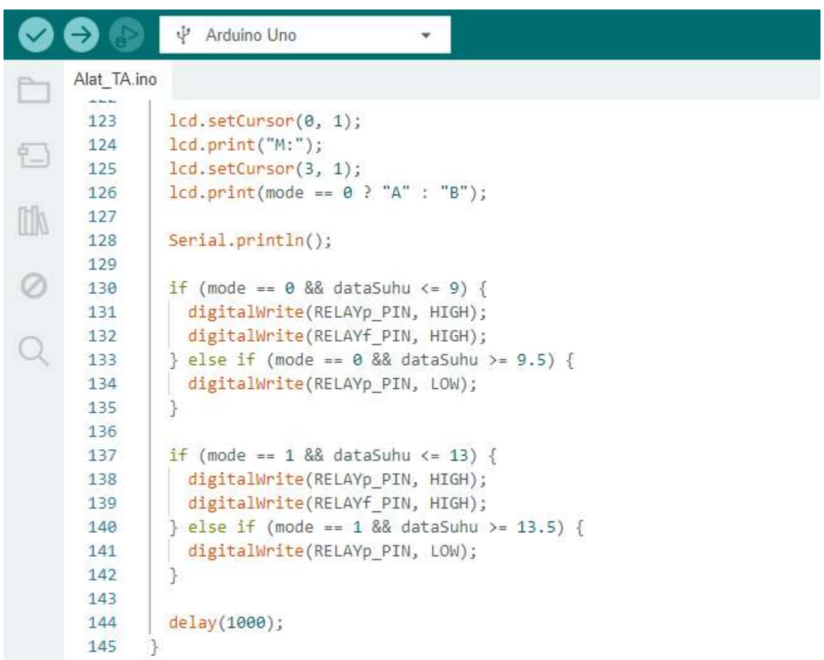


Figure 4. Relay program and mode.

In Figure 4. In response to an instruction, the relay is set up to switch between connecting and disconnecting electricity from the battery. The program consists of two modes: A and B. Mode A will cause the relay to go HIGH when the temperature drops below 9 ºC and LOW when the temperature rises above 9.5 ºC. Mode B will cause the relay to go HIGH when the temperature drops below 13 ºC and LOW when the temperature rises above 13.5 ºC. The LCD will display the mode indicator, and all programs that are commanded will be executed repeatedly.

Sensor calibration is required when using several measuring instrument sensor components, such as temperature and anemometer sensors. This is done to increase the accuracy of the measured values that are produced. Regardless of the program's success, the temperature sensor—which is crucial—needs to be calibrated to improve its accuracy. This way, the readings from other temperature-measuring devices will remain consistent throughout the trial run. This is especially true when the sensor is calibrated correctly. To fully test this tool's ability to turn air into water and produce the best possible water results, researchers need wind data. Procedures for thermoelectric condensation device testing:

a. Verify that the temperature sensor is accurately positioned within the heatsink to ensure an accurate temperature reading and that there are no mistakes in the temperature indicator on the LCD.
b. Adjust the mode to the surrounding air quality
c. After that, complete the condensation process. This will happen automatically by the Arduino software.
d. To determine the ideal temperature for additional testing, use the heatsink's dew point as a reference
e. As an example, see the figure, and make sure the relay is still in the Arduino program command at all times. When the temperature drops below 9 ºC, the relay will be HIGH; when the temperature rises beyond 9.5 ºC, it will be LOW. Additionally, the test will run for an hour based on the battery's capacity.

3. RESULTS AND DISCUSSION

3.1. Dew Point

Finding the dew point values in five trials with different time and temperature circumstances based on the field trial findings Figure 5.

