National University of Comahue. Research Report.

Economic Viability of Photovoltaic Energy Generation for SMEs and Residences in the Alto Valle Region.

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Contenido

Abstract.

This study analyzes the economic and financial viability (feasibility) of investing in distributed generation through photovoltaic solar energy (PV) in the commercial (SME and MSE) and residential sectors of the Alto Valle region of Argentina. The objective is to address the low adoption of renewable energy sources, which is attributed to the lack of appropriate evaluation tools and communication strategies that demonstrate their feasibility. A mixed-design methodology was applied, combining economic-financial analysis with surveys on community perception.

The primary obstacle identified was the high initial cost of the equipment. Furthermore, 78.8% of respondents were unaware of financing models such as solar leasing or specific credits. The dominant concern was exchange rate variability (66.7%), surpassing the local interest rate, because system components are priced in US dollars. Despite these barriers, financial indicators, such as Net Present Value (NPV) and Internal Rate of Return (IRR), confirmed the project's viability. Even before the training, 63.6% already considered it viable. The study concludes that it is crucial to strengthen the diffusion of financial and regulatory knowledge (such as Law N° 27.424). Training activities improved the perception of viability and increased the intention to adopt photovoltaic technology.

Keywords: Microgeneration; Economic Viability; Financing

1. INTRODUCTION.

This academic project addresses a theme of growing relevance in the global and regional context: the transition toward sustainable energy sources. The development of new forms of generation and the promotion of technologies enabling access to electricity are imperative (urgent) for achieving sustainable development. This initiative directly aligns with

the Sustainable Development Goal (SDG) N° 7 of Agenda 2030, which seeks to guarantee universal access to affordable, secure, sustainable, and modern energy.

From the perspective of energy security, it is crucial that countries reduce their reliance on fossil fuels. Nationally, Argentina's energy matrix still relies heavily on fossil fuel combustion, which constitutes 86% of the primary energy produced. Confronting this dependency, Distributed Generation (DG) utilizing photovoltaic solar energy (PV) has been widely studied globally. This technology is considered a viable alternative for delivering electricity to populations, and its usage has been increasing at annual rates of approximately 40%.

To establish the niche and justify the study, it is explained that despite the demonstrated potential and international growth of DG, its massive adoption faces challenges intrinsic to the sector. The main issue hindering the expansion of this energy source lies in the high cost of acquisition and installation of clean technologies, such as solar panels.

This barrier is exacerbated by a significant financial information gap. There is a lack of knowledge regarding the actual potential for cost reduction, available financing methods, and incentives provided by distribution companies. In fact, 78.8% of respondents reported being unaware of financing models, such as solar leasing or specialized bank credits. Furthermore, in the Argentine context, exchange rate variability (TC) is perceived as the most relevant financial risk factor (even above the local interest rate), because the main components of the system are commercialized in US dollars.

The need for this research is justified by a clear regional knowledge gap. While previous international studies have analyzed the economic viability of grid-connected photovoltaic installations and micro-installations using key methodologies and metrics like Net Present Value (NPV), the Internal Rate of Return (IRR), and the Discounted Payback Period (DPBP), these studies were conducted in other countries and regions. Therefore, the

necessity for an analysis specifically localized in the Alto Valle region of Argentina is emphasized.

In light of this scenario, the central purpose of this work is twofold:

1. To conduct an Economic/Financial Viability Analysis of the investment in photovoltaic energy generation, focused on the commercial industry (particularly SMEs and MSEs) and residential consumers.

2. To materialize this analysis through the delivery of an instructional course, designed for students of the Faculty of Economics and Administration and other interested faculties.

The primary problem this study seeks to solve is the uncertainty regarding the financial viability of implementing distributed generation projects. This uncertainty stems from the difficulty of affording the initial investment and the time required for the return. This work employs a mixed research design, combining economic-financial analysis with the evaluation of community perception (via surveys).

2. METHODOLOGY.

2.1 CONTEXT AND PARTICIPANTS.

The study was conducted by four students of the National University of Comahue, enrolled in various programs within the Faculty of Economics and Administration. Participants range from 20 to 25 years old and reside in Cinco Saltos, Neuquén Capital, and Cipolletti, located in the provinces of Río Negro and Neuquén. Accordingly, the analysis focuses on the biocapacity of this particular territory.

