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Achieving Solar Powered -Diffusion Adsorption Refrigeration System in Nigeria: Way Forward

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Abstract-* Over the years, the global energy crisis and the uncertainty in the prices of petroleum fractions have lowered and choked the use of energy for powering both domestic and industrial machines such as compressors, pumps, electric motors and refrigeration systems. Consequently, the cost of refrigerating food items, industrial raw materials as well as low temperature processes becomes very challenging to the engineers and organizations. As electricity production is dominated by indigenous natural gas, coal and hydro which are now under the state of depletion and unsustainable; there is cogent need to device a reliable, eco-friendly, sustainable and cost effective means of generating energy to power most of the important machines such as refrigeration systems. Tailoring to ways and means to reducing the cost of energy consumption in refrigerating plants brought about the model of diffusion absorption refrigeration system where the hermetic compressor is replaced with thermal generator and bubble pump that consume less energy and they are 100% solar powered which makes the whole system economical.

***Keywords:* Solar, Refrigeration, Diffusion, Power, Adsorption, Electricity.**

I. INTRODUCTION

Achieving a steady electricity power supply through the construction of additional power plants stations proposed by Federal Ministry of Power have also increased the price of electricity among the citizens. This is because energy is the lifeblood of modern civilization and an indispensable asset for sustainable development. The continued increase in world population and rapid urbanization has resulted in a rapid increase in global energy demands. As well, due to the growing concern and awareness of environmental issues among the scientific community, power generation from renewable energy sources, particularly solar energy has become significantly important for the last few decades.

According to Desai (2012), solar energy reaching to the surface of the earth can be utilized directly in two ways viz. directly converting the solar radiation to the electricity for useful purposes by the means of solar photovoltaic (SPV) modules or by heating the medium source for low temperature heating applications. Photovoltaic module is not only an expensive but also an essential component of any photovoltaic system and therefore its thermal assessment based on the energy analysis is also paramount important.

100% solar powered diffusion absorption refrigeration system can be used in both rural and remote areas for food storage and vaccine preservation when access to conventional electricity supply is delimited. Similarly, disaster relief 100% solar powered diffusion absorption refrigerators are used to store critical medical supplies and perishable food during emergencies. However, 100% solar powered diffusion absorption refrigerators require regular maintenance, such as cleaning the solar panels and monitoring the battery state of charge to ensure optimal performance.

1.1 Background of the Study

Developed countries use fossil fuels like coal, oil and natural gas as a source of energy to power various domestic and industrial refrigeration plants. In the past two decades, fossil fuel expenditure has increased dramatically. The consumption of these fuels contributes greatly to environmental degradation. Fossil fuels in general are subject to depletion, and at the same time building a society without considering alternative energy sources might endanger the future generation, hence creating a threat of adverse effect to the sustainable development in the long run. Consumption of fossil fuels also explicitly gives rise to greenhouse gas (GHG) concentrations in the atmosphere. Among the greenhouse gases, carbon dioxide (CO2), sulfur dioxide (SO2) emission is thus considered an emerging problem of the world community for its ongoing effect on the environment and the ecosystem, and especially on the surrounding climate change.

Khurmi and Gupta (2013), suggested biogas, wind and solar as alternative energy sources through which industrial and domestic refrigerator systems could be powered. Obviously, wind and solar energy resources are known for zero environmental negative impact. But the sparely nature of wind in Nigeria has limited its reliability as a means of powering refrigerators across the geo-political zones of Nigeria. Solar energy, being abundant in nature, not sparely seen, has been trenched as a reliable means through which refrigerator systems can be powered and as well bring to innovation. The constraints opposing the harnessing of this solar energy in Nigeria has been attributed to availability solar radiation due to weather changes, balancing rate of production and demand with its high initial cost implications. However, the cleanliness, zero operating noise and low operating cost have exacerbated its adoption in powering both industrial and domestic refrigeration systems.

