

Financial evaluation for the solar heater prototype made with recycled tire rubber**Evaluación económica del prototipo de calentador solar fabricado con caucho de neumático reciclado**

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Abstract

The objective of this research is to carry out the economic feasibility study of the prototype of a solar heater made of recycled tire rubber in the metropolitan areas of Puebla. Regarding the methodology, the type of research was applied qualitatively. The project was initially developed with a significant acceptance survey of the solar tire heater product in the study area, developing a questionnaire for the collection and analysis of information, the market and the technical factors to which the prototype is subjected were analyzed. Afterwards, an economic analysis is prepared with production forecasts for a pilot test of the development of the solar tire heater. Obtaining as results an approval of the Project for its development and a feasible innovation Project for its implementation in the metropolitan area of Puebla.

Economic, solar heater, Methodology, Analysis**Resumen**

El objetivo de la presente investigación es realizar el estudio económico de factibilidad del prototipo de calentador solar de caucho reciclado de neumático en las zonas conurbadas de Puebla. Con respecto a la metodología, el tipo de investigación fue aplicada de tipo cualitativa. El proyecto se desarrolló inicialmente con una encuesta significativa de aceptación del producto calentador solar de neumático en la zona de estudio, elaborando un cuestionario para recopilación y análisis de información, se analizó el mercado y los factores técnicos en los cuales se somete el prototipo. Después se elaboró un análisis económico con pronósticos de producción para una prueba piloto de la elaboración del calentador solar de neumático. Obteniendo como resultados una aprobación del Proyecto para su elaboración y un proyecto de innovación factible para su puesta en marcha en la zona conurbada de Puebla.

Económico, Calentador solar, Metodología, Análisis

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Introduction

The evaluation of projects for feasibility is an assessment process in which all the elements involved in the project are analysed in order to determine its viability, thus calculating the possible risks and determining the responses to them (Baca, 2020).

To carry out an economic feasibility analysis, a set of study methods are carried out considering: the characteristics and size of the project through a technical analysis, detailed description of the inputs or raw materials required, market analysis, to investigate the behaviour of the product or service where it will be established and the financial study exercise of the project (Baca, 2020).

Within a technical study, the techniques and indicators for operation and monitoring must be established; within the technical study, the operational aspects necessary for the efficient use of available resources in the production of a good or service being evaluated are contemplated (Baca, 2020).

For the market, two aspects are considered: supply and demand. On the supply side, the specific sector must be identified, which must be based on information on current and projected production volumes, installed and used capacities, expansion plans, and current and future costs (Sapag and Sapag, 2015). On the other hand, demand is a function of the real need for a good or service and how it is distributed by its price, the income level of a population and econometric indicators. In order to determine the demand, market research tools are used, which are referred to and distinguish the type of demand (Baca, 2020).

On the other hand, for the elaboration of the financial exercise of the Project, the amount of the necessary economic resources that the realisation of the project implies prior to its start-up, the determination of the total cost required in its period of operation, estimating an annual production probability, with the purpose of measuring the return on initial investment, must be estimated (Baca, 2020).

The economic evaluation study is the final part of the whole sequence of feasibility analysis of a project, up to this point it will be known that there is an attractive potential market, the optimal location, the size of the project, the acceptance of the product, etc. (Baca, 2020).

This project details a financial evaluation of the prototype solar pneumatic heater in the urban area of Puebla, measuring the economic profitability of the project.

Methodology

The investigation was carried out through an analysis of data applied research of qualitative type through an analysis of data and statistics, for the obtaining of the information, a questionnaire of 10 reagents with Likert scale was carried out. For this research according to the General Secretariat of the National Population Council (2018) 16 municipalities were considered that are within the metropolitan area Puebla-Tlaxcala with high index of marginalization, which by their way of heating water for bathing, are the main municipalities interested for the implementation of this project, within the list of municipalities that have at least one zone of marginalization in the state of Puebla is shown in Table 1:

#	Name	#	Name
1	Acajete	9	Ocoyucan
2	Amozoc	10	Puebla
3	Coronango	11	San Andrés Cholula
4	Cuatlancingo	12	San Felipe Teotlancingo
5	Chiutzingo	13	San Gregorio Atzompa
6	Domingo Arenas	14	San Martín Texmelucan
7	Huejotzingo	15	San Miguel Xoxtla
8	Juan C. Bonilla	16	San Pedro Cholula

