Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias

Ciba

ISSN: 2007 - 9990

https://doi.org/10.23913/ciba.v8i16.94

Artículos Científicos

Factibilidad financiera de infraestructura solar para pequeños y medianos agricultores y productores de nuez en Delicias, Chihuahua

Financial Feasibility of Solar Infrastructure for Small and Medium Sized Farmers and Pecan Nuts Producers in Delicias, Chihuahua

Viabilidade financeira da infraestrutura solar para pequenos e médios agricultores e produtores de nozes em Delicias, Chihuahua

José Esteban Hernández Salas
Universidad Autónoma de Chihuahua, Facultad de Ciencias Agrícolas y Forestales, México
jesalas@uach.mx
https://orcid.org/0000-0003-0462-434X

Walter Márquez Fierro
Universidad Autónoma de Chihuahua, Facultad de Economía Internacional, México
wmarquez@uach.mx
https://orcid.org/0000-00021632-0776

Jerónima Antonieta Pérez
Universidad Autónoma de Chihuahua, Facultad de Ciencias Agrícolas y Forestales, México
jeperez@uach.mx
https://orcid.org/0000-0002-8290-1739

María Guadalupe Macías López
Universidad Autónoma de Chihuahua, Facultad de Ciencias Agrícolas y Forestales
gmacias@uach.mx
https://orcid.org/0000-0002-4823-7651

Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias

Ciba

ISSN: 2007 - 9990

Resumen

La producción sostenible de energía eléctrica ha cobrado cada vez mayor preponderancia en el desenvolvimiento de todas las actividades humanas. De las muchas actividades humanas que son fundamentales garantizar su sustentabilidad, la producción agrícola es vital, puesto que la accesibilidad a los alimentos es uno de los mayores logros en los que ha podido avanzar la humanidad. Con la visión de buscar que la actividad agrícola de México se direccione a la vanguardia energética, este estudio se propuso determinar la factibilidad que puede tener la implementación de paneles solares para irrigación fotovoltaica en nogaleras en comunidades de pequeños y medianos agricultores de la región de Delicias, Chihuahua, México. Para ello se procedió a hacer un estudio de campo con productores de la región para evaluar los costos financieros y las infraestructuras necesarias para la implementación de dicha tecnología. El análisis respectivo arrojó resultados que mostraron que no es factible la inversión financiera de productores en paneles solares que puedan almacenar y conducir la energía solar necesaria en el bombeo para irrigación de nogaleras de la región por los altos costos de inversión inicial que requieren, así como unas tasas de retorno de inversión que oscilan entre 9 % y 13 % después de los 20 meses. En conclusión, actualmente se evidencia que la competitividad en el mercado y la sostenibilidad a largo plazo de los recursos energéticos siguen siendo conceptos dicotómicos, lo que hace imperativo seguir estudiando las posibilidades de tender puentes que garanticen un futuro energético sostenible para las comunidades agrícolas de la región.

Palabras claves: energía, fotovoltaica, panel, rentabilidad, solar.

Abstract

The production and sustainability of electrical energy has become increasingly important in the development of all human activities. Of the many human activities that are essential to ensure their sustainability, agricultural production is the most vital, since accessibility to food is one of the greatest achievements in which humanity has been able to advance. With the vision of directing Mexico's agricultural activity to the energy vanguard, this study represents an action research on the feasibility of implementing sustainable forms of energy production such as solar panels in communities of small and medium farmers in the region of Delicias, Chihuahua, Mexico. To this end, a field study was conducted with producers in the region to evaluate the financial costs and infrastructure needed for the implementation of solar panels.

The respective analysis yielded results that showed that it is not very feasible for producers to invest in solar panels that can store and conduct solar energy for the generation of energy needed in the photovoltaic pumping for irrigation of vegetables and walnuts in the region due to the high initial investment costs they require, as well as a rate of return on investment that ranges between 9% and 13% after 20 months. In conclusion, it is currently evident that market competitiveness and long-term sustainability of energy resources remain as dichotomous concepts, which makes it imperative to continue studying the possibilities of building bridges to ensure a sustainable future for farming communities in Mexico.

