Journal of the Nigerian Association of Mathematical Physics
Volume **22 (November, 2012), pp 553 – 560**

Economic Analysis, Design and fabrication of a Solar Powered Barbing Salon

[1]Ebunilo P.O.B [2]Kwasi-Effah C.C. and [3]Sadjere E.G

[1]Department of Mechanical Engineering,
University of Benin, P.M.B 1154, Benin City, Nigeria
[2]Department of Mechanical Engineering,
University of Benin, P.M.B 1154, Benin City, Nigeria
[3]Niger Delta Development Commission, Port-Harcourt, Nigeria

Abstract

Industrialization and economic growth rate of a developing country depends on the small and medium enterprises (SMEs), availability and utilization of energy in that country. In this paper, a solar powered barbing salon having an average energy consumption of 1175Watt-Hour was designed and fabricated. With an Initial investment of N162,000 and considering 10% annuity in a period of 5 years, comparison between 3 design concepts showed that the pay-back period for the most viable design is 3 months 14 days with a Net Present Value (NPV) and Profitability Index (PI) of N1, 964, 751 and 13.128 respectively. However, profitability index of the design prototype was found to be 11.10 > 1 showing that the project was truly feasible. The design analysis has shown that the solar powered barbing salon is a stand-alone energy system. This energy resource is renewable, has zero or low GWP (global warming potential) and zero ODP (ozone depletion potential), is environmentally friendly, noiseless and stress free during operation.

Keywords: Solar energy, Barbing Salon, Net Present Value, Profitability Index, Pay-back Period, Renewable, Global Warming, Design.

Abbreviations:
R= Rent,
G=Gross profit,
$\cap$ = Initial investment,
Hrs=Hours,
P_r = Theoretical power required (W),
P_{ra} =Actual required power (W) ,
BC = Battery capacity (Ah),
Gp = Gross profit ,
Cre= Cost of rent.
Cf = Cash flow
Rt = Rate of return
NPV = Net Present Value
R_{ep} = Revenue per day
N_{CT}= Number of clients
P_{rt} = Price per hair cut

1.0 Introduction

Nigeria is richly endowed with abundant human and natural resources. The country is blessed with a variety of mineral deposits including petroleum, natural gas and other solid minerals. Over the last 3 decades, the country has earned over 300 billion US dollars from oil sales. However, this has not reflected on the standard of living of its citizenry [1]. In recent times,

[1]Corresponding author: ***Ebunilo P.O.B,*** E-mail: ebunilo17@yahoo.co.uk, Tel. +234 8037136102

the government has come to recognize the importance of entrepreneurship in economic development. Economic development is not fostered by few large scale or multinational industries but by numerous entrepreneurial ventures or small scale enterprises having the capacity to provide employment and aid economic growth [2].

Nigeria has been working tirelessly to achieve economic independence. Efforts have been streamlined towards macroeconomic stabilization and investment liberalization program through privatization of public work places aimed at attracting foreign investment with the hope of accelerated economic growth [3]. As part of the MDG's objective to eradicate poverty in the country by year 2015, the barbing Salon has so far contributed immensely as a Nigerian Small and Medium Scale Enterprise [4]. However, the unreliable energy supply in the country has contributed significantly to the reduction of profit and increased maintainability cost thus, reducing the value of income to those running the business. Fossil fuels can power motor generators for electrical service in barbing salon, but these generators are often nonfunctional, always expensive, emit greenhouse gases. However, renewable energy from the sun is an abundant, ubiquitous and sustainable resource which has zero or low GWP (Global Warming Potential) and ODP (Ozone Depletion Potential), and is thus more environmentally friendly [5]. Although capable of providing plentiful and reliable electricity, these resources are largely untapped. Hence, this paper is aimed at showing that solar energy which is a cost effective alternative is highly reliable and can be used to powering a barbing salon.

2.0 Materials and Methods

Having conducted a survey in some barbing salons, the major appliances found and energy consumed by each appliance are shown in Table 1.

Table 1: Energy consumed by appliances.

