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Estimation of a business model of Animal feed solar cooker for entrepreneurship development

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ABSTRACT

The development of a region requires high consumption of energy. The conventional sources of energy are responsible for leading to pollution. It is therefore the need of the day to use renewable energy source, which reduce the CO_2 emission and make the environment green. In view of this, cost-economics of a business model for fabrication of AFSC was carried out. It ensures profit, employment and reduces CO_2 emission. Therefore the cost-economics of the business of fabricating animal feed solar cooker (AFSC) was carried out. The economic attributes such as NPV, IRR etc. were considerably high. The value of Break-even point comes to 172 units. The economic attributes were computed for producing 300 animal feed solar cookers annually. The net average annual benefit accrued from this business was ₹ 682220. The values of economic attributes, such as pay-back period (PBP), internal rate of return (IRR), net present value (NPV) and benefit cost ratio (BCR) were found to be 0.16 yr, 670%, ₹ 4650690 and 1.26, respectively. In addition, this business ensures high profit and employment to four persons.

Keywords: Techno-economic evaluation, Business model, Animal feed Solar cooker

INTRODUCTION

The consumption of energy is increasing with fast growing population and rapid development and it is projected that world conventional energy sources will be exhausted in 50 to 100 years. Since the development of any region is reflected in its energy consumption pattern, it is essential to search for alternative source of energy. In this context, solar energy offers several advantages to arid region (Thar desert) ensuring sustainable development. Solar cooking has proved to be one of the simplest, viable and attractive options for solar energy utilization and also found environment-friendly and cost-effective. Even the solar cookers are very useful for common people in developing world specifically because of reduced drudgery. Cooking needs a lot of energy coming mainly from conventional source of energy e.g. fuel wood, agricultural waste, cow dung, kerosene, LPG etc. It is also used for boiling animal feed and human meals which are full of drudgery (Poonia *et al.,* 2017). The environmental effects of fuel wood burning have been reported in several literatures (Elliott, 2004; Tingem and Rivington, 2009; Panwar *et al.,* 2011; Panwar *et al.,* 2013; Huttunen, 2009). The fuel wood requirement is 0.4 tons per person per year in India. In rural areas, firewood crisis is grave. If cow dung is not burnt for cooking and used as manure, it will supplement the fertilizer to a great extent. The arid zone receives abundant mean solar radiation 6 $kWhm^{-2}day^{-1}$ and 8.9 sunshine hours a day at Jodhpur (Poonia *et al.,* 2022).

The solar energy business can play a big role in generating employment in rural area thereby ensuring profit and providing green environment in addition to economic growth of the country. Generally, solar water heater and roof-top PV generation have gathered momentum to a great extent. India has 12 lakh rural schools where mid-day-meal is served, and this solar cooker market can be worth 10000 crore rupees. Further, it was estimated that solar energy of 1 percent of land area, wind power of 5 percent of land area and biogas (80 percent collection efficiency) can provide 1504 kWh $year^{-1}$ energy per capita in arid region while the average per capita total energy consumption of India is 1122 kWh $year^{-1}$. In this context, renewable

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sources of energy like solar energy, wind power and biogas need to be harnessed for the sustainable development in general and catering the farmers requirements in particular. For starting a new business, economic feasibility needs to be assessed in terms of break-even analysis and economic attributes. Banks provide loans only on the basis of economic attributes of the project. Therefore, an attempt has been made to determine the various costs and economic indicators of fabricating animal feed solar cooker for evaluating the feasibility of investment on fabrication to guide new entrepreneurs.

MATERIALS AND METHODS

Design of animal feed Solar Cooker

A double glazed non-tracking animal feed solar cooker with reflector was designed and developed at ICAR-CAZRI, Jodhpur, India. The length to width ratio of glazing and reflector was kept as 3:1 to receive maximum amount of reflected radiation. The cooker was fixed with its orientation to south direction and provided with three cooking bowls as given in Fig. 1. The thickness of glass and reflector was 4mm. The pearl millet husk was put on the bottom as insulation material and a GI sheet 24 SWG (blackened) was provided over the insulation.