The central purpose of the project is to evaluate the economic and financial viability of investing in photovoltaic energy generation for both the commercial sector (SME and

MSE) and residential use, and to apply this analysis through a training course aimed at students from the Faculty of Economics and Administration and other interested faculties.

2.2 RESEARCH DESIGN.

The study utilizes a mixed research design that combines economic-financial analysis with the evaluation of community perception (surveys). The project aims to resolve the problem of low adoption of renewable energies in Neuquén and surrounding areas, which is caused by the lack of technical and financial evaluation tools and the absence of effective communication strategies demonstrating viability. The main contribution is offering an economic viability analysis using concrete data.

2.3 UNIT OF ANALYSIS AND DATA COLLECTION.

For the production unit, a solar panel system previously acquired and installed in the home of one of the group members was used. Data obtained from this system included initial investment, installation cost, maintenance cost, average generation in kW, and estimated investment recovery time.

For the consumption unit, a family business located in Cinco Saltos was taken as a case study. Data collected from this business included standard electricity consumption, seasonal and monthly consumption, applied tariffs, and installation type. Additionally, residential tariffs from 15 users were incorporated to estimate an average residential consumption.

2.4 INSTRUMENTS AND MEASURES.

The economic viability of the investment was determined using key financial metrics: the Net Present Value (NPV) and the Internal Rate of Return (IRR). These measurements allowed for the quantification of the energy generation and consumption of the case study, adjusting cash flows to current prices.

The effectiveness of the training course was evaluated through a survey applied to participants, which included a pre-course instance to measure initial knowledge and perceptions. Factors analyzed included:

- Factors explaining the low adoption of solar panels.
- Investment recovery period between MSEs and residential consumption.
- Impact of the inflationary context and tariff increases.
- Level of financial knowledge about solar leasing.
- Influence of the exchange rate and interest rate on financial risk.
- Main technical concerns related to solar energy adoption.
- Perception of photovoltaic project viability.

Respondents included students from various UNComa majors (Economics, Administration, Public Accounting, and Electrical Engineering), as well as students from other universities, family, and associates of the authors.

For course development, relevant variables such as cost and generation capacity of different projects were analyzed. A sample of 61 solar kit listings on Mercado Libre (including panels, inverters, batteries, connectors, and cables) was taken. These kits were grouped

into four categories based on their estimated generation (kWh/day) and average price in Argentine pesos, determining the average cost per consumption group.

2.5 FINANCIAL ANALYSIS.

First, the actual and detailed electricity consumption of the business was established as the basis for the financial viability study. Figure 1 (in the source document) shows the business's consumption in KWh over the last year, separated by bimestre.

Figure 1. Historical Energy Consumption Data (kWh) of the Commercial Establishment.

1. Actual Consumption (analyzed via utility bill)

The actual analyzed business provided the following data on its EDERSA utility bill:

• Registered Consumption: 2365 KWh over a 62-day period.

• Average Daily Consumption: 38.77 KWh.

2. Calculation of Projected Annual Consumption.

- To calculate the projected annual consumption of the Cinco Saltos business, the average daily consumption is extrapolated to a full year (365 days):

- Calculation Formula: Annual Consumption (KWh/year) = Average Daily Consumption (KWh/day) × 365 days.
- Substituting the bill data: 14,151.05 KWh/year.
- Calculation Conclusion: The projected annual electricity consumption of the commercial establishment located in Cinco Saltos is approximately 14,151 kWh per year.
- Data (1): The average annual solar radiation in the Neuquén area is 4.49 kWh/m²/day. When multiplied by 365 days, this results in a total annual radiation of 1,638.85 kWh/m²/year, representing the typical amount of sunlight the region receives throughout the year.
- Data (2): The panel efficiency used for the calculation is 0.1585, which is considered a relatively common value for this type of equipment.
- Electricity cost reference: 1 kWh = ARS $229.21.
- Estimated Annual Energy Savings: 14,151.05 kWh/year × ARS $229.21/kWh = ARS $3,243,562.17.
- Total Effective Savings: 14,151.05 kWh/year × ARS $336.60/kWh = ARS $4,763,243.43.

However, in our opinion, this latter value is more realistic and aligns more closely with the main objective of the project: to demonstrate the economic feasibility of photovoltaic implementation through the actual reduction of operational energy costs for the business.

It is also important to consider the impact of taxes and contributions, such as Value Added Tax (VAT), Gross Income Tax, and other municipal or provincial charges, which affect the net financial savings achieved.