Appliances	Number	Power Rating (Watt)	Duration of Work (Hrs)	Energy Consumed per day (WH)
Electric clippers	2	10	14	280
Energy saving bulb	1	25	5	125
Electric fan	1	50	5	700
Miscellaneous		5	14	70
Total				1175

From Table 1, the total energy consumed per day is 1175WH. Three design models where considered for this energy demand, and the most cost effective was recommended.

Design 1

Solar Panel Sizing

Since the average daily insolation period in Nigeria is 11hrs, the total daily power requirement for battery charge

$$P_r = \frac{1175}{11} = 106.8\text{W} \tag{1}$$

Assuming 20% Inefficiency,

$$P_{ra} = \frac{120}{100} * 106.8 = 128.16\text{W} \tag{2}$$

Using a 65W, 24V solar panel; Number of panel is 128.16/65=1.97 approximately 2 panels.

Inverter sizing

Total power of appliances = 100W
For safety, the inverter should be considered 25-35% bigger in size [6]
Hence inverter size should be 130W on the average.

Battery Sizing

To find out the size of battery, calculation was done as follows [6]:

$$BC = \frac{\text{Total Watt-hours per day used by appliances}}{(0.85 \times 0.6 \times \text{nominal battery voltage})} \times \text{Days of autonomy} \quad (3)$$

Where 0.85 is the battery loss

0.6= depth of discharge. Note that, it is advisable to maintain a reasonable depth of discharge (DOD) to prolong battery's life.

From Table 1, total Watt –hour/day= 1175WH

Assuming nominal battery voltage= 24V (series)

Days of autonomy (i.e number of days system needs to operate without power from PV panel)=2

$$BC= \frac{1175}{(0.85x0.6x24)} \text{ x } 2= 191.99AH \quad (4)$$

So the battery capacity should be rated 200AH, 24V for 2 days autonomy.

Table 2: Design 1 component specification

Quantity	Components
2	65W Solar panel,
1	200AH Deep cycle battery,
1	130W Inverter

Design 2

Solar panel sizing

The total daily power requirement for charge

From equations (1) and (2), using a 80W, 24V solar panel; Number of panel is

$$N_p= \frac{128.16}{80} =1.60 \quad (5)$$

Approximately 2 panels.

Inverter sizing

Total power of appliances = 100W

Hence inverter size should be 130W on the average.

Battery Sizing

$$BC= \frac{1175}{(0.85X0.6X24)} \text{ x } 2 = 191.99AH \quad (6)$$

So the battery capacity should be rated 200AH, 24V for 2 days autonomy.

Table 3: Design 2 components specification

Quantity	Components
2	80W Solar Panel,
1	200AH Deep cycle battery,
1	130W Inverter

Design 3

Solar panel sizing

Using a 170W, 24V solar panel; Number of panel is

$$N_p= \frac{128.16}{80170} =0.75 \quad (7)$$

Approximately 1 panel.

Since the load remains constant, the design 3 specification is shown in Table 4:

Table 4: Design 3 components specification

Quantity	Components
1	170W Solar Panel,
1	200AH Deep cycle battery,
1	130W Inverter

Economic analysis

It is important to determine the cost effectiveness of the 3 designs and recommend the most feasible for implementation. Tables 5-7 show the initial investment for various designs as at May 2012.

Table 5: Design1 initial investment

Components	**No of Components**	**Cost price/component**	**Total Cost ₦**
65W panel	2	32,500	65000
Inverter	1	40,000	40,000
Deep cycle battery	1	50,000	50,000
Clippers	2	3,500	7,000
Total			162000

Table 6: Design 2 initial investment

Components	**No of Components**	**Cost price/component**	**Total Cost ₦**
80W panel	2	44,000	88,000
Inverter	1	40,000	40,000
Deep cycle battery	1	50,000	50,000
Clippers	2	3,500	7,000
Total			**185000**

Table 7: Design 3 initial investment

Components	**No of Components**	**Cost price/component**	**Total Cost ₦**
170W panel	1	90,000	90,000
Inverter	1	40,000	40,000
Deep cycle battery	1	50,000	50,000
Clippers	2	3,500	7,000
Total			**187000**

The monthly revenue and rent of a sample of 12 shops is shown in Table 8.