Table 1 Municipalities with marginalised areas in the state of Puebla

Source: Own elaboration with data from the General Secretariat of the National Population Council. (2018)

A selection of municipalities was made in the main areas surrounding the state capital, due to mobility issues, so the municipalities of: San Martín Texmelucan, San Felipe Teotlancingo, San Nicolás de los Ranchos and Chignahuapan (INEGI, 2016). Considering the following population numbers table 2:

Concept	Quantity	Unit
Total dwellings in Sn. Martín Texmelucan	32,961	households
Total housing in Sn. Felipe Teotlalcingo	2,630	households
Total housing in Sn. Nicolas de los Ranchos	1,421	households
Total housing in Chignahuapan	13,995	households
Total number of dwellings	51,007	households

Table 2 Population values in Puebla

Source: Own elaboration with data from INEGI (2020)

Calculation of the number of surveys to be carried out

A 10-question questionnaire with a self-administered Likert-type scale was used as a data collection instrument. A total of 396 surveys were carried out in the aforementioned conurbations due to mobility issues in the research.

The type of survey to be applied was descriptive, with the objective of defining the competitive advantages and disadvantages that the use of a solar heater made from recycled tyres would have; within the communities, 360 homes were surveyed, according to the Population and Housing Census carried out by the National Institute of Statistics and Geography (INEGI, 2020).

To determine the number of surveys to be conducted, the appropriate statistical model is used to determine the sample size for finite populations when estimating proportions. In this case, estimators with a standard error of 0.15 and a reliability of 95% will be taken as detailed in formula 1 below with the subscripts shown in table 4:

Formulas	Where
n	sample size
E	margin of error
N	population size

Table 4 Sample estimation model

Source Own elaboration with Baca (2020)

$$n = \frac{N}{E^2(N-1)+1} \quad (1)$$

$$n = \frac{51007}{0.05^2(51007-1)+1}$$

$$n = \frac{51007}{128.515}$$

$$n = 396$$

Technical analysis

According to the costing exercise, the market for solar heaters was sought, this will depend on the brand, capacity and material with which they are made, in Mexico according to the General Directorate of Consumer Studies (DGEC) of the Federal Consumer Protection Agency [PROFECO] (2016), in the market there are heaters mostly of vacuum tubes which have an average of the following costs, broken down in Table 3

Total capacity (litres)	Tubes	Users/People	Heater price 00/100 MN
110	8	2-4	\$5,354.00
130	10	4 a 6	\$5,900.00
150	12	6 a 9	\$8,310.00
210	15	9 a 12	\$9,126.00

Table 3 Table of average prices of solar heaters in Mexico by capacity

Source: Own elaboration based on PROFECO (2016)

Within the demand, in the state of Puebla, in 2020, 7.92% of households had solar water heaters and 92.8% did not have solar water heaters (OBTRENMX, 2022). Considering the following population numbers, the following quantities are considered table 5:

Concept	Quantity	Unit
Total population in the state of Puebla	6,583,278	persons
Total dwellings in Puebla	1,713,381	households
Percentage with solar water heater	7.92	%
Percentage without solar water heater	92.8	%

Table 5 Population values in Puebla

Source: Own elaboration with data from INEGI (2020)

For this research, a prototype of the solar heater made of recycled tyre material was made to verify its functionality and proceed to the continuous manufacture of this product, making production estimates in the future, in order to measure the feasibility of the project, for which the following steps are carried out:

Description of the product: according to compliance with NOM-027-ENER/SCFI-2018

Market

Distribution and marketing system: To define the way in which the solar tyre heater product will be marketed, the Ansoff matrix also known as product-market matrix, which shows four growth options for the companies formed by confronting the existing and new products/services with the existing and new markets (Baca, 2020), will be used as a starting point.

Resources: for the description of the necessary resources in monetary terms, the financial analysis is carried out involving the costs for the dimensional study of the company, in order to measure the feasibility of the opening of the company.