Keywords: energy, photovoltaics, panel, profitable, solar.

Resumo

A produção sustentável de eletricidade tornou-se cada vez mais importante no desenvolvimento de todas as atividades humanas. Das muitas atividades humanas fundamentais para garantir sua sustentabilidade, a produção agrícola é vital, uma vez que a acessibilidade aos alimentos é uma das maiores conquistas em que a humanidade conseguiu avançar. Com o objetivo de buscar que a atividade agrícola do México seja direcionada à vanguarda da energia, este estudo teve como objetivo determinar a viabilidade da implementação de painéis solares para irrigação fotovoltaica em nogaleras em comunidades de pequenos e médios agricultores na região de Delicias , Chihuahua, México. Para isso, foi realizado um estudo de campo com produtores da região para avaliar os custos financeiros e a infraestrutura necessária para a implementação da referida tecnologia. A respectiva análise produziu resultados que mostraram que o investimento financeiro de produtores em painéis solares que podem armazenar e conduzir a energia solar necessária no bombeamento para irrigação de nogaleras na região não é viável devido aos altos custos de investimento inicial que eles exigem, bem como taxas de retorno do investimento que variam entre 9% e 13% após 20 meses. Concluindo, é atualmente evidente que a competitividade do mercado e a sustentabilidade a longo prazo dos recursos energéticos permanecem conceitos dicotômicos, o que torna imperativo continuar estudando as possibilidades de construção de pontes que garantam um futuro energético sustentável para as comunidades agrícolas da região. região.

Palavras-chave: energia, fotovoltaica, painel, rentabilidade, solar.

Revista Iberoamericana de las Ciencias Biológicas y Agropecuarias

ISSN: 2007 - 9990

Fecha recepción: Abril 2019 **Fecha aceptación:** Diciembre 2019

Introduction

It is well known that electricity can be generated by various alternative sources. The considered clean sources that use renewable resources are usually more expensive in terms of their initial investment and less reliable than the traditional ones for a long-term return on investment (six or seven years after the initial investment). This is undoubtedly the reason why fossil fuels continue to be the main source of electricity generation. However, renewable energies have become vitally important as climate change mitigation strategies and this has led to some type of public policy or strategy that focuses on energy conservation and efficiency, to reduce energy emissions and the use of renewable sources such as solar (Hess, 2009).

In many regions of the world, groups of farmers producing through solar energy have been observed, which has given rise to the so-called energy communities (St. Denis and Parker, 2009). This term refers to those producers who have the ability to manage their electrical resources and become active participants in the electricity supply and demand of their community (Hess, 2009; Laborgne, 2011; St. Denis and Parker, 2009).

These communities are described in the literature as those that have the ability to manage themselves, adopting some type of local energy production and administration and establishing a close link between generation and consumption, which promotes a sustainable environment of economic benefits (Hess, 2009; St. Denis and Parker, 2009).

These groups have been successful in contexts of developed countries, where communities tend to be small, usually rural; where the efforts of local and national governments to implement the use of renewable energy have been notable (St Denis and Parker, 2009). In countries like Canada, Germany, Japan and more recently the United States, energy community plans have been implemented for about 10 years and have been truly successful in adopting renewable technologies for energy generation (Hess, 2009; St. Denis and Parker, 2009). This boom is mainly due to a favorable public policy environment in which the use and generation of alternative energy is openly promoted through incentives and norms in national legislation that seek to comply with the international policies and agreements of the green agenda.

In developing countries such as Mexico, and in their regions in particular, various factors limit the adoption of such initiatives, including levels of poverty, corruption and the lack of a sustainable energy policy that promotes such comprehensive proposals. .

A model of energy communities that has been suggested for countries with an emerging economy is the one proposed by the Food and Agriculture Organization of the United Nations (FAO): Integrated Food and Energy Systems (IFES) , whose purpose is to alleviate energy poverty and food insecurity in developing countries (Bogdanski, 2010). By integrating energy production with food for small producers, which are considered the largest group of agricultural producers worldwide (Bogdanski et al., 2010), the safety of both locally and even nationally can be improved. while reducing extreme poverty and the environmental impact caused by energy consumption from other non-renewable sources.