Efficiency of animal feed solar cooker (η)

Performance of AFSC has been carried out extensively by measuring stagnation plate temperature and rise in water temperature in cooking utensils in known interval of time. The efficiency of the cooker has been found by the following relations proposed by Poonia *et al.,* (2017 and 2019):

$$\eta = \frac{(MC_w + M_1C_u)(T_{w2} - T_{w1})}{CA\int_0^t G dt} \text{ ---------------- (1)}$$

Where A = Absorber area (m^2); C = Concentration ratio; C_u = Specific heat of cooking utensil (J/kg/°C); C_w = Specific heat of water (J/kg/°C); G = Solar radiation (W/m^2) ; M = Mass of water in cooking utensils (kg); M_1 = Mass of cooking utensils (kg); T_{w1} = Initial temperature of water (°C); T_{w2} = Final temperature of water (°C); t = Time interval (s) and η = Efficiency of non-tracking solar cooker (%).

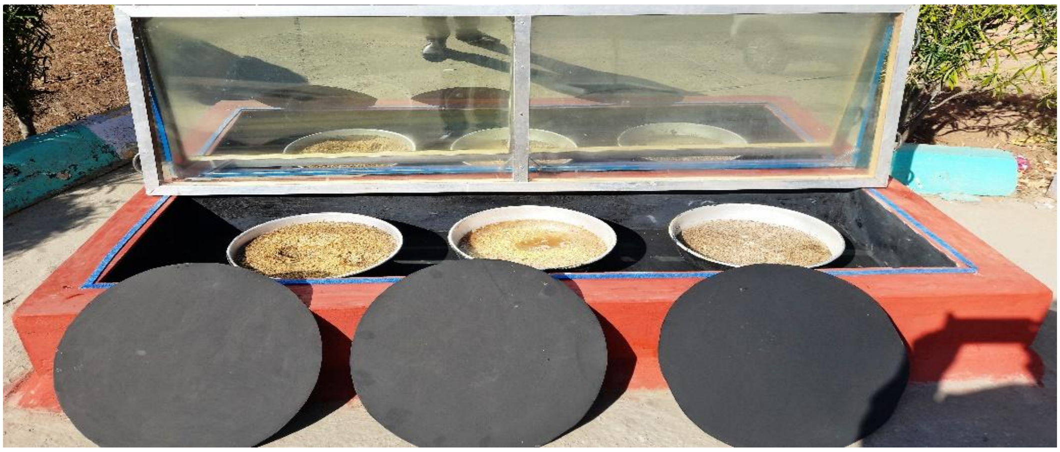

Fig. 1: Animal feed solar cooker

Economic analysis of fabricating animal feed solar solar cooker

The various economic attributes of fabricating AFSC such as break-even point, net present value (NPV), pay-back period (PBP), benefit-cost ratio (BCR), annuity (A) and internal rate of return (IRR) were determined for judging the economic viability of the solar devices (Chandell *et al.,* 2017, Singh *et al.,* 2017, Poonia *et al.,* 2018, Singh *et al.,* 2020, Poonia *et al.,* 2022). Two types of cost i.e. fixed or ownership costs and variable or operating costs were associated with fabrication of solar devices. The main components of the fixed costs were depreciation, average annual interest on investment, taxes, insurance and housing/rent cost. Variable or operating costs were expenditure incurred on electricity, materials, repair and maintenance, operational and labour wages associated with devices fabrication.

