

A Comparative Analysis of a Solar Powered Dc Refrigerator and a Conventional Ac Powered Refrigerator

Raheem A. O.,AbubakarB.,Mahmood M. K,Lawal O. K.,Kabir S. D.

The Federal Polytechnic Bida

National Board for Technical Education

Corresponding Author:Raheem A. O

ABSTRACT

This Paper Presents A Comparative Analysis Of A Solar Powered Dc Refrigerator (A Tertiary Education Trust Fund Sponsored Project 2016/2017, The Federal Polytechnic Bida, Niger State) And A Conventional Ac Powered Refrigerator. The Comparison Was Based On Current Consumption And Corresponding Cooling Effect Of Each Refrigerator Using A Multi-Meter And Lm35 Temperature Sensor Through A Liquid Crystal Display (Lcd) To Display The Temperature On Screen In Degree Celsius. The Dc Refrigerator Has A Compressor Rating Of 74w Having Same Litres Capacity Of 75l With The Ac Refrigerator Of 80w Compressor. The Multi-Meter Was Connected In Series With Each Load For Six Hours; The Current Was Measured And Recorded While The Lm35 Sensor Displays The Temperature. The Starting Current Of The Dc Refrigerator Was 5.68a While 3.8a Was Recorded For Ac Refrigerator, The Dc Refrigerator Was Operating On 12v And The Battery Went As Lower As 10.68v Before It Went Off While The Ac Refrigerator Was Supported With A Stabilizer To Step Up The Low Voltage From The Utility Company Which Was Too Low To Start The Unit And The Supply From The Utility Lasted For Just Six Hours. With The Same Volume Of Item In Both Refrigerators And Refrigerator Capacity, The Dc Unit Shows More Efficiency Since It Has A Smaller Compressor Made By Danfoss, And Even With Low Voltage The Unit Was Able To Operate With A Reasonable Cooling Effect. Its Reliability In Terms Of Power Supply Supersedes The Ac Unit. This Paper Has Demonstrated The Viability Of Using Dc Powered Refrigerator And The Need To Promote Its Usage Especially In Developing Countries Like Nigeria Where Continuous Power Supply From Utility Is Far From Reality.

Keywords: Renewable Energy, Solar Power System, Dc Power, Dc Refrigerator, Ac Refrigerator.

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I. INTRODUCTION

A Pv Powered Refrigerator Or Freezer Has A Cooling Capacity Lower Than Typical Alternative Current (Ac) Unit Because Of Its Smaller Compressor. Using The Energy Efficiently In Solar Or Other Renewable Energy Powered Systems Is More Crucial Than Others Since The Limited Sources And High Costs For The Storage Capacity [1]. Refrigerators Used In Daily Life Are One Of The Indispensable Tools. Uninterrupted Power Should Be Supplied To Refrigerators In Order To Maintain Cooling Service. Photovoltaic (Pv) Systems Provide An Independent, Reliable Electrical Power Source At The Point Of Use, Making It Particularly Suited To Remote Locations. For This Reason, Nowadays, The Use Of Pv Solar Energy In Refrigeration Has Been Increasing In Rural Regions [2]. Refrigeration Is A Method Of Lowering The Temperature Of Substances Below That Of The Surrounding In Order To Preserve Or Make Them Suitable For Consumption In The Nearest Future [3].

This Paper Compares And Analysis A Dc Powered Refrigerator With A Conventional Ac Powered Refrigerator. The Objectives Of This Paper Is To Compare The Current (A) Consumption And Cooling Effect Of A Dc And Ac Powered Refrigerator, And Also Their Reliability In Terms Of Power Supply

The Rest Of The Paper Is Prearranged Thus: Section 2 Presents The Literature Review. Section 3 Presents The Method Of Comparison And Parameters Compared. Section 4 Covers The Results, And Section 5, Conclusion And Recommendations Were Made.

II. LITERATURE REVIEW

The Author Of [4] Reviewed Solar Refrigeration Options On Different Technologies That Are Available To Deliver Refrigeration From Solar Energy. The Review Covers Solar Electric, Solar Thermal And Some New Emerging Technologies. The Solar Thermal Systems Include Thermo-Mechanical, Absorption And Desiccant Solutions. A Comparison Was Made Between The