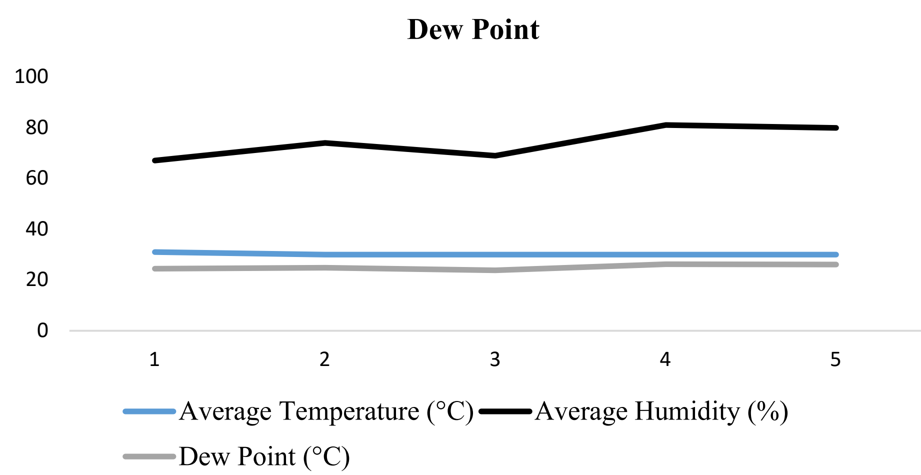


Figure 5. Dew point value graph.

In Figure 5 the fourth experiment has the greatest dew point value, with an air temperature of 30 °C. The dew point value will be closer to 26.2 °C the higher the air humidity, at 81%. This is being done to facilitate tool testing.

3.2. Battery Performance

Calculate how long it will take for the battery capacity to run out with a 12V 7Ah 84 Wh battery capacity.

$$t = \frac{84 \text{ Wh}}{57.6 \text{ W}}$$

$$t = 1.45 \text{ jam}$$

If the generator rotates 300 RPM to calculate how long it takes to charge the battery, namely:

$E = 12\text{V} \times 7\text{A} \times t$

$E = 84 \text{ Wh} \times t$

$19.5 \text{ Watt} \times t = 84 \text{ Wh} \times t$

$$t = \frac{84 \text{ Wh}}{19.5 \text{ W}}$$

$t = 4.31\, jam$

When thermoelectric power is supplied by an 84 Wh battery and a 57.6 W DC fan, the battery's capacity will last for 1.45 hours, or until the battery runs out of power in the absence of a charging source from the wind turbine generating motor. If the shaft rotation is constant at 300 RPM, charging a 12V/7Ah battery takes about 4.31 hours.

Calculating the Coefficient of Performance (COP)

$$COP = \frac{Qc}{W}$$

$$COP = \frac{61{,}65}{58{,}05}$$

$COP = 1{,}062\, w$

Because the COP value balances with the energy utilized by the thermoelectric system, the performance efficiency calculation for thermoelectrics with a COP value of 1.062 W demonstrates that the thermoelectric system is efficient in converting electrical energy into the necessary temperature differential.

Calculating electric resistance in thermoelectrics

$$R = \frac{2 \times 0.00112 \times 127}{0.937}$$

$R = 0.30360\, \Omega$

The resulting resistance value is quite low, which means it will produce a more efficient thermoelectric system and can produce larger temperature differences.

DS18B20 temperature sensor calibration

The DS18B20 temperature sensor had incorrect values in the temperature sensor calibration experiment; Table 2 displays the temperature sensor test table for the DS18B20.

Table 2. DS18B20 Temperature sensor error value.

Test	**Measuring Instrument (°C)**	**DS18B20 sensor (°C)**	**Error Value**
1	30.4	30	0.4
2	31.8	31.4	0.4
3	30	29.6	0.4
4	30.4	30	0.4
5	31	30.6	0.4
Average	30.72	30.32	0.4

It is clear from the data in Table 2, that the temperature sensor's error value was 0.4 because during the calibration tests, there were variations in the results of the computations between the DS18B20 sensor and the digital thermometer measuring device used as a reference.

Anemometer Calibration

Carrying out the calibration process, the following results will be shown in Figure 6.

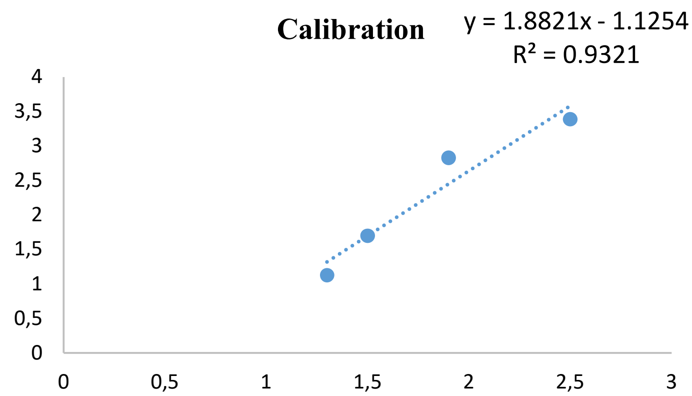


Figure 6. Graph of anemometer error values.