Costs

The cost analysis for the elaboration of a solar heater and the selling price is developed under the following:

The materials destined for the elaboration of a solar heater are defined under the following materials, starting from the unit to carry out the exercise of cost estimation, next, the materials required for the elaboration of the product are detailed, as shown in table 6:

Raw material x 1 Solar tyre heater				
Description	Cant.	U.Medida	C. Uni.	Total
Ground rubber	3	kg	\$8.75	\$26.25
Recycled rubber fibre	2	kg	\$5.50	\$11.00
Wooden box	1	m	\$120.00	\$120.00
Steel sheet	1	kg	\$180.00	\$180.00
1 inch black screws	20	pzs	\$1.00	\$20.00
Rubber resin and TP Catalyst	1	pz	\$150.00	\$150.00
Black matte finish paint	2	bote	\$90.00	\$180.00
Copper elbows	6	pzs	\$70.00	\$420.00
¾ inch copper pipe	5	m	\$190.00	\$950.00
		Total	\$815.25	\$2,057.25

Table 6 Raw material costs for the production of a solar tyre heater
Source: Own Elaboration

Both the acquisition of raw materials and the labour costs of the workers are direct expenses, which are directly linked to the production of the product offered:

Direct expenses					
Partners	Description	Year	Month	Weekd	Day
3	Workmanship	\$207,360.00	\$17,280.00	\$4,320.00	\$664.62
		Total	\$17,280.00		

Table 7 Average overheads of 3 employees in production
Source: Own Elaboration

To estimate the necessary equipment for the production of solar tyre heaters, it is estimated that the following inputs will be used, in such a way that according to the percentage of depreciation it is estimated between 10% to 20% per year, making a prorata to submit it in the indirect expenses table 8:

Equipment for production			
Description	% depreciation	Price	Total
Wood cutter	10%	\$795.00	\$79.50
Copper tube cutter	10%	\$160.00	\$16.00
Siler solder paste	25%	\$145.00	\$36.25
Linmex Gas G-3 1 134 torch	20%	\$519.00	\$103.80
Sheet cutter	10%	\$561.00	\$56.10
Shear and roller press brake	10%	\$25,500.00	\$2,550.00
	Total	\$27,680.00	\$2,841.65

Table 8 Production equipment for the production of solar heaters
Source: Own Elaboration

On the other hand, the indirect costs are those which must be considered to estimate the global net cost of production, which are defined as follows table 9:

Indirect costs				
Description	Year	Month	Weekd	Day
Rent	\$108,000.00	\$9,000.00	\$2,250.00	\$346.15
Equipment	\$3,396.65	\$283.05	\$70.76	\$10.89
General lighting	\$2,400.00	\$200.00	\$50.00	\$6.67
IMSS	\$12,156.00	\$1,013.00	\$253.25	\$38.96
Water	\$2,160.00	\$180.00	\$45.00	\$6.92
TOTAL	\$28,112.65	\$10,676.05	\$2,669.01	\$409.59

Table 9 Indirect costs
Source: Own Elaboration

The expected production according to the time and personnel allocated for the production of solar tyre heaters, as shown in table 10, is described below:

Production time x 1 heater		
Wooden box form	20	min
Rubber lining of the box walls	60	min
Soldering of pipes and elbows	30	min
Rubber coating of copper pipes	60	min
Cutting of steel sheet	30	min
Welding of storage tank	30	min
Heater assembly	35	min
Total time	265	min
Total production per year	494	Heaters

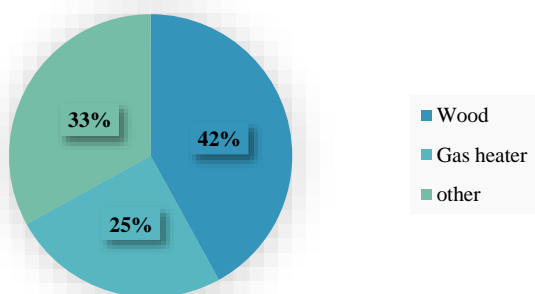
Table 10 Breakdown of the production time forecast
Source: Own Elaboration

Once the technical, market and cost analysis has been carried out, a financial study can be established to measure the behaviour of this project over time, and to determine whether its implementation is feasible.