Different Solutions Both From The Point Of View Of Energy Efficiency And Economic Feasibility. Solar Electric And Thermo-Mechanical Systems Appear To Be More Expensive Than Thermal Sorption Systems. Absorption And Adsorption Are Comparable In Terms Of Performance But Adsorption Chillers Are More Expensive And Bulkier Than Absorption Chillers. The Total Cost Of A Single-Effect Libr–Water Absorption System Was Estimated To Be The Lowest. The Author Of [1] Did A Performance Evaluation Experimentally On A Pv-Powered Refrigeration System Based On Exergy Analyses Of A Household Refrigerator To Obtain Efficient Operation Conditions Based On The Experimental Data And It Was Discovered From The Result Obtained That According To Energy Analysis The Highest Coefficient Of Performance Of The Refrigerator (Cop_r) 0.670 Was Observed During The No Storage Condition. Also, Compressor Power Consumption Was Low For That Period. However, The Highest Exergetic Coefficient Of Performance Is 0.068 At The Low Load Condition. Therefore, It Was Concluded That A Small Household Refrigerator With Dc Compressor Can Be Operated Pv Power Without Any Inverter. The Author Of [5] Performed A Developmental And Experimental Study Of Solar Powered Thermoelectric Refrigeration System, The Developed Experimental Prototype Had A Refrigeration Space Of 1liter Capacity And Was Refrigerated By Using Four Numbers Of Peltier Module (Supercool : Pe-063-10-13, $Q_{max}=19w$) And A Heat Sink Fan Assembly Used (Model No: Tdex6015/Th/12/G, $R_{th}=1.157 Oc/W$). The Result Shows That The Developed Thermoelectric Refrigeration System Is Having Potential Application Of Storage, Transportation Of Life Saving Drugs ,Biological Materials At Remote Areas And The Performance Of Thermoelectric Refrigerator (Ter) System Can Be Improved Further With Use Of Increased Figure Of Merit Peltier Modules And Efficient Heat Exchange Technology. Ref.[6] Used Solar Energy To Design And Develop Energy Efficient Solar Based Refrigeration System For Milk Cooling At Village Level Society With Solar Based Vapour Absorption System For Milk And Milk Related Cooling Operations. It Was Concluded That The Field Level Application Of Solar Based Refrigeration System For Milk Cooling And Solar Based Vapour Absorption System For Commercial Application For Milk And Milk Related Cooling Operations Are Minimum. There Is An Urgent Need To Develop Commercially Viable Solar Based Refrigeration System For Such Applications.

2.1 Efforts Made On Dc Refrigerators And Comparisons So Far.

Ref. [4] Did Comparison On Only Energy Efficiency And Economic Feasibility Of Solar Electric, Solar Thermal And Some New Technologies Refrigerators But Did Not Perform Any Comparison On Dc Powered Refrigerator With Dc Compressor And An Ac Powered Refrigerator. The Performance Evaluation Done By [1] Was Only Based On Exergy Analysis Of A Dc Powered Refrigerator. Meanwhile, The Work Done By [5] Was Based On Experimental Study Of Solar Powered Thermoelectric Refrigerator System, The Performance Was Observed On Storage Application, Transportation Of Life Saving Drugs And Biological Materials But No Comparison Was Done On The Power, Cooling Effect Or Current Consumption. The Author Of [6] Only Observed That The Field Level Application Of Solar Power Refrigerator To Be Minimum Compare To The Conventional Ac Powered, No Comparison Was Made On It Reliability Or Energy Consumption.

III. METHOD OF COMPARISON AND PARAMETERS USED

The Comparison Was Done On Designed 74w Dc Compressor Powered Refrigerator, A Tertiary Education Trust Fund (Tetfund) Sponsored Institution Based Research (Ibr) Work 2016/2017 Fund With A Conventional 80w Ac Powered Refrigerator Of Equal Capacity And Volume Of Item.

In This Comparison, The Hourly Current (I) Consumption Of Both Units And The Cooling Effect Were Observed And Measured Using A Multi-Meter, And Lm35 Was Used To Measure The Temperature With Liquid Crystal Display(Lcd) 16by4 As A Display.

3.1 Circuit Connection Of The Multi-Meter.

Reading Current Is One Of The Trickiest And Most Insightful Readings In The World Of Embedded Electronics. It's Tricky Because Current Has To Be Measured In Series. While Voltage Is Measure By Poking At Vcc And Gnd (In Parallel), To Measure Current There Is Need To Physically Interrupt The Flow Of Current And Put The Meter In-Line.

In This Test On The Multi-Meter, The Red Cable Was Inserted Into The 10a Jack And The Meter Switch Was Set To Measure 10a Dc. Then The Black Cable Was Put Into The Com (Ground) Jack. For Polarity, Positive Current Flows Into The Red Lead And Back Out Of The Black Common Lead. Measurements Are Made By Placing The Meter Leads In Series With The Refrigerator. The Scale Was Set To 10a Dc For Dc Refrigerator And The Lead In The 10a Jack For Ac Refrigerator. The Readings Were Taken For Both Dc And Ac Powered Refrigerators For Six Hours.

Six Hours Was Chosen Because The Utility Company Supplies Six Hours Of Power At Must In A Day. The Pictorial View Of The Multi-Meter Jack Connection And A Single Line Series Circuit Of Current Measured For Both Dc And Ac Power Is Shown In Figure 3.1 And 3.2 Respectively.