Based on the graph presented in Figure 6, the researcher repeated the experiment, varying the distances of 20, 30, 50, and 70 cm between the anemometer and fan to provide air to the propeller of the anemometer. Following the acquisition of wind speed data, the experiment's error value, 0.9321, was determined by the researchers.

3.3. Controller Performance Results

The apparatus for turning air into water was tested, and the results were produced in the form of water at preset humidity and temperature parameters. The outcomes that the researchers were able to gather were.

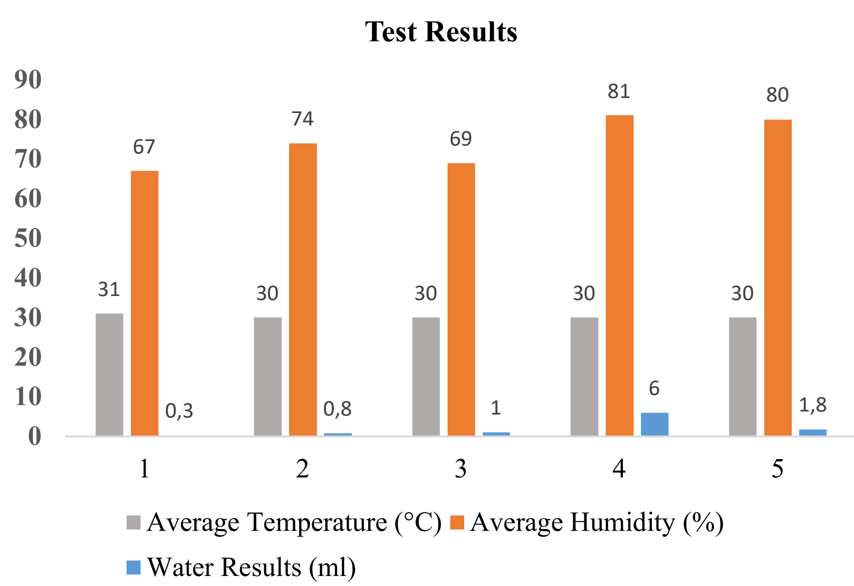


Figure 7. Test results.

Outcomes are shown in Figure 7. As seen in the fourth trial, where the tool generated 6 ml of water at an average temperature of 30 °C, it can be concluded that higher ideal humidity and air temperature values result in bigger water yields. RH 81% on average.

4. CONCLUSION

The researchers concluded that the water produced by the condensation process in the air-to-water converter controlled by the Arduino Uno controller was that which was produced by determining known environmental condition parameters, specifically in the fourth experiment where the average temperature condition was 30 °C and the average humidity was 81%, resulting in the production of 6 ml of water within an hour of the experiment. Along with the effectiveness of the Arduino program, which is designed to be as efficient as possible across all sensors and primary components, it can execute commands automatically and optimally. Additionally, by taking into account the variables that affect the air-to-water converter controller's performance, these variables can be appropriately resolved to ensure that all controllers function as intended. maximum without expending needless energy.

REFERENCE

[1] U. S. Ucok, "A Perancangan Pompa Hidram Pada Tabung Udara Dengan Metode VDI 2221," *TEKNOSAINS J. Sains, Teknol. dan Inform.*, vol. 7, no. 1, 2020, doi: 10.37373/tekno.v7i1.7.

[2] F. A. BELAM, "The importance of clean food," *Med. Off.*, vol. 80, no. 16, p. 176, 1948, doi: 10.2671/BJSTR.2018.08.001719.

[3] R. K. Mishra, "Fresh Water availability and It's Global challenge," *J. Mar. Sci. Res.*, vol. 2, no. 1, pp. 01–03, 2023, doi: 10.58489/2836-5933/004.

[4] P. Kumar *et al.*, "Current assessment and future outlook for water resources considering climate change and a population burst: A case study of Ciliwung River, Jakarta City, Indonesia," *Water (Switzerland)*, vol. 9, no. 6, 2017, doi: 10.3390/w9060410.