In the case of Mexico, and particularly of Delicias, Chihuahua, the current trends of global transformation, such as population growth, economic development and climate change, propitiate that resources such as water, energy, land use and Labor is seriously under pressure to support socio-economic development and maintain the demand for services. In addition to this, the opening of the markets accentuates this pressure for producers to be increasingly competitive: reduce their production costs, become certified to improve quality processes and adopt new technologies that allow them to be more productive and more efficient. This has greatly affected small producers in the region, who, being limited, often decide to leave the land and migrate to other cities or countries (Bogdanski *et al.*, 2010).

At this point it is necessary to go back a few steps and clarify that most of the IFES that exist integrate, as their own name anticipates, food and energy crops: the former can be placed on the same ground as renewable energy technologies like solar and wind.

It is therefore vital to know if there is the feasibility of financial investment of solar panel installation on food production.

Materials and methods

The methodology used to determine the financial feasibility of solar paper infrastructure for photovoltaic irrigation was practical action research, which, in Burns's terms (2007), had as facilitator the Faculty of Agricultural and Forestry Sciences of the Autonomous University of Chihuahua by integrating producers in the region through training

workshops, and thus generate and transfer know-how technology in different types of agribusiness.

The methodology allowed knowing the adaptation of solar energy in small and medium-sized farmers and nut producers in Delicias, Chihuahua, Mexico, from the financial technical point of view.

In the case of Mexico, and particularly in the regions of the state of Chihuahua, the analysis must be traced to the competitive conditions in which producers must be in order to remain in the market. Therefore, it is imperative to explore various ways of generating efficient alternatives for agricultural field production. This is oriented so that Chihuahua's producers can improve their living standards, and even generate a synergy of development and economic growth in their diverse communities. Under this hypothesis, the feasibility of implementing photovoltaic panels in the region already specified was analyzed. A financial study of some possible solar panel suppliers that could provide information regarding their investment costs and thus be able to establish financial runs was carried out.

This study analyzed the budgets that are managed from the materials necessary for the implementation of the project. This together with estimates of the costs of energy produced and energy saved through the photovoltaic panels, which yielded amounts of savings that would be obtained in annual time lapses. The foregoing allowed us to visualize when the project would begin to be financially competitive. Everything said here is reflected in the own elaboration tables located below.

Collection, processing and data analysis

- Congregation of producers from the Delicias region interested in evaluating the financial and economic feasibility of energy consumption for photovoltaic irrigation pumping.
- Delivery of workshops aimed at producers who were presented with the know-how of how to install solar panels, as well as a wide range of financing where they can request initial investment support.
- Meetings were held with individual producers of walnut trees, those willing to provide their costs and information necessary to make them financial runs. These producers have already invested in solar panels.

The sample was random because it was obtained from those attending the workshop held at the Faculty of Agricultural and Forestry Sciences.

Results

The data obtained through various walnut producers in the region of Delicias, Chihuahua, Mexico, allowed to measure the financial profitability, through its internal rate of return (IRR), net present value (NPV) and its cost-benefit analysis , in order to know when they would recover their initial return, how much their profits would amount to in the long term and how expensive it would be for the producer to use this solar infrastructure.

The results show that in the initial months the rate of return is very low compared to the investment that small and medium producers made; In fact there is no rate of return: it is very expensive in terms of disbursement of money.

The investment begins to recover much later. Therefore, it is not enough for these producers to finance or equate their expenses according to that investment during the early stages of recovery of the investment, that is, it is expensive, therefore, it is not feasible.

The implementation of solar energy infrastructure reflects the price of Producer A; The costs in dollars are included with the conversion in Mexican pesos, calculated at the time of the presentation of this article (table 1).