Figure 3.1: The Pictorial View Of The Multi-Meter Jack

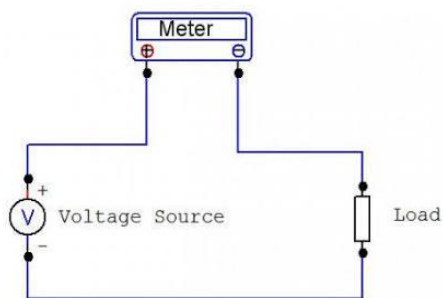


Figure 3.2: A Single Line Series Circuit Of Current Measured For Both Dc And Ac Powered Refrigerator

1.2 Lm35 Temperature Sensor

The Temperature Sensor Is An Lm35 Which Is A Three Terminal Semi-Conductor Device That Convert Analog Temperature To Voltage In Millivolts. The Lm35 Was Interface With The Microcontroller Through The Analog To Digital Port (Adc) But Only Of One The Adc Pin Was Used Since The Temperature Sensor Has Only One Output Pin. The Lm35 Senses The Temperature And Convert It To Voltage Which Is Now Process By The Microcontroller And Finally Converted To Digital Form. This Temperature Sensor Can Sense Up To Maximum Of 150 Degree Centigrade (4800°f). Figure 3.3 Show The Complete Pictorial View Of The Display Temperature.

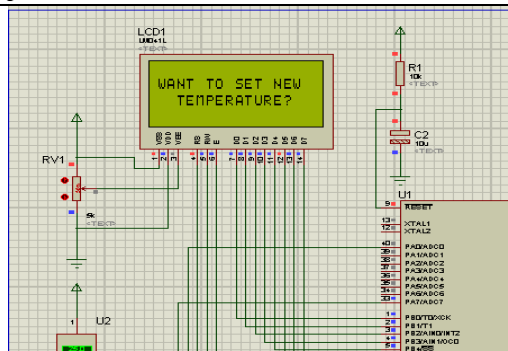


Figure 3.3a: Simulation Display Of Temperature Setting On Proteus



Figure 3.3b: Result On Lcd Display Of Temperature Setting

IV. RESULTS

The Refrigerators Were On And Readings Were Taken And Recorded Using Multi-Meter. The Temperatures Of The Refrigerators Were Observed On The Lcd And The Degree Changes In Temperature Of The System With Time Were Also Taken.

4.1 Result On Ac Powered Refrigerator

Table 4.1 Shows The Current And Temperature Change On The Ac Refrigerator Recorded For Six Hours. The Refrigerator Was Powered By The Utility Company Supply (Abuja Electricity Distribution Company) And After Six Hours Due To Epileptic Nature Of Utility, The Supply Was Interrupted And The Measured Values Were Recorded. The Starting Current Was Recorded To Be 3.8a At 27°c.

Time (Hour)	Temperature (°c)	Current (A)
1 st	18	0.64
2 nd	12	0.62
3 rd	09	0.62
4 th	06	0.61
5 th	05	0.61
6 th	03	0.60

Meanwhile The Refrigerator Was Supported With Stabilizer To Produce The Required Out Voltage 230v To Power The Unit Since The Power Supply From The Utility Company (Aedc) Is Always Low Voltage.

4.2 Result On Dc Powered Refrigerator

Table 4.2 Shows The Current And Temperature Change For The Dc Refrigerator Recorded For Six Hours Too. The Refrigerator Was Powered Directly From The Battery (Two 12v/100ah Connected Parallel) And Lasted For More Than 24hours But Six Hours Was Recorded For The Analysis. The Battery Voltage Was 13.82v; Staring Current Was 5.68 At 26°C.

Time (hour)	Temperature (°C)	Current (A)
1 st	19	3.61
2 nd	15	3.38
3 rd	09	3.17
4 th	05	2.98
5 th	03	2.75
6 th	02	2.69

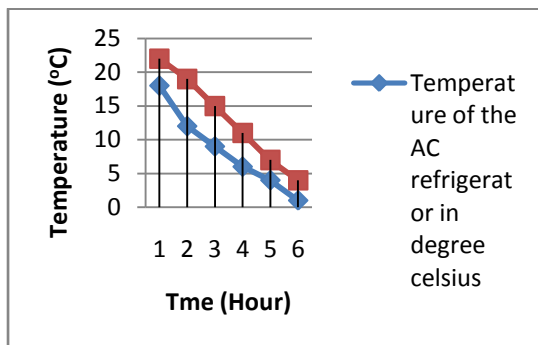


Figure 4.3: Graphical Representation Of Current Consumed By The Ac And Dc Refrigerator With Time

V. CONCLUSION AND RECOMMENDATIONS

This Paper Has Demonstrated The Effectiveness And Efficiency Of Using Renewable Energy From Solar To Power Dc Refrigerator Over Ac Refrigerator Especially In Remote Areas Of Developing Countries. The Dc Refrigerator Was Running With Voltage As Low As 10.68v From

The Battery And Continuously Without Interruption, Its Temperature Drops With Time And Corresponding Current Drops To As Low As 2.30a. Meanwhile, The Ac Refrigerator Was Effective But Not Reliable As The Voltage Supply From The Utility Company Is Always Low (120v And Below) To Power The Unit And The Supply Is Epileptic. The Result Of This Work Indicates That Appliances Use In Homes, Place Of Work, Hospital Et Cetera Can Be Powered Directly Using Dc Means With Low Power Requirement. Therefore, It Is Recommended That Dc Power Refrigerators Should Be Promoted In Developing Countries Like Nigeria To Improve In Agro Storage, Sme Business And Clinical Storage For Sustainable Development.

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