Table 1: Details of investment costs

S. No.	Machines/tools	Quantity	Total cost (₹)
1.	Sheet-bending machine	01 no.	20000.00
2.	Wood planner-cum cutter with gauge	01 no.	40000.00
3.	Portable welding machine	01 no.	10000.00
4.	Hand drill with stand	01 no.	5000.00
5.	Cut off machine for angle cutting	01 no.	7000.00
6.	Hand cut-off machine	01 no.	2000.00
7.	Scissor	02 nos.	
8.	Small size hammer	02 nos.	
9.	Medium size hammer	02 nos.	
10.	Screw driver	01 set	
11.	Centre punch	01 nos.	
12.	wooden chisel	01 nos.	
13.	Tri-square	02 nos.	20000.00
14.	L-square	02 nos.	
15.	Wooden hammer	02 nos.	
16.	Measuring tape	02 nos.	
17.	Silicon machine	01 nos.	
18.	Spanner set	01 nos.	
19.	Drill bit set	01 nos.	
20.	Manual wooden planer	01 nos.	
21.	Glass cutter	01 nos.	
	Total		₹ 104000

Table 2: Details of operational cost

S. No.	Cost	(Volume/month)	Total cost (₹)
1.	Rent of land and building/month	One	7000
2.	Carpenter/month	One	18000
3.	Sheet metal cutter-cum-welder/month	One	18000
4.	Store keeper cum sales executive/month	One	18000
5.	Unskilled labour/month	One	9000
	Total		₹ 70000

Economic attributes

The economic analysis of fabrication of solar thermal devices was carried out and net present value (NPV), payback period (PBP), benefit-cost ratio (BCR), annuity (A) and internal rate of return (IRR) were taken into account for economic assessment.

Net Present Value (NPV)

Net present value (NPV) was calculated by using 14% interest rate (based on State Bank of India interest rate for agriculture loan) which was considered as capital cost of a firm. This is the present value of expected return likely to be earned by the entrepreneur during the entire life of the project. To find out the present value of cash flows expected in future periods, all the cash outflows and cash inflows were discounted at the above rate. The net present value of solar devices was worked out using following equation:

$$NPV = \frac{(E-M)}{a}\left[1-\left(\frac{1}{1+a}\right)^{n}\right]-C \quad ------------(2)$$

- Initial cost (C) = ₹ 104000, a = 12% and n = 15 years
- Gross benefits from sale of three hundred units (E) = 13500 × 300= 4050000
- Cost of 300 hundred units (M) = Electricity cost + Materials cost + Operational and labour charges + Annual rent
- Cost of 300 hundred units (M) = Electricity charge/unit × No. of units + Materials cost/unit ×no. of units + labour charges/month ×12 + Monthly rent ×12=50 × 300 + 8000 × 300 + 70000 ×12+ 8000× 12= ₹ 15,000+ 24,00,000+ 8,40,000+ 96,000= ₹ 33,51,000

where, C is initial cost, a is the rate of interest, n is the number of years, b = inflation rate (%)
When we take inflation into account the net present value (NPV) is calculated by using equ (9)

The Benefit-Cost Ratio (BCR)

Benefit-cost ratio was expressed as the ratio of sum total of initial cost and net present value to the initial cost as given below,

$$BCR=\frac{E\sum_{n=1}^{15}\frac{1}{(1+a)^n}}{C+M\sum_{n=1}^{15}\frac{1}{(1+a)^n}}-----------(3)$$

Annuity (A)

The annuity (A) of the project indicates the average net annual returns. This term can be given as,

A (Annuity) = $$\frac{NPV}{\sum_{t=1\ to\ n}\left(\frac{1}{1+a}\right)^n}----------(4)$$

Pay Back Period (PBP)

Payback period was worked out as the length of time required to recover initial investment through net average annual cash inflows generated by investment. The payback period formula was used to determine the length of time it will take to recoup the initial amount invested on a project or investment. PBP was calculated by equation:

$$PBP=\frac{\log\frac{(E-M)}{a}-\left(\log\frac{(E-M)}{a}-C\right)}{\log(1+a)}------------(5)$$

Internal rate of return (IRR):

The IRR was determined using the following relationship and taking low discount rate and higher discount rate. It can also be determined by equating NPV to zero and computing value of a.