Results

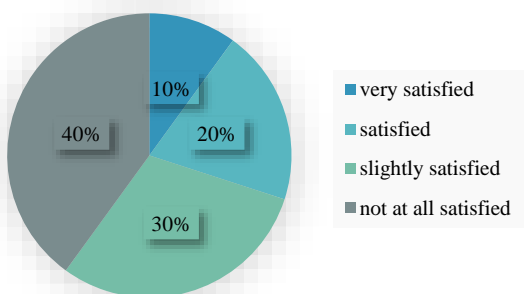
As mentioned above, household surveys were conducted where a family member was asked to answer the questions. The majority of the households interviewed were female (60%), while in terms of occupation, 37% were farmers/livestock farmers, 34% were engaged in commerce, 22% were labourers or workers, either in a local or foreign company, and 7% did housework. According to the results of the survey, the most relevant items are listed below:

How to heat water for bathing ?



Graph 1 Item How do you heat water for bathing?
Source: Own Elaboration

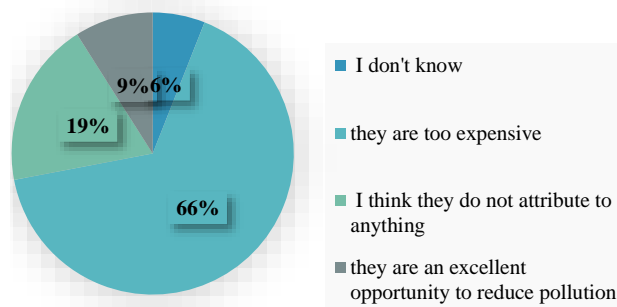
How satisfied are you with the functionality of your water heating system?



Graph 2 Item How satisfied are you with the functionality of your water heating system?
Source: Own Elaboration

The unsatisfied demand shown in graph 2 in the households shows the current efficiency of the type of water heating method, whereby 30% are not very satisfied and 40% are not at all satisfied. And only 30% are satisfied or have no serious effect on their efficiency.

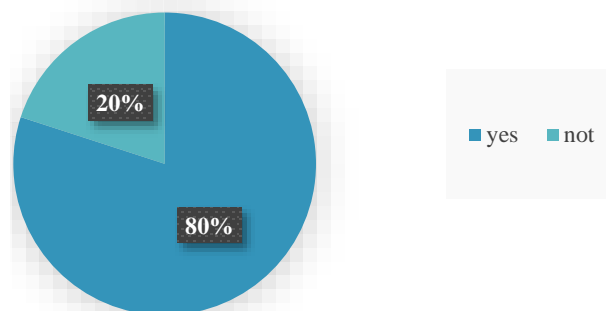
What is your perception about solar heaters?



Graph 3 Item What is your perception of solar heaters?
Source: Own Elaboration

From the interviewees, it could be observed how the concept of solar water heaters, or knowledge about them, is perceived. This allows us to interpret that the clients (households) consider the solar water heater expensive, with 66% of the households interviewed, followed by 19% who consider it a product without attributes, which opens an area of opportunity for environmental education with sustainable innovation.

Would you buy a solar heater?



Graph 4 Item What is your perception of solar heaters?
Source: Own Elaboration



Graph 5 Item If you were given the option to build your own solar heater, would you be interested in doing so or just buying it?

Source: Own Elaboration

Project evaluation

Being a new company that will offer a new product in materials and in the market of solar heaters, the type of strategy to follow will be "market penetration", under the following aspects:

Defined market: houses that are considered within the urban area of the state of Puebla that do not have a solar heater.

Product offered: solar heater made from end-of-life tyres, which is a unique and current product in the market.

The system to be used to distribute and market the product: through own points of sale, the point of sale must meet the specific technical requirements under the Mexican standard NOM-027-ENER/SCFI-2018 in order to provide a high level of service and customer satisfaction.

Within the objective of verifying the viability of the project, an exercise of economic-financial behaviour is carried out in order to measure the viability of investment, opening and permanence of the project, for which an estimate was made of the costs that would be generated both in production and in the permanence of the project, so a cash flow was made by calculating the net profit and net cash flow which will be the preamble for the financial estimate.

In this way, the following exercise is carried out, adding the components to estimate the net production cost, plus the profit percentage to calculate the cost of sale of the service.