Desai (2012), maintained that many countries' fossil fuel depletion and energy-saving policies have contributed to the development and innovation of solar powered absorption chillers and have been considered an alternative to compression refrigeration chillers. Diffusion absorption refrigeration system can be operated using renewable energy sources, such as geothermal energy, solar heat energy, and waste gas heat from industrial processes. It is also noted that absorption refrigeration machines has contributed to huge reserve of fossil fuel and non-renewable resources that increase purchase costs of conventional cooling systems. The results data from the International Institute of Refrigeration (IIF) show that 17% of the world's electricity production is channeled into heating and cooling of conventional air-conditioning and refrigeration systems to meet the edification and comfort of the humans as well as industrial process plants.

In their study of review of membrane contactors applied in absorption refrigeration system stated that the globe is challenged with energy shortage problem. They proposed that there would be increase in interest of industries and engineers in absorption refrigeration system; since it can be operated with renewable energy sources and also environmentally friendly refrigerants that have zero ozone depletion potentials. The spread of absorption refrigeration system across the globe is well appreciated or a welcome development. However, the area of system plant and equipment optimization to achieve best cooling performance level is really on a speed lane and powered by erudite researchers.

wang (2012) highlighted the various constituent elements of the diffusion absorption refrigeration system as absorber, generator or boiler, energy source, condenser, evaporator, heat exchanger, pump. They further added that different technologies could be combined such as compression refrigeration and adsorption refrigeration systems with several or a single energy source.

Solar energy has been found as one of the ways to drive diffusion adsorption refrigeration system, as cited in Bisulandu et al (2023) therefore, this project aims to present and overview of hybrid 100% solar powered diffusion adsorption refrigeration system that would serve as a necessary sign post in the design, analysis and construction of the diffusion adsorption refrigeration system. The work would also examine the conventional diffusion adsorption refrigeration system and subsequently compare its component elements, performances to predict the shortcomings associated with 100% solar driven system and how to improve the proposed system.

According to Ugwuegbu (2025), Nigeria is blessed by abundant renewable energy resources such as solar, wind, geothermal and nuclear but the harnessing of these energies have been on a slow rate.

Table 1.0: Nigerian's Energy Resources and their Electric Power Potentials

Energy Resource	Potential
Solar	4.0 to 6.5kW/m^2/day
Wind	520Kw/m^2/year
Geothermal	130.28MW/m^2
Nuclear	2400MW

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Hydro	11,250 MW

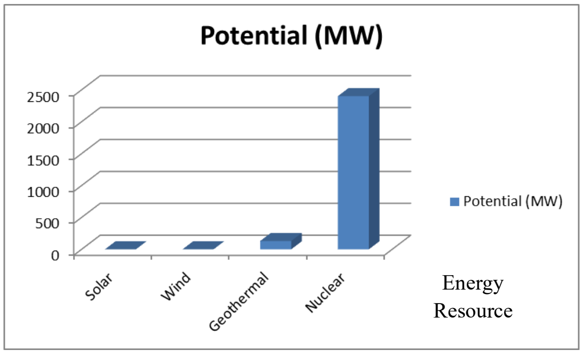

Fig 1.0: Bar Chart of Nigerian's Energy Resources and their Electric Power Potentials

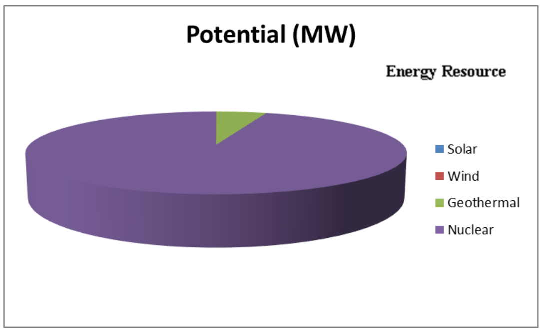

Fig 2.0: Pie Chart of Nigerian's Energy Resources and their Electric Power Potentials