Table 8: Monthly revenue and rent

Shop	Revenue(₦)/Month	Rent(₦)/Month
1	45,000	3500
2	54,000	3000
3	21,000	4000
4	24,000	3000
5	30,000	4000
6	60,000	700
7	381,000	4000
8	67,500	5000
9	90,000	3000
10	112,500	5000
11	90,000	4000
12	30,000	3000
Total	**1,005,000**	**42,200**

Source: [4]
Average gross profit anticipated

$$Gp = \frac{\sum G}{N} = \frac{1,005,000}{12} = ₦83,750/\text{ month} \quad (8)$$

Anticipated operating expenses=cost of rent + 40% (gross profit) payments of employee plan
Average cost of rent

$$Cre = = \frac{\sum R}{N} = \frac{42,200}{12} = ₦\ 3,516.67 \quad (9)$$

Approximately 3500/ month
Cash inflow = Gross profit-Operating expenses (rent + 40% of gross profit)
Cash inflow = (83,750-3500 + (0.4x83, 750)) = ₦ 46750/month
Annual cash inflow = N46750x12= ₦ 561,000/yr on annuity consideration.

Table 9: Cash flow for comparing design 1, 2 and 3

No of years	Design 1 ∩ = N 162,000 Cash flow	Design 2 =N 185,000 Cash flow	Design 3 ∩ =N 187,000 Cash flow
1	561,000	561,000	561,000
2	561,000	561,000	561,000
3	561,000	561,000	561,000
4	561,000	561,000	561,000
5	561,000	561,000	561,000

The Pay-back period (PB)

Pay-back period denotes the time to recover the capital based on projected cash flow [8]

Design 1

Average Pay-back period

$$PB = \frac{\cap}{cash\ flow} = \frac{162,000}{561,000} = 0.2887\text{yrs} \quad (10)$$

Approximately 3 months 14 days.

Design 2

Average Pay-back period

$$PB == \frac{185,000}{561,000} = 0.3297\text{yrs} \quad (11)$$

Approximately 4 months

Design 3

Average Pay-back period

$$PB= \frac{187{,}000}{561{,}000} = 0.3333 \text{ yrs} \quad (12)$$

Approximately 4 months.

All the designs are acceptable on the basis of average payback period consideration. However, design 1 is of higher advantage.

The Net Present Value (NPV)

It is defined as the difference between the cash flow discounted by the firms cost of capital and the initial investment.

$$NPV= \sum \frac{CF}{(1+R)t} / \cap \quad (13)$$

For Design 1,

From the annuity table see[9], 10% in period of 5 yrs.

$$\sum \frac{CF}{(1+R)t} / \cap =3.791 \quad (14)$$

$$NPV= (3.791x561, 000)-162{,}000= \text{₦}1, 964, 751 \quad (15)$$

Design 2,

From the annuity table 10% in period of 5 years

$$\sum \frac{CF}{(1+R)t} / \cap =3.791 \quad (16)$$

$$NPV= (3.791x561, 000) - 185{,}000 = \text{₦}1{,}941{,}751 \quad (17)$$

Design 3

From the annuity table 10% in period of 5 years

$$\sum \frac{CF}{(1+R)t} / \cap = 3.791 \quad (18)$$

$$NPV= (3.791x561, 000) - 187{,}000 = \text{₦}1{,}939{,}751 \quad (19)$$

Profitability Index (PI)

$$PI = \sum \frac{CF}{(1+Rt)t} / \cap \quad (20)$$

The profitability index is evaluated using equation 20.