Tabla 1. Cotización para la implementación de la infraestructura de energía solar para el Productor A

Empresa	**Descripción del material**	**Piezas**	**Precio unitario en dólares**	**Total en dólares**
Vol. Ingeniería	Panel solar	309	231.00	71, 379.00
	Inversor (Fronius)	2	11, 893.80	22, 983.60
	Estructura de soporte	1	13, 128.00	13,128.00
	Instalación y calibración	1	800.00	800.00
			Subtotal	108, 290.60
Total en pesos mexicanos	2, 182, 018.325		Total con impuesto al valor agregado (IVA) incluido (1.16)	125, 617.10

Fuente: Elaboración propia

Through the work, estimates of the costs of energy produced and energy saved through the photovoltaic panels were determined, which yielded the amounts of savings that would be obtained in annual time lapses in the case of Producer A (table 2).

Tabla 2. Estimaciones de costes de energía producida y ahorrada por los paneles fotovoltaicos para el Productor A

Año	Costo energía (kWh) producida	Costo de energía producida p/año	Acumulado equivalente	Ahorro en pesos	Inversión	Monto inversión
1	$0.94	$133, 072.23	$133, 072.23	-$2 058 946,09	Negativo	$2,192 018,32
2	$1.02	$146, 379.46	$279, 451.69	-$1 779 494,40	Negativo	
3	$1.12	$161, 017.40	$440, 469.09	-$1 339 025,31	Negativo	
4	$1.23	$177, 119.14	$617, 588.24	-$721 437,07	Negativo	
5	$1.35	$194, 831.06	$812, 419.30	$90 982,22	A favor	
6	$1.49	$214, 314.16	$1,026,733.46	$1 117 715,68	A favor	
7	$1.64	$235, 745.58	$1,262,479.04	$2 380 194,72	A favor	
8	$1.80	$259, 320.14	$1, 521, 799.18	$3 901 993,90	A favor	
9	$1.98	$285, 252.15	$1, 807, 051.33	$5 709 045,24	A favor	
10	$2.18	$313, 777.37	$2, 120, 828.70	$7 829 873,94	A favor	
11	$2.40	$345, 155.11	$2, 465, 983.81	$10 295 857,75	A favor	
12	$2.64	$379, 670.62	$2, 845, 654.42	$13 141 512,17	A favor	
13	$2.90	$417, 637.68	$3, 263, 292.10	$16 404 804,27	A favor	
14	$3.19	$459, 401.45	$3, 722, 693.55	$20 127 497,82	A favor	
15	$3.51	$505, 341.59	$4, 228, 035.14	$24 355 532,95	A favor	
16	$3.86	$555, 875.75	$4, 783, 910.88	$29 139 443,84	A favor	
17	$4.25	$611, 463.32	$5, 395, 374.21	$34 534 818,04	A favor	
18	$4.67	$672, 609.66	$6, 063, 983.86	$40 602 801,91	A favor	
19	$5.14	$739, 870.62	$6,803, 854.49	$47 410 656,39	A favor	
20	$5.65	$813, 857.68	$7, 621, 712.17	$55 032 368,56	A favor	
21	$6.22	$895, 243.45	$8, 516, 956.62	$63 549 324,18	A favor	
22	$6.84	$984, 767.80	$9, 501, 723.42	$73 051 047,60	A favor	
23	$7.52	$1, 083, 244.58	$10,584 ,968.00	$83,636,015.6 0	A favor	
24	$8.24	$1, 191 ,569.04	$11,776,537.0 0	$95,412, 552.63	A favor	

Fuente: Elaboración propia

Table 3 reflects, for Producer A, the financial analysis based on the estimated projections.

Tabla 3. Análisis financiero con base en la proyección: Productor A

Variable	Proyección
Valor presente neto	-2, 080,46
Tasa interna de retorno	13 %
Relación beneficio/costo	$ 6, 318, 685.302

Fuente: Elaboración propia

Table 4 shows, for Producer B, the dollar price of the implementation of solar energy infrastructure. In addition, the value in Mexican pesos is included (amount subject to change of the day)

Tabla 4. Cotización para la implementación de la infraestructura de energía solar para el Productor B

Empresa	Descripción Material	Piezas	Precio Unitario en dólares	Total en dólares
Megaconser	Panel solar	304	258.62	78, 620.48
	Inversor IG Plus (Fronius)	8	2000.00	16, 000.00
	Estructura de soporte	1	1,800.00	1, 800.00
	Instalación y calibración	1	17, 820.00	17,820.00
			Subtotal	114,240.48
Total en pesos mexicanos	$2, 312, 455.796	Total con IVA incluido (1.16)		$132, 518.957

Fuente: Elaboración propia

Table 5 shows, for Producer B, the estimates of the costs of energy produced and energy saved through the photovoltaic panels.