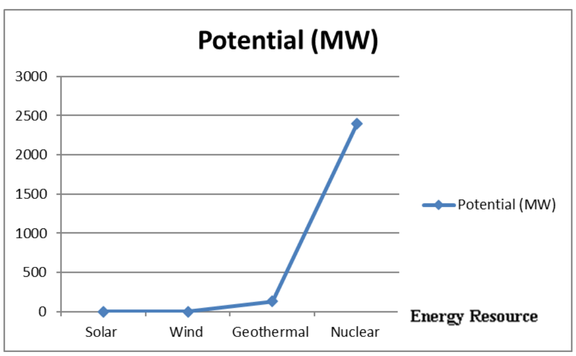

Fig 3.0: Line Graph of Nigerian's Energy Resources and their Electric Power Potentials

Nikbakhti, Wang, and Chan (2020) as cited by Desai (2012) stated that the solar energy is a renewable and environmentally friendly source and presents a substantial potential source of reducing ozone layer depletion and also sustain energy reserve. It was also observed that the harnessed solar energy could be either used directly from dish or trough collector to generator or could be converted to electrical energy, then to heaters or heat exchangers. There is also evolution of hybrid solar that could produce both the needed thermal energy by generator and electric energy required to start the bubble pump drive motor. This is the model the paper aims to adopt. Research studies reviewed, showed that increasing the operational temperature of 100% solar powered absorption refrigeration system, increases both generator and evaporator performances. Wang (2012), stated that a solar heat energy source temperature of 92.7 °C, would give an evaporation temperature of 13 °C, with cooling capacity of 1.9 W and a COP of 1.156. These results are very economical when compared with the same power derived from conventional energy sources. Literature studies suggested that solar flux density received on the panels is a function of time and increases in magnitude with time increment. It was also seen that for the first one hour of operation in a 100% solar powered diffusion absorption refrigeration plant, system response was poor or nearly to zero. Although, the issue of energy management and energy cost remain a significant issue that encompass both the choice of energy source and the availability of energy at all times. Hence, the project aimed at studying hybrid 100% solar powered diffusion- absorption refrigeration system.

According to Ugwuegbu (2025), the cost of on-Grid energy resources for renewable energies are shown below.

Table 2.0: Energy Resources and their Cost of on-Grid Energy

Energy Resource	Cost of on-Grid Energy USD/(kWhr)
Solar	0.157
Wind	0.13
Geothermal	0.053
Nuclear	0.12

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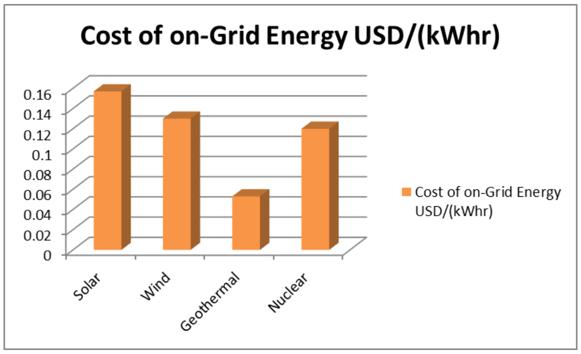

Fig 4.0: Bar Chart of Energy Resources and their Cost of on-Grid Energy

Solar Panel Cooling Wind Speed of Nigeria (Njoku et al, 2023)

Table 3 average monthly wind speed for study locations at 10m/s from 1981-2021 (NASA)