$$IRR=lower\ discount\ rate+\frac{Difference\ of\ discount\ rate\ x\ NPV\ at\ lower\ discount\ rate}{(NPV\ at\ lower\ discount\ rate-NPV\ at\ higher\ discount\ rate)}---(6)$$

RESULTS AND DISCUSSION

The land and building area for this solar devices manufacturing centre is 441 m^2 and 81 m^2 of the building (Fig. 2). The number of working days in a year is 300 days and the production capacity 300 units/year. The investment cost in this fabrication centre of combined unit business is allocated to start the business covering land and building lease, and machinery and tools. Table 1-2 presents the components of the fabrication centre of combined unit of solar devices business investment cost and details of operational cost.

Operational costs or variable costs always depend on the size of the production per period. These operational costs include the cost of purchasing raw materials, operational equipment, machine maintenance and labor costs. The most significant of the operational costs expenditure was the purchasing of raw material for fabrication of animal feed solar cooker, technical skilled/unskilled labour as presented in Table 3-4. The purchase price of raw material for animal feed and non-tracking solar cooker is ₹ 8000/unit (Table 5), while selling price of fabricated AFSC is ₹ 13500/unit.

In this analysis, total fixed cost and variable cost were calculated. The purchase price of fabrication machinery and tools of animal feed is ₹ 104000 and an appropriate discount rate 12% (based on State Bank of India interest rate for loan 2017) was selected to reflect the time value of money. The discount rate chosen reflected the minimum acceptable rate of return for an investment. The break-even point was determined as the level of operation where total income from sale of the units is equal to total expenses. Equ. (3) has been used to compute the break-even point analysis of fabrication of animal feed solar cooker by putting BCR as 1.0 and computing for number of units and it reveals that the BEP of the devices is 172 units.

The efficiency of the animal feed solar cooker has been obtained by putting 4.0 kg of water in each cooking utensils. There are three cooking utensil that can be accommodated in the animal feed solar cooker. Therefore cooker was loaded with 12.0 kg of cold water. The efficiency of the animal feed was calculated using the equ (1) and it was found 26.4 %. Thermal efficiency of the animal feed solar cooker depends on many factors such as, solar radiation, mass of the loaded water, time taken to boil the water, control of the reflector etc. The present animal feed solar cooker has shown the best performance and highest efficiency for the maximum load (12 kg) is an indication of better heat retention ability of the cooker as compared with others found in the literature (Poonia *et al,* 2017 and Nahar *et al,* 1996).