Tabla 5. Estimaciones de costes de energía producida y ahorrada por los paneles fotovoltaicos para el Productor B

Año	Costo energía (kWh) producida	Costo de energía producida p/año	Acumulado equivalente	Ahorro en pesos	Inversión	Monto inversión
1	$0.92	$133, 072.23	$133, 072.23	-$2, 179, 383.56	Negativo	$2, 312, 455. 79.
2	$1.02	$146, 379.46	$279, 451.69	-$1, 899, 931.87	Negativo	
3	$1.12	$161, 017.40	$440, 469.09	-$1, 459, 462.78	Negativo	
4	$1.23	$177,119.14	$617, 588.24	-$841, 874.54	Negativo	
5	$1.35	$194, 831.06	$812, 419.30	-$29, 455.25	Negativo	
6	$1.49	$214, 314.16	$1, 026, 733.46	$997, 278.21	A favor	
7	$1.64	$235, 745.58	$1, 262, 479.04	$2, 259, 757.25	A favor	
8	$1.80	$259, 320.14	$1, 521, 799.18	$3, 781, 556.43	A favor	
9	$1.98	$285, 252.15	$1, 807, 051.33	$5, 558, 607.77	A favor	
10	$2.18	$313, 777.37	$2, 120, 828.70	$7, 709, 436.47	A favor	
11	$2.40	$345, 155.11	$2, 465, 983.81	$10, 175, 420.28	A favor	
12	$2.64	$379, 670.62	$2, 845, 654.42	$13, 021, 074.70	A favor	
13	$2.90	$417, 637.68	$3, 263, 292.10	$16, 284, 366.80	A favor	
14	$3.19	$459, 401.45	$3, 722, 693.55	$20, 007, 060.35	A favor	
15	$3.51	$505, 341.59	$4, 228, 035.14	$24, 235, 095.48	A favor	
16	$3.86	$555,875.75	$4, 783, 910.88	$29, 019, 006.37	A favor	
17	$4.25	$611, 463.32	$5, 395, 374.21	$34, 414, 380.57	A favor	
18	$4.67	$672, 609.66	$6, 063, 983.86	$40,482, 364.44	A favor	
19	$5.14	$739, 870.62	$6, 803, 854.49	$47, 290, 218.92	A favor	
20	$5.65	$813, 857.68	$7, 621, 712.17	$54,911,931.09	A favor	
21	$6.22	$895, 243.45	$8, 516, 956.62	$63,428,886.71	A favor	
22	$6.84	$984, 767.80	$9, 501, 723.42	$72,930,610.13	A favor	
23	$7.52	$1, 083,244.58	$10, 584, 968.00	$83,515, 578.13	A favor	
24	$8.24	$1,191, 569.04	$11, 776, 537.00	$95,292,115.16	A favor	

Fuente: Elaboración propia

Table 6 summarizes the financial analysis based on the projection proposed for Producer B.

Tabla 6. Análisis financiero con base en proyección: Productor B

Variable	**Proyección**
Valor presente neto	-$608.68
Tasa interna de retorno	12 %
Relación beneficio/costo	$6,406, 519.718

Fuente: Elaboración propia

Table 7 shows the price of Producer C for the implementation of solar energy infrastructure (presentation in dollars; on the left the value is presented in national currency).