3. Minimum Total Area Required to Meet This Annual Energy Demand.

$$A_T = \frac{14.151}{1.638,85 \times 0,1585} = 55\ \mathrm{m}^2$$

4. Nominal Power (indicates how many kilowatts (kW) the system can generate under standard conditions).

The number of panels fitting the space is 55m^2 / (1,6 m^2/panel) = 35 panels.

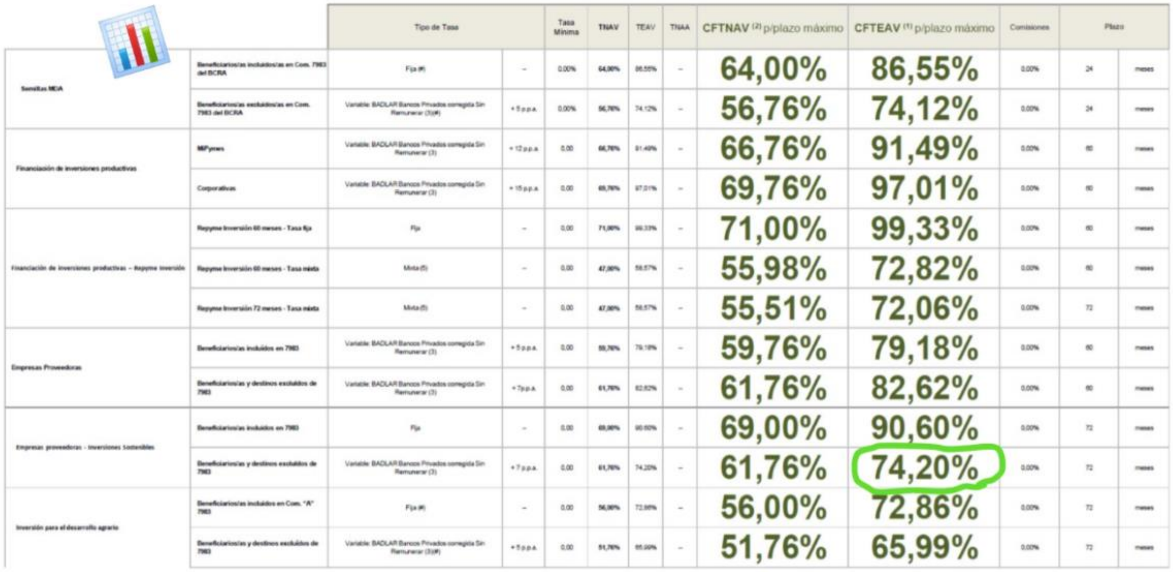
These 35 panels, multiplied by 250 watts (standard nominal power per panel), give the installed nominal power: 35×250 watts = **8.6 kW.**

5. Estimated Total Investment Cost based on a representative Kit consuming 35 kWh/day.

Since the business requires 38.77 kWh/day on average, the estimated initial investment cost is: $ 12,700,000 ARS.

- The most attractive financing option for the photovoltaic investment project is the line offered by the Banco Provincia for Sustainable Investments, with a CFTEAV (Effective Annual Financial Cost) of 74.20%.)

Figure 2. Financing Scenarios.