[5] R. Li, Y. Shi, L. Shi, M. Alsaedi, and P. Wang, "Harvesting Water from Air: Using Anhydrous Salt with Sunlight," *Environ. Sci. Technol.*, vol. 52, no. 9, pp. 5398–5406, 2018, doi: 10.1021/acs.est.7b06373.

[6] Z. Ahrestani, S. Sadeghzadeh, and H. B. Motejadded Emrooz, "An overview of atmospheric water harvesting methods, the inevitable path of the future in water supply," *RSC Adv.*, vol. 13, no. 15, pp. 10273–10307, 2023, doi: 10.1039/d2ra07733g.

[7] Y. Liang, D. Che, and Y. Kang, "Effect of vapor condensation on forced convection heat transfer of moistened gas," *Heat Mass Transf. und Stoffuebertragung*, vol. 43, no. 7, pp. 677–686, 2007, doi: 10.1007/s00231-006-0148-0.

[8] R. Setiadi, "Study of tension control systems for automatic rotogravure machines," *JTTM J. Terap. Tek. Mesin*, vol. 4, no. 2, pp. 137–147, 2023, doi: 10.37373/jttm.v4i2.537.

[9] Y. Chen, H. Yang, and Y. Luo, "Indirect evaporative cooler considering condensation from primary air: Model development and parameter analysis," *Build. Environ.*, vol. 95, pp. 330–345, 2016, doi: 10.1016/j.buildenv.2015.09.030.

[10] B. Khalil *et al.*, "A review: dew water collection from radiative passive collectors to recent developments of active collectors," *Sustain. Water Resour. Manag.*, vol. 2, no. 1, pp. 71–86, 2016, doi: 10.1007/s40899-015-0038-z.

[11] L. E. Bell, "Cooling, heating, generating power, and recovering waste heat with thermoelectric systems," *Science (80-.).*, vol. 321, no. 5895, pp. 1457–1461, 2008, doi: 10.1126/science.1158899.

[12] B. A. Prior, "Measurement of Water Activity in Foods: A Review," *J. Food Prot.*, vol. 42, no. 8, pp. 668–674, 1979, doi: 10.4315/0362-028x-42.8.668.

[13] H. Jameel and H. Kareem, "Low-cost energy-efficient smart monitoring system using open-source microcontrollers," *Int. Rev. Autom. Control*, vol. 9, no. 6, pp. 423–428, 2016, doi: 10.15866/ireaco.v9i6.10315.

[14] M. Tupac-Yupanqui, C. Vidal-Silva, L. Pavesi-Farriol, A. Sanchez Ortiz, J. Cardenas-Cobo, and F. Pereira, "Exploiting Arduino Features to Develop Programming Competencies," *IEEE Access*, vol. 10, pp. 20602–20615, 2022, doi: 10.1109/ACCESS.2022.3150101.

[15] N. Pandiarajan and R. Muthu, "Mathematical modeling of photovoltaic module with Simulink," *2011 1st Int. Conf. Electr. Energy Syst. ICEES 2011*, no. May, pp. 258–263, 2011, doi: 10.1109/ICEES.2011.5725339.

[16] M. A. Zoui, S. Bentouba, J. G. Stocholm, and M. Bourouis, "A review on thermoelectric generators: Progress and applications," *Energies*, vol. 13, no. 14, 2020, doi: 10.3390/en13143606.

[17] J. R. Salvador *et al.*, "Conversion efficiency of skutterudite-based thermoelectric modules," *Phys. Chem. Chem. Phys.*, vol. 16, no. 24, pp. 12510–12520, 2014, doi: 10.1039/c4cp01582g.

[18] C. Li, A. Guerrero, S. Huettner, and J. Bisquert, "Unravelling the role of vacancies in lead halide perovskite through electrical switching of photoluminescence," *Nat. Commun.*, vol. 9, no. 1, 2018, doi: 10.1038/s41467-018-07571-6.

[19] S. Pezzutto *et al.*, "Screening of Cooling Technologies in Europe: Alternatives to Vapour Compression and Possible Market Developments," *Sustain.*, vol. 14, no. 5, pp. 1–24, 2022, doi: 10.3390/su14052971.