Tabla 7. Cotización para la implementación de la infraestructura de energía solar para el Productor C

Empresa	**Descripción Material**	**Piezas**	**Precio unitario en dólares**	**Total en dólares**
Mego Solar	Panel solar marca Axitec	304	314.28	95, 541.12
	Inversor marca Inverter	8	4,938.57	39,508.36
	Estructura de soporte	1	1,300.00	1,300.00
	Instalación y calibración	1	22,800.00	22,800.00
			Subtotal	159,149.68
Total en pesos mexicanos	$3,221,507.823	Total con IVA incluido (1.16)		$184,613.629

Fuente: Elaboración propia

Table 8 shows, for Producer C, the estimates of the costs of energy produced and energy saved through the photovoltaic panels, which yielded amounts of the savings that would be obtained in annual time periods.

Tabla 8. Estimaciones de costes de energía producida y ahorrada por los paneles fotovoltaicos para el Productor C

Año	Costo energía (kWh) producida	Costo de energía producida p/año	Acumulado equivalente	Ahorro en pesos	Inversión	Monto inversión
1	$0.924	$133,072.23	$133, 072.23	-$3,088,435.59	Negativo	-$3,221,508.20
2	$1.02	$146,379.46	$279,451.68	-$2,808,983.90	Negativo	
3	$1.12	$161,017.40	$440,469.09	-$2,368,514.81	Negativo	
4	$1.23	$177,119.14	$617,588.24	-$1,750,926.57	Negativo	
5	$1.35	$194, 831.06	$812,419.30	-$938, 507.28	Negativo	
6	$1.49	$214, 314.16	$1,0,6,733.46	$88, 226.18	A favor	
7	$1.64	$235, 745.58	$1,262,479.04	$1, 350, 705.22	A favor	
8	$1.80	$259, 320.14	$1,521,799.18	$2, 872, 504.40	A favor	
9	$1.98	$285,252.15	$1,807,051.33	$4, 679 ,555.74	A favor	
10	$2.18	$313,777.37	$2,120,828.70	$6, 800, 384.44	A favor	
11	$2.40	$345,155.11	$2,465,981,38	$9, 266 ,368.25	A favor	
12	$2.64	$379,670.62	$2,845,654.42	$12, 112, 022.67	A favor	
13	$2.90	$417,637.68	$3,263,292.10	$15, 375, 314.77	A favor	
14	$3.19	$459,401.45	$3,722,693.55	$19, 098, 008.32	A favor	
15	$3.51	$505,341.59	$4,228,035.14	$23, 326, 043.45	A favor	
16	$3.86	$555,875.75	$4,783,910.88	$28, 109, 954.34	A favor	
17	$4.25	$611,463.32	$5,395,374.21	$33, 505, 328.54	A favor	
18	$4.67	$672,609.66	$6,063,983.86	$39, 573, 312.41	A favor	
19	$5.14	$739, 870.62	$6,803,854.49	$46, 381, 166.89	A favor	
20	$5.65	$813,857.68	$7,621,712.17	$54, 002, 879.06	A favor	
21	$6.22	$895,243.45	$8,516,956.62	$62 ,519 ,834.68	A favor	
22	$6.84	$984,767.80	$9,501,723.42	$72, 021, 558.10	A favor	
23	$7.52	$1,083,244.58	$10,584,968.00	$82,606, 526.10	A favor	
24	$8.24	$1,191,569.04	$11,776,537.00	$94,383,063.13	A favor	

Fuente: Elaboración propia

Table 9 reflects the financial analysis based on the projection for Producer C.

Tabla 9. Análisis financiero con base en proyección: Productor C

Variable	Proyección
Valor presente neto	-$2,707.05
Tasa interna de retorno	9 %
Relación beneficio/costo	6,908,758.366

Fuente: Elaboración propia

Table 10 shows the price of Producer D for the implementation of solar energy infrastructure (presentation in dollars; on the left the value is presented in national currency, which is subject to change based on the value of the dollar).

Tabla 10. Cotización para la implementación de la infraestructura de energía solar para el Productor D

Empresa	Descripción Material	Piezas	Precio Unitario en dólares	Total en dólares
Esolar	Panel solar	304	250.32	76,097.28
	Inversor Galvo (Fronius)	10	3,525.22	35,252.2
	Estructura de soporte	1	1,000.00	1,000.00
	Instalación y calibración	1	10, 000.00	10, 000.00
			Subtotal	122, 449.48
Total en pesos mexicanos	$2,478,622.374	Total con IVA incluido(1.16)		$142, 041.40

Fuente: Elaboración propia

Table 11 reflects for Producer D estimates of the costs of energy produced and energy saved through the photovoltaic panels, which, as in the previous cases, yielded amounts of savings that would be obtained in annual time periods.