Locations	*Lat. (°N)*	*Long. (°E)*	*Elev. (m)*	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Ave*
Abakaliki	6.33	8.12	88.44	2.77	2.54	2.7	2.84	2.67	2.88	3.16	3.21	2.76	2.26	1.84	2.4	2.67
Abeokuta	7.15	3.37	80.92	2	2.23	2.44	2.44	2.26	2.42	2.84	2.94	2.45	1.99	1.65	1.73	2.28
Abuja	9.08	7.4	406.97	2.9	2.75	2.56	2.48	2.2	2.19	2.42	2.45	1.99	1.77	2.12	2.67	2.37
Ado-Ekiti	7.62	5.24	379.21	2.14	2.2	2.39	2.46	2.23	2.28	2.62	2.68	2.11	1.75	1.64	1.88	2.2
Akure	7.26	5.21	379.21	2.14	2.2	2.39	2.46	2.23	2.28	2.62	2.68	2.11	1.75	1.64	1.88	2.2
Asaba	6.21	6.7	103.94	2.53	2.43	2.56	2.64	2.5	2.79	3.19	3.28	2.81	2.3	1.86	2.14	2.59
Awka	6.23	7.09	103.94	2.53	2.43	2.56	2.64	2.5	2.79	3.19	3.28	2.81	2.3	1.86	2.14	2.59
Bauchi	10.31	9.83	518.79	4.11	4.18	3.83	3.47	3.28	3.01	2.59	2.3	2.3	2.63	3.28	3.82	3.23
Benin-City	6.34	5.61	93.92	1.76	1.71	1.74	1.74	1.64	1.8	2.06	2.13	1.83	1.5	1.29	1.5	1.73
Bida	9.08	6.01	126.59	2.26	2.21	2.23	2.35	2.17	2.14	2.34	2.36	1.89	1.66	1.71	2.05	2.11
Birinin Kebbi	12.44	4.2	241.96	3.64	3.64	3.24	3.08	3.27	2.99	2.43	1.96	1.75	1.89	2.54	3.29	2.81
Calabar	4.98	8.35	39.48	2.08	2.25	2.38	2.43	2.41	2.72	2.99	3.07	2.76	2.39	1.97	1.88	2.45
Damaturu	11.75	11.97	402.61	4.81	4.94	4.62	4.06	3.96	3.94	3.38	2.74	2.39	2.58	3.86	4.54	3.81
Duste	11.75	9.34	465.94	3.02	3.11	3.07	2.98	2.79	2.61	2.17	1.8	1.77	1.99	2.39	2.78	2.53
Enugu	6.46	7.55	151.33	2.78	2.61	2.74	2.85	2.67	2.91	3.28	3.32	2.81	2.3	1.88	2.37	2.71