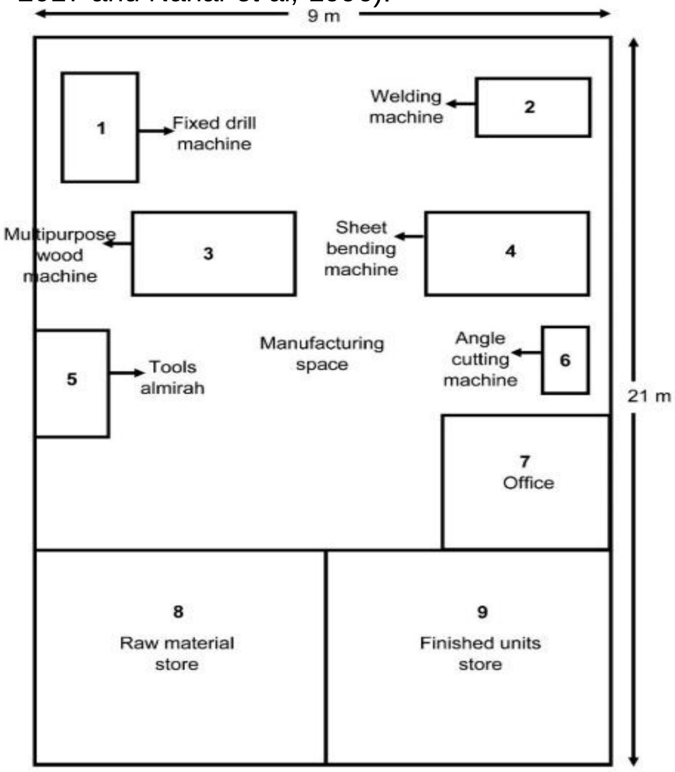

Fig. 2: Layout of Solar devices manufacturing centre

Table 3: Details of investment costs

Machines/tools	Quantity	Total cost (₹)
Sheet-bending machine	01 no.	20000.00
Wood planner-cum cutter with gauge	01 no.	40000.00
Portable welding machine	01 no.	10000.00
Hand drill with stand	01 no.	5000.00
Cut off machine for angle cutting	01 no.	7000.00
Hand cut-off machine	01 no.	2000.00
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wooden chisel	01 nos.	
Tri-square	02 nos.	20000.00
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Wooden hammer	02 nos.	
Measuring tape	02 nos.	
Silicon machine	01 nos.	
Spanner set	01 nos.	
Drill bit set	01 nos.	
Manual wooden planer	01 nos.	
Glass cutter	01 nos.	

₹ 104000

Table 4: Details of operational cost

S. No.	Cost	(Volume/ month)	Total cost (₹)
1.	Rent of land and building/month	One	₹ 8000
	Labour charges		
2.	Carpenter/month	One	21000
3.	Sheet metal cutter-cum-welder/month	One	21000
4.	Store keeper cum sales executive/month	One	18000
5.	Unskilled labour/month	One	10000
Total			₹ 70000

The net present value of total cash inflow and outflow for fabrication of solar thermal devices was calculated by the sum of all discounted net benefits throughout the project. The initial cost of machinery and tools of animal feed solar cooker is ₹ 104000, a = 12% and life of devices is 15 years. The gross benefit of selling of 300 units is ₹ 405000 and the fabrication cost of 300 units is ₹ 3351000. Equ (2) has been used to determine the net present value (NPV) of animal feed solar cooker and it reveals that the NPV of investment made on animal feed solar cooker is ₹ 4650690. The benefit cost ratio has been calculated by dividing present worth of benefit stream with the present worth of cost stream by using equ. 3. It comes out for fabrication of animal feed solar cooker as 1.26. Equ. (4) has been used to determine the annuity of the animal feed solar cooker indicates the average net annual returns from devices is ₹ 682220. The payback period is 0.16 (2 months) years which is much lower than the expected life of the animal feed solar cooker i.e. about 15 years. Entrepreneurs may prefer to invest on machinery with shorter payback period because the invested funds can be recovered sooner as investments with longer payback periods are considered more risky and full of uncertainties (Chandel *et al.,* 2017, Singh *et al.,* 2020). Sherrick *et al.,* (2002) observed that the capital budgeting practices employed by large firms to make decisions were mainly IRR (88% firms) and NPV methods (63% firms). Therefore, the decision making tool used here was evidently the IRR, which was found to be the highest for (670 %). The IRR is greater than the cost of capital (14%).

Table 5: Raw material for animal feed solar cooker

S. No.	Material	Quantity	Approx. price (₹)
1.	Stone Chaps / bricks / cement concrete		
	(i) 0.15 m thick	1.59 sqm	2500.00
	(ii) cement concrete 5.30 x 0.30 x 0.15)	0.2385 cum	
2.	Aluminium angle (35 mm x 12 mm)		
	(i) 2 (1.87 + 1.87 + 0.68 + 0.68)	10.2 m	700.00
	(ii) Aluminium flat (35 mm wide) 2 x (0.68)	1.36 m	300.00
3.	Mirror (4 mm thick) for reflector 2 x 0.60 x 0.90	1.08 sqm	750.00
4.	Plain glass (4 mm thick)		
	4 x (0.60 x 0.90)	2.16 sqm	1000.00
5.	Aluminium handle (130 mm long)	4 Nos.	120.00
6.	Iron angle (25 x 25 x 6 mm) (1.87 + 1.87 + 0.95 + 0.95)	5.64 m	550.00
7.	G.I. Sheet (24 gauge)	2.11 sqm	400.00
8.	Wooden batten (2 nos.)	2×0.00783 cum	950.00
9.	Rubber gasket (25 mm wide)	5.1 m	80.00
10.	Silicon	for 5.1 m	150.00
11.	Nut bolts/screws	100 g	100.00
15.	Fevicol	200 g	100.00
16.	Black board paint	0.5 lit.	150.00
17.	Synthetic Enamel paint	0.5 lit.	150.00
		Total (₹) 8000.00	