Tabla 11. Estimaciones de costes de energía producida y ahorrada por los paneles fotovoltaicos para el Productor D

Año	Costo energía (kWh) producida	Costo de energía producida p/año	Acumulado equivalente	Ahorro en pesos	Inversión	Monto inversión
1	$0.92	$133,072.23	$133,072.23	-$2,345, 550.14	Negativo	-$2,478,622.37
2	$1.02	$146,379.46	$279,451.69	-$2,066,098.45	Negativo	
3	$1.12	$161,017.40	$440,469.092	-$1,625,629.36	Negativo	
4	$1.23	$177,119.14	$617, 588.24	-$1,008,041.12	Negativo	
5	$1.35	$194,831.06	$812,419.30	-$195,621.83	Negativo	
6	$1.49	$214,314.16	$1,026,733.46	$831, 111.63	A favor	
7	$1.64	$235,745.58	$1,262,479.04	$2,093,590.67	A favor	
8	$1.80	$259,320.14	$1,521,799.18	$3,615,389.85	A favor	
9	$1.98	$285,252.15	$1,807,051.33	$5, 442, 441.19	A favor	
10	$2.19	$313,777.37	$2,120,828.7	$7, 543, 269.89	A favor	
11	$2.40	$345,155.11	$2,465,983.81	$10, 009, 253.70	A favor	
12	$2.64	$379,670.62	$2,845,654.42	$12, 854, 908.12	A favor	
13	$2.90	$417,637.68	$3,263,292.1	$16, 118, 200.22	A favor	
14	$3.19	$459,401.45	$3,722,693.55	$19, 840, 893.77	A favor	
15	$3.51	$505,341.59	$4,228,035.14	$24, 068 928,90	A favor	
16	$3.86	$555,875.75	$4,783,910.88	$28, 852, 839.79	A favor	
17	$4.25	$611,463.32	$5,395,374.21	$34, 248, 213.99	A favor	
18	$4.67	$672,609.66	$6,063,983.86	$40, 316, 197.86	A favor	
19	$5.14	$739,870.62	$6,803,854.49	$47,124, 052.34	A favor	
20	$5.65	$813,857.68	$7,621,712.17	$54,745, 764.51	A favor	
21	$6.22	$895,243.45	$8,516,956.62	$63,262, 720.13	A favor	
22	$6.84	$984,767.80	$9,501,723.42	$72,764, 445.55	A favor	
23	$7.52	$1,083,244.58	$10,584,968.00	$83,349, 411.55	A favor	
24	$8.24	$1,191,569.04	$11,776,537.00	$95,125,948.58	A favor	

Fuente: Elaboración propia

Table 12 reflects the financial analysis based on the projection for Producer D.

Tabla 12. Análisis financiero con base en proyección: Productor D

Variable	Proyección
Valor presente neto	-$16,635.12
Tasa interna de retorno	11 %
Relación beneficio/costo	6,517, 660.817

Fuente: Elaboración propia

Discussion

It was observed that the investment is very high at the beginning, therefore, it is difficult for producers to have these costs, which very minimally begin to recover until the sixth month after the investment. However, the rate of return on investment (IRR) begins to be reflected until after 20 months of the investment, therefore, in no way is it affordable for medium-sized producers to invest in this type of infrastructure.

The investigation determined that, although several authors describe the benefits of the financial feasibility of establishing a photovoltaic system, the results show the opposite, that is, the idea that it could be a goodness and a profitability alternative for the small and medium-sized walnut producers in the region, since the investment begins to recover long after it is made. Thus, in the initial months, as the rate of return is very low compared to the investment they would make, it does not even exist. It is very expensive in terms of disbursement of money.

Therefore, nogalero producers in the region do not have sufficient financial resources to finance or equalize their expenses individually without government support. In short, it is expensive, therefore, it is not feasible.