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Gombe	10.28	11.18	381.62	4.47	4.62	4.12	4	4.06	3.76	3.27	2.76	2.36	2.32	3.08	4.01	3.56
Gusau	12.17	6.68	529.87	4.92	4.82	4.28	3.84	3.61	3.51	3.08	2.61	2.31	2.68	3.74	4.53	3.66
Ibadan	7.38	3.95	188.89	2.17	2.31	2.6	2.71	2.52	2.65	3.08	3.16	2.53	2.03	1.71	1.89	2.45
Ijebu-Ode	6.83	3.92	90.82	1.77	1.94	2.12	2.14	2	2.17	2.54	2.63	2.2	1.78	1.46	1.54	2.02
Ikeja	6.61	3.36	25.49	2.48	2.9	3.24	3.21	2.98	3.36	3.92	4	3.54	2.88	2.29	2.15	3.08
Ikom	5.97	8.73	116.85	2.16	2.31	2.51	2.58	2.48	2.74	3.01	3.12	2.73	2.29	1.82	1.9	2.47
Ilorin	8.48	4.55	344.93	2.72	2.96	3.51	3.84	3.4	3.21	3.47	3.51	2.62	2.25	2.14	2.4	3
Jalingo	8.9	11.38	251.79	3.51	3.5	3.61	4.1	3.67	3.49	3.45	3.16	2.4	2.08	2.32	3.13	3.2
Jos	9.9	8.86	980.85	4.3	4.2	3.82	3.43	2.89	2.68	2.54	2.49	2.41	2.71	3.45	4.06	3.24
Kaduna	10.52	7.42	623.54	4.77	4.49	3.67	3.18	2.85	2.73	2.61	2.47	2.09	2.23	3.46	4.43	3.24
Kano	12.01	8.6	442.08	2.84	2.89	2.78	2.64	2.51	2.39	1.94	1.52	1.44	1.69	2.16	2.58	2.28
Katsina	12.97	7.63	474.54	5.05	4.93	4.54	4.03	3.77	3.85	3.46	2.72	2.45	2.94	4.02	4.7	3.86
Lafia	7.81	6.74	167.21	2.38	2.54	3.01	3.23	2.82	2.71	2.88	2.84	2.32	2.03	1.89	2.12	2.57
Lokoja	7.81	6.74	167.21	2.38	2.54	3.01	3.23	2.82	2.71	2.88	2.84	2.32	2.03	1.89	2.12	2.57
Maidugri	11.84	13.16	318.25	4.57	4.78	4.65	4	3.77	3.98	3.64	2.88	2.57	2.79	3.91	4.34	3.82
Makurdi	7.74	5.54	373.17	2.53	2.65	3.01	3.16	2.83	2.82	3.14	3.19	2.52	2.12	1.97	2.23	2.68
Mbaise	5.54	7.29	92.75	2.34	2.28	2.35	2.41	2.33	2.6	2.92	3.02	2.65	2.21	1.79	1.98	2.41
Minna	7.61	8.09	149.83	3.02	3	3.3	3.42	2.98	2.97	3.18	3.14	2.57	2.17	1.98	2.59	2.86
Nguru	12.88	10.46	345.61	4.94	4.95	4.75	4.07	3.57	3.62	3.39	2.7	2.52	3.1	4.33	4.75	3.89
Onitsha	6.14	6.8	103.94	2.53	2.43	2.56	2.64	2.5	2.79	3.19	3.28	2.81	2.3	1.86	2.14	2.59
Oshogbo	7.79	4.55	337.39	2.43	2.6	3.03	3.23	2.91	2.9	3.31	3.38	2.55	2.06	1.89	2.13	2.7
Owerri	5.47	7.02	62.54	2.26	2.18	2.22	2.25	2.16	2.44	2.77	2.87	2.52	2.1	1.72	1.9	2.28
Port-Harcourt	4.34	7.05	6.8	1.65	1.77	1.76	1.66	1.62	1.86	2.17	2.29	2.03	1.71	1.5	1.45	1.79
Potiskum	11.7	11.09	411.77	4.36	4.47	4.13	3.56	3.43	3.33	2.8	2.27	2.06	2.25	3.38	4.06	3.34

Sokoto	13.01	5.25	276.18	4.51	4.42	3.94	3.59	3.8	3.71	3.12	2.44	2.19	2.38	3.3	4.14	3.46
Umuahia	5.53	7.5	92.75	2.34	2.28	2.35	2.41	2.33	2.6	2.92	3.02	2.65	2.21	1.79	1.98	2.41
Uyo	5.04	7.92	39.48	2.08	2.25	2.38	2.43	2.41	2.72	2.99	3.07	2.76	2.39	1.97	1.88	2.45
Warri	5.55	5.57	9.6	1.36	1.41	1.4	1.3	1.2	1.36	1.64	1.79	1.58	1.28	1.07	1.15	1.38
Yelwa	10.84	4.75	257.74	3.94	3.89	3.36	3.35	3.15	2.9	2.65	2.48	2.07	2.05	2.81	3.54	3.01
Yenegoa	4.93	6.28	17.26	2.08	2.15	2.23	2.19	2.09	2.37	2.72	2.87	2.56	2.14	1.78	1.77	2.25
Yola	9.04	12.5	344.13	2.48	2.82	3.36	3.55	2.94	2.68	2.59	2.36	1.91	1.91	2.05	2.21	2.57
Zaria	11.13	7.73	646.9	4.86	4.67	3.97	3.5	3.23	3.11	2.82	2.53	2.2	2.39	3.51	4.45	3.43
			Ave	3.01	3.05	3.04	2.97	2.77	2.82	2.88	2.76	2.36	2.18	2.33	2.71	2.74
			Max	5.05	4.95	4.75	4.1	4.06	3.98	3.92	4	3.54	3.1	4.33	4.75	3.89
			Min	1.36	1.41	1.4	1.3	1.2	1.36	1.64	1.52	1.44	1.28	1.07	1.15	1.38