Other things being equal and using IRR as the decision criterion, the one with the highest IRR may be considered as the better choice. One reason for this conclusion is that a higher IRR indicates less risk (Chandel *et al.,* 2017, Singh *et al.,* 2020). The values of five economic attributes, namely, benefit-cost ratio (BCR), net present value (NPV), annuity (A), internal rate of return (IRR) and pay back period (PBP) are presented in Table 6.

Table 6: Economic attributes of animal feed solar cooker

S. No.	Attributes economics	Values
1	BCR	1.26
2	NPV	₹ 4650690
3	A	₹ 682220
4	IRR (per cent)	670
5	PBP (years)	0.16 years

The capital budgeting method based on NPV, IRR, Payback Period and BCR can be used by the entrepreneurs to derive a confident decision on investment.

Energy saving and CO_2 mitigation

Animal feed solar cooker will save 5035 MJ of conventional energy annually considering the efficiency of solar cooker as 30%, respectively. Animal feed solar cooker is in a position to replace the 100 percent biomass and save about 3189.80 kg of CO_2 on annual basis, if it replaces firewood. Considerable amount of CO_2 reduction is also seen in case of coal (1701.11 kg), kerosene (750.00 kg), LPG (529.51 kg) and electricity (830.37 kg). The annual CO_2 emission saving for various types of fuel is presented in Table 7. In view of the above mentioned points, the policy makers and Indian Government should encourage such devices by providing small subsidies, which will address social, economic and environmental issues to a great extent.

Table 7: Annual CO_2 emission saving of a unit of animal feed solar cooker for various fuel

Type of Fuel	Calorific Value ($MJkg^{-1}$)	Annual fuel saving	Efficiency (%)	CO_2 emission ($kgMJ^{-1}$)	Annual CO_2 emission (kg)
Firewood	19.89 MJ kg^{-1}	721.31	17.3	0.1098	1575.28
Coal	27.21MJ kg^{-1}	325.77	28.0	0.0946	838.56
Kerosene	45.55MJ L^{-1}	113.52	48.0	0.0715	369.71
LPG	45.59MJ kg^{-1}	90.74	60.0	0.0631	261.02
Electricity	3.6 $MJkWh^{-1}$	907.16	76.0	0.217	708.68

Thus, the use of animal feed solar cooker would help conserve conventional fuels, such as firewood in rural areas of India, and LPG, kerosene, electricity and coal in the urban areas. Conservation of firewood would help in preserve the ecosystem. It is evident from Table 7 that firewood is the highest CO_2 intensive fuel (1900.48 kg CO_2 yr^{-1} of firewood) whereas, LPG is the lowest CO_2 intensive fuel (315.48 kg CO_2 yr^{-1} of LPG). Moreover, the use of the animal feed would result in reduction of the release of CO_2 to the environment.

CONCLUSION

In view of considerably high values of NPV, IRR, annuity and low value of PBP, the business of animal feed solar cooker is highly profitable. Break-even point comes to 172 numbers of animal feed solar cookers. As many as 300 units can mitigate about 3190 kg of CO_2 annually by replacing fire wood and can go a long way in supplementing conventional source of energy. The need of the hour is the transition from CSE to renewable energy sources such as solar thermal which is available in abundance.

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