Conclusions

The cost of implementing solar panels to generate photovoltaic solar energy for walnut irrigation in the region of Delicias, Chihuahua, Mexico, is not shown as a very attractive option for small and medium agricultural producers, due to its high cost of initial investment and its low rate of return in the short term. Therefore, financial support and accompaniment must be given continuously during a medium to long term period ranging from two to five years. So it is evident that sustainable energy options, such as photovoltaic panels, are not yet an attractive option for the market, as they are still less competitive than fossil energy sources. While it could be argued that, in exchange for future energy sustainability, investment is a cost that society should be willing to bear, the reality is that in low-income populations it represents a luxury that is not within reach without support Economic and technical

References

Bogdanski, A., Dubois, O., Jamieson, C. and Krell, R. (2010). *Making integrated food-energy systems work for people and climate: An overview*. Rome, Italy: FAO.

Comisión Nacional del Agua [Conagua]. (2018). Programa Nacional contra la Sequía: Monitoreo de la Sequía. México: Comisión Nacional del Agua. Recuperado de https://www.gob.mx/conagua/acciones-y-programas/programa-nacional-contra-la-sequia-monitoreo-de-la-sequia-64594.

Consejo Nacional de Evaluación de la Política de Desarrollo Social [Coneval]. (2012). *Informe de pobreza y evaluación en el estado de Chihuahua 2012*. Ciudad de México, México: Consejo Nacional de Evaluación de la Política de Desarrollo Social.

Gobierno de Chihuahua. (2010). Plan Estatal de Desarrollo del Estado de Chihuahua. México: Gobierno de Chihuahua. Recuperado de http://transparencia.uach.mx/planeacion/plan_estatal_desarrollo_2010-2016.pdf.

Gobierno de Chihuahua. (2018). Plan Municipal de Desarrollo 2018-2021. Municipio de Chihuahua. *Anexo al Periódico Oficial*, (4). Recuperado de http://www.chihuahua.gob.mx/atach2/anexo/anexo_04-2019_acuerdo_065_pmd_chihuahua_bajo.pdf.

Hess, D. J. (2009). *Localist Movements in a Global Economy: Sustainability, Justice and Urban Development in the United States*. Cambridge, United States: MIT Press.

Instituto Nacional de Estadística y Geografía [Inegi]. (2015). México en Cifras: Información Nacional por entidad Federativa y Municipios. México: Instituto Nacional de Estadística y Geografía. Recuperado de http://www3.inegi.org.mx/sistemas/mexicocifras/default.aspx?e=08.

Laborgne, P. (2011). Energy Sustainability: The role of Small Local Communities. In Järvelä, M. and Juhola, S. (eds.), *Energy, Policy and the Environment: Modeling Sustainable Development for the North* (pp. 193-214). New York, United States: Springer.

Organización de las Naciones Unidas [ONU]. (2014). Objetivos de Desarrollo del Milenio. Informe de 2014. Nueva York, Estados Unidos: Organización de Naciones Unidas.

Organización de lasNaciones Unidas para la Alimentación y la Agricultura (FAO): Sistemas Integrados de Alimentos y Energía (IFES) http://www.fao.org/home/es/

St. Denis, G. and Parker, P. (2009). Community energy planning in Canada: The role of renewable energy. *Renewable and Sustainable Energy Reviews*, *13*(8), 2088-2095.

Rol de Contribución	Autor (es)
Conceptualización	José Esteban Hernández Salas
Metodología	José Esteban Hernández Salas
Software	NO APLICA
Validación	Walter Márquez Fierro
Análisis Formal	Jerónima Antonieta Pérez
Investigación	José Esteban Hernández Salas
Recursos	José Esteban Hernández Salas
Curación de datos	María Guadalupe Macías López
Escritura - Preparación del borrador original	José Esteban Hernández Salas
Escritura - Revisión y edición	Jerónima Antonieta Pérez
Visualización	Walter Márquez Fierro
Supervisión	NO APLICA
Administración de Proyectos	Maríz Guadalupe Macías López
Adquisición de fondos	NO APLICA