1.2 Problem Statement

Obviously, studies from literatures showed the importance of delving into other means of powering diffusion absorption refrigeration systems to save the world's energy reserve. According to results data from the International Institute of Refrigeration (IIF), 17% of the world's electricity production is channeled into heating and cooling of conventional air-conditioning and refrigeration systems to meet the edification and comfort of the humans as well as industrial process plants. The review of countries' fossil fuel depletion and energy-saving policies by Lingeswaran and Hemalatha, (2014) revealed that many countries suggested the development and innovation of solar powered absorption chillers and have been considered an alternative to compression refrigeration chillers as a means of energy savings.

Developed countries use fossil fuels like coal, oil and natural gas as a source of energy to power various domestic and industrial refrigeration plants. In the past two decades, fossil fuel expenditure has increased dramatically. The consumption of these fuels contributes greatly to environmental degradation. Fossil fuels in general are subject to depletion, and at the same time building a society without considering alternative energy sources might endanger the future generation, hence creating a threat of adverse effect to the sustainable development in the long run. In addition, as electricity production is dominated by indigenous natural gas, coal and hydro which are now under the state of depletion. There is immediate need to foster a reliable, affordable and eco-friendly means of generating energy to power most of the important machines such as refrigeration systems.

Finally, among the alternative energy sources through which diffusion absorption refrigeration system can be powered, solar energy showed more flexibility and could be harnessed, used as hybrid solar that could produce both the needed thermal energy by generator and electric energy required to start the bubble pump drive motor, according to Nikbakhti, Wang, and Chan (2020). It is on this note that the study aimed at studying hybrid 100% solar powered diffusion-absorption refrigeration system.

1.3 Justification of Study

The result of this study will be beneficial to Nigerians, scientists /air condition and refrigeration engineers in the following ways:

i. Air condition and refrigeration engineers can understand how to solve the problem of decoupling air condition and refrigeration systems from conventional energy sources to proffer solution to the epileptic power supply in Nigeria.
ii. The outcome of this research will bring to the limelight the domestication and deployment of diffusion absorption refrigeration system to rural and remote areas marginalized from electric power supply.
iii. This project will be a contribution to the body of literature in the area of refrigeration and air condition systems.

1.4 Aim and Objectives

The study aims to study a hybrid 100% solar powered diffusion- absorption refrigeration system.

The objectives are:

i. Design conceptualization of a 100% solar powered diffusion absorption refrigeration system.
ii. Analyzing the problem of solution circulation in a 100% solar powered diffusion absorption refrigeration system.
iii. Solar heat energy and solar electric energy hybrid diffusion absorption refrigeration system.

1.5 Scope of the Study

This research study focused on a hybrid 100% solar powered diffusion- absorption refrigeration system. So, all efforts would be directed towards the aim and the project should follow engineering recommended approaches in the design conceptualization of the system.

The design of the hybrid 100% solar powered diffusion absorption refrigeration system would be carried out using AutoCAD software, and data analysis would be achieved using relevant engineering software. In addition, the study will not consider the impact of weather changes on system performance and other external environmental factors affecting solar radiation. Some of the limitations of the study include financial constraint- insufficient fund tends to impede the efficiency of the researcher in sourcing the relevant materials, literature, or information and in the process of data collection. Time constraint- the researcher will simultaneously engage in this study with other academic work. This consequently will cut down on the time devoted to the research work.