Solar tyre heater							
Production January - June 2023	Monthly production	Raw material/solar heater	Labour/solar heater	Indirect costs/solar heater	Total unit cost	Unitary gain 15%	Unit selling price/solar heater
824	137	\$2,057.25	\$125.80	\$184.09	\$2,367.14	\$355.07	\$2,722.21

Table 11 Unit costing of a solar tyre heater

Source: Own Elaboration

As a result, the estimated selling price for each solar water heater is reflected (table 11), which has a production cost of \$2367.14 pesos MXN and a selling price of \$2722.21 pesos MXN with a profit of 15%, this heater has a capacity to supply hot water for 2 to 5 members, considering an average of 5 to 10 members per household, in the study sample mentioned above.

The selling cost of this solar water heater is below the average price of conventional solar water heaters with the same capacity that currently exist in the market, with a 49.1% saving in its acquisition.

Regarding the calculation of the necessary investment of the project, it was made by adding all the expenses that are considered (cost of production, cost of administration, cost of sale, financial costs, ISR, RUT) this in order to calculate the net that is needed for the opening and continuity of a project.

Annual		
Description	Expenditure	Revenue
Cost of production	\$575,479.46	4,412,009.16
Marginal profit	3,836,529.71	-
Administration costs	\$480,000.00	
Selling costs	\$6,000.00	
Financial costs	\$5,783.30	
Gross profit	\$3,344,746.41	
INCOME TAX (30%)	\$1,003,423.92	
RUT (10%)	\$334,474.64	
Net profit	\$2,006,847.84	
Net cash flow	\$2,006,847.84	

Table 12 Unit costing of a solar tyre heater

Source: Own Elaboration

Next, we will detail the method to estimate the period in which the initial investment will be paid, with the exercise of the cash flow within the first 5 years of existence (table 13), this considering inflation of 20%, doing the following: net income - net expenses = final balance; and final balance*1.2 (inflation) = accumulated balance, the latter verifying in what period of time the loan account would be paid off (initial investment).

	Yaers					
	0	1	2	3	4	5
Income	Initial investment	\$4,412,009.16	\$4,853,210.08	\$5,338,531.09	\$5,872,384.20	\$6,459,622.61
Expenditure		\$2,405,161.32	\$2,645,677.45	\$2,910,245.20	\$3,201,269.72	\$3,521,396.69
Closing balance	\$2,405,161.32	\$2,006,847.84	\$2,207,532.63	\$2,428,285.89	\$2,671,114.48	\$2,938,225.93
Cumulative balance		\$2,006,847.84	\$4,214,380.47	\$6,642,666.36	\$9,313,780.84	\$12,252,006.77

Table 13 Cash flow in the period of 5 years for the opening of a solar tyre heater company
Source: Own Elaboration

Once the initial investment payment calculation exercise was done, the feasibility of the project was calculated with the Internal Rate of Return (IRR), the Net Present Value (NPV), the Discount Rate (DIS), the Pay Back, and the Cost Benefit, as a result of the project feasibility analysis, with its economic and financial profitability and the points involved for its opening (table 14).

IRR	87.67%	It must be GREATER than the discount rate (TREMA).
NPV	\$12,252,006.77	If + the project is viable
Pay back years (Payback time)	1.2	If it is less than 10 years, the project is profitable.
Cost-Benefit		It must be >1 to be profitable (For every 1 peso you spend
	\$398,313.47	you get 2 pesos profit)

Table 14 Table of feasibility analysis of the investment project
Source: Own Elaboration

According to the Internal Rate of Return, it came out at 87.67% being a rate higher than 50% to be profitable the project, also the Net Present Value, with a value of \$12,252,006.77 MXN pesos, with a return on investment in one year, two months and a cost benefit of \$398,313.47 MXN pesos.

Conclusions

When carrying out a financial evaluation of the solar pneumatic heater project through a viability and feasibility analysis, where an investment project exercise was carried out, which, according to the results, highlighted the importance of costing the procedure to incorporate the financial economic analysis, involving raw materials, labour involved in the construction of the project, the direct and indirect elements considered for the financial economic analysis, (detailed above), and this based on the results obtained previously.

It is concluded that the profitability of the project is feasible for its elaboration and creation of a solar water heater manufacturing plant with a total return on investment in one year and two months in the significant forecasting exercise, considering the results obtained in our product acceptance survey exercise in the existing market, concluding that at present the conurbations of the state of Puebla, especially the areas defined as low-income areas are the main areas of incorporation for the benefit of households that currently have the method of water heating by wood, coal and do not have a solar heater, involving the excessive cost that is currently in the market for these products.

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