Design 1

From the annuity table 10% in a period of five years [8] is:

$$\sum \frac{1}{(1+Rt)t} = 3.791$$

Cf = 561,000

$\cap$ = 162, 000

P.I = (3.791x561, 000)/162,000

=2,190,439.8/162,000 = 13.128

Design 2

$\sum \frac{1}{(1+Rt)t}$ =3.791

Cf = 561,000

$\cap$ = 185,000

P.I = (3.791x561, 000)/185,000

= 2,190,439.8/185,000 = 11.496

Design 3

$\sum \frac{1}{(1+Rt)t}$ =3.791

Cf = 561,000

$\cap$ = 187,000

P.I = (3.791x561, 000)/187,000

=2,190,439.8/187,000 = 11.373

3.0 Test, Result And Discussion

All the designs are acceptable on the basis of the profitability index consideration. However, design 1 is most economically viable compared to design 2 and design 3.

Suppose the barbing salon is being powered by fossil fuel (gasoline), and price per liter is N97. Assuming fuel consumption of generator is 0.3liter/hr and runs for an average of 12 hrs/day. It thus means that the solar power system has readily accounted for at least 22% increase in cash inflow per month within the payback period. Thus, an exponential increase in profit is certain for a period of time equivalent to 25 years life span of the solar panel. However, the battery can be changed considerably, depending on mode of usage and maintenance. Also, if the cost of electricity supply per unit is approximately N20.00/KWh. It therefore means that the solar power system can readily account for at least 15% increase in cash inflow per month within the pay-back period. A profitability assessment was further carried out on the demo solar barbing salon (using Design 1). Table 10 shows the number of clients per day for a 2 weeks Run period.

Table 10: Number of clients per day

Day	**Number of Clients**	**Average time duration/Hair cut**
1	11	15
2	14	16
3	12	10
4	14	15
5	11	15
6	10	14
7	12	17
8	14	15
9	15	16
10	14	16
11	13	16
12	14	14
13	12	15
14	13	14
Average / day	**13**	

Price per hair cut = ₦100

Revenue per day is:

$$R_{ep} = N_{CT} \text{ X } P_{rt} \tag{21}$$

= 13 x 100 = ₦1300

Revenue per Year = 1300x365 = ₦474,500

Pay-back period = $\frown$/Cf

=162,000/474,500 = 0.341 yrs approximately 4 months 3 days

The Pay-back shows that the solar powered barbing salon is very lucrative.

The NPV = (3.791 x 474,500) – 162,000 = ₦1,636,829.5

The Profitability Index (PI) = (3.791 x474, 500)/162,000 = 11.10

Since 11.10 > 1 this means that the project is economically viable. Thus, the idea of going into this design venture is economically wise.

4.0 Conclusion And Recommendations

The solar powered barbing salon is a stand-alone energy system. Based on designs 1, 2 and 3 concepts, design 1 proved to be most economically viable with a profitability index of 13.128. Moreover, design 1 prototype was fabricated to investigate the feasibility of the actual Profitability Index (PI), Net Present Value (NPV) and Pay-back period. The values gotten were not in any way different from the anticipated values of initial survey carried out.

Having demonstrated the effectiveness of a solar powered barbing salon; it is recommended that, existing barbing salons should implement this design and entrepreneurs are highly encouraged to venture into this Small scale business so as to contribute in the eradication of poverty. Also, It is strongly recommended that the design be reviewed to improve upon the profitability index.

References

[1]. National Economic Reconstruction (2012). www.nerfund.gov.ng/pdf

[2]. David B.E, Nyong O, (2010). Characteristics problems of small and medium scale enterprises in Nigeria. Small scale business project survey group.

[3]. The Nigerian Millennium Development goal (2012).www.nigeria.unfpa.org./pdf

[4] Wariboko P. T, Agho N., Eke O. A , Odiase I. H, Ugege A.O, (2011). Design and Fabrication of a solar powered barbing salon undergraduate project, Department of Mechanical enginerring, University of Benin.

[5]. Solar power design, photovoltaic maintenance, solar power industry news"(2012). www.solarpowerengineering.com.

[6]. Solar power design analysis (2012). www.leonics.com/support/articles en.php/pdf.

[7] Time Value of Money (2012).www.studyfinance.com/pdf.

[8]. Present Value of Ordinary Annuity (2012). www.principles of accounting.com/pdf