II. SOLAR PHOTOVOLTAIC AS A HYBRID ENERGY DEVICE

Solar photovoltaic (SPV) refrigeration system consists of two 80W SPV panels used to convert solar energy into electrical energy and are arranged in parallel. The purpose of this arrangement was to have sufficient potential difference across the properly charging 12V battery. The panels are kept on fixed masonry structure at 35° (tilt angle) from horizontal, facing south direction. A battery is used so that it could give high starting current required to start the motor of the bubble pump. It consisted of one 12 V – 150 Ah sealed lead batteries connected in parallel. Panels were connected to the battery via charge controller which prevents the battery from deep discharge. Battery supplied DC current to refrigerator as it operated on DC current. The incident radiation falling on the surfaces of panels produces thermal energy that can be transferred to cooling water running inside tube under neat the panels. The heated water inside the tube can be piped to the generator or heat exchanger as a heat source.

The solar photovoltaic (SPV) powered refrigeration system generates both electrical and thermal energy from solar radiation. As a result, the energy and exergy analysis of the system is to be determined. The energy analysis is concerned only with the quantity of energy in use and the efficiency of energy processes. Exergy is the maximum work potential which can be obtained from energy. The Solar energy reaching the surface of the earth can be converted into both electric energy and thermal energy respectively, required to drive the motor pump and for heating the generator for low temperature heating.

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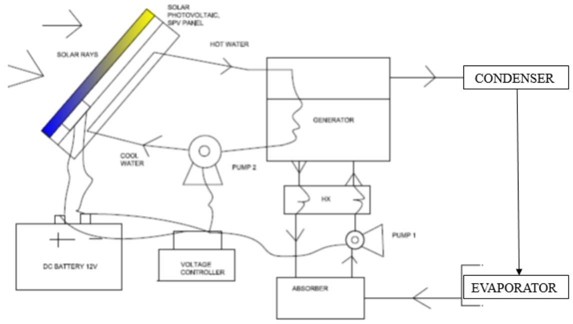

Fig 5.0: Adopted Model of 100% Solar Powered Diffusion Absorption Refrigeration System with Hybrid Energy Solution (Efosa, Ibezim, Iwueze and Ewurum, 2025).

REFERENCES

[1] Desai, P, S. (2012). Text book of Modern Refrigeration and Airconditioning for Engineers.

[2] Efosa, O., Ibezim,J.M., Iwueze, I & Ewurum, T.I. (2025). Development and Application of 100% Solar Powered Diffusion Absorption Refrigeration System as a Panacea for Nigeria Electricity Challenges. *International Journal Research Publication and Reviews.*

[3] Nikbakhti, R., Wang, X & Chan, A. (2020). Performance Analysis of an Integrated Adsorption and Absorption Refrigeration System. International Journal of Refrigeration, (117), pp: 269–283.

[4] Khurmi, R.S and Gupta, J.K. (2013). Text book of Thermal Engineering.

[5] Wang, H. A. (2012). New Style Solar-Driven Diffusion Absorption Refrigerator and Its Operating Characteristics. Energy Procedia, (18), pp: 681–692.

[6] Karamangil, M.I., Coskun, S., Kaynakli, O & Yamankaradeniz, N. (2010). A Simulation Study of

[7] Performance Evaluation of Single-Stage Absorption Refrigeration System Using Conventional Working Fluids and Alternatives. *Renewable and Sustainable Energy Revised, (14), 1969–1978.*

[8] Lingeswaran, K. &Hemalatha, C. (2014). Experimental Studies on Solar Powered Diffusion Absorption Refrigeration. *Middle-East Journal of Scientific Research 20 (7) ,pp: 876-880.*

[9] Ugwuegbu, D. C.(2025). Comparative analysis of solar, wind, geothermal and nuclear energies in solving nigeria's perennial problem of inefficient electric power supply. *Iconic Research and Engineering Journal.*