		Tipo de Tasa		Tasa Mínima	TNAV	TEAV	TNAA	CFTNAV [2] p/plazo máximo	CFTEAV [3] p/plazo máximo	Comisiones	Plazo	
Semillas MEA	Beneficiarios/as incluidos/as en Com. 7983 del BCRA	Fija (#)	–	0,00%	64,00%	86,55%	–	64,00%	86,55%	0,00%	24	meses
	Beneficiarios/as excluidos/as en Com. 7983 del BCRA	Variable: BADLAR Bancos Privados corregida Sin Remunerar (3)(#)	+ 5 p.p.a.	0,00%	56,76%	74,12%	–	56,76%	74,12%	0,00%	24	meses
Financiación de inversiones productivas	MiPymes	Variable: BADLAR Bancos Privados corregida Sin Remunerar (3)	+ 12 p.p.a.	0,00	66,76%	91,49%	–	66,76%	91,49%	0,00%	60	meses
	Corporativos	Variable: BADLAR Bancos Privados corregida Sin Remunerar (3)	+ 15 p.p.a.	0,00	69,76%	97,01%	–	69,76%	97,01%	0,00%	60	meses
Financiación de inversiones productivas – Repyme inversión	Repyme inversión 60 meses - Tasa fija	Fija	–	0,00	71,00%	99,33%	–	71,00%	99,33%	0,00%	60	meses
	Repyme inversión 60 meses - Tasa mixta	Mixta (5)	–	0,00	47,00%	72,82%	–	55,98%	72,82%	0,00%	60	meses
	Repyme inversión 72 meses - Tasa mixta	Mixta (5)	–	0,00	47,00%	72,06%	–	55,51%	72,06%	0,00%	72	meses
Empresas Proveedoras	Beneficiarios/as incluidos en 7983	Variable: BADLAR Bancos Privados corregida Sin Remunerar (3)	+ 5 p.p.a.	0,00	59,76%	79,18%	–	59,76%	79,18%	0,00%	60	meses
	Beneficiarios/as y destinos excluidos de 7983	Variable: BADLAR Bancos Privados corregida Sin Remunerar (3)	+ 7p.p.a.	0,00	61,76%	82,62%	–	61,76%	82,62%	0,00%	60	meses
Empresas proveedoras - inversiones Sostenibles	Beneficiarios/as incluidos en 7983	Fija	–	0,00	69,00%	90,60%	–	69,00%	90,60%	0,00%	72	meses
	Beneficiarios/as y destinos excluidos de 7983	Variable: BADLAR Bancos Privados corregida Sin Remunerar (3)	+ 7 p.p.a.	0,00	61,76%	74,20%	–	61,76%	74,20%	0,00%	72	meses
Inversión para el desarrollo agrario	Beneficiarios/as incluidos en Com. "A" 7983	Fija (#)	–	0,00	56,00%	72,86%	–	56,00%	72,86%	0,00%	72	meses
	Beneficiarios/as y destinos excluidos de 7983	Variable: BADLAR Bancos Privados corregida Sin Remunerar (3)(#)	+ 5 p.p.a.	0,00	51,76%	65,99%	–	51,76%	65,99%	0,00%	72	meses

This choice is justified by the line's capacity to mitigate the primary perceived barrier: the high initial investment cost.

Financing 100% of the investment (including VAT) offers a unique term of 72 months (6 years), which is better than the 60 months offered by BBVA or 48 months by Santander. Longer terms reduce the impact of the monthly installment on the business's cash flow.

It is estimated that panels lose efficiency over time, with a degradation of 0.7% annually, slightly reducing production each year. An assumed inflation of 35% annually (2.91% monthly) is applied to the Adjusted Savings.

Figure 3. Effect of Inflation on Adjusted Savings.

Año	Ahorro Ajustado	Factor de Descuento	Valor Actual del Ahorro	VAN Acumulado
1	4763243,43	0,574052813	2734353,289	-9965646,711
2	6385365,98	0,350127797	2235694,121	-7729952,589
3	8559902,365	0,207176211	1773408,139	-5956544,451
4	11474977,11	0,122589474	1406711,408	-4549833,042
5	15382780,57	0,07253815	1115838,449	-3433994,593
6	20621386,49	0,042921982	885110,7886	-2548883,805
7	27643999,67	0,025397623	702091,8743	-1846791,93
8	37058163,75	0,015028179	556916,7232	-1289875,207
9	49678321,42	0,008892414	441760,1853	-848115,0218
10	66596273,78	0,005261783	350415,1577	-497699,8641
11	89275634,81	0,003113481	277958,0116	-219741,8525
12	119678452,2	0,001842297	220483,2026	**741,3501187**

The IRR is 77%, which is higher than the discount rate used, and therefore above the break-even point (as explained during the course).

Net Present Value (NPV): The NPV is greater than zero (NPV > 0).

Based on the financial analysis performed, it is concluded that the project is viable and presents optimal results. The NPV (Net Present Value) was positive starting from year 12, indicating that the project generates value surplus relative to the capital's opportunity cost. The IRR (Internal Rate of Return) is 77%, which is superior to the discount rate used, reinforcing the project's economic viability as it implies profitability exceeding the minimum required.

3. RESULTS.

The analysis of the Pre-Course Survey results identified the main problems perceived regarding photovoltaic investment. The most frequently mentioned barrier was the high initial cost of the equipment, which received the maximum score. However, an interesting trend

was observed: 66.7% considered that the pursuit of energy independence and greater supply reliability justifies the investment, especially in a context of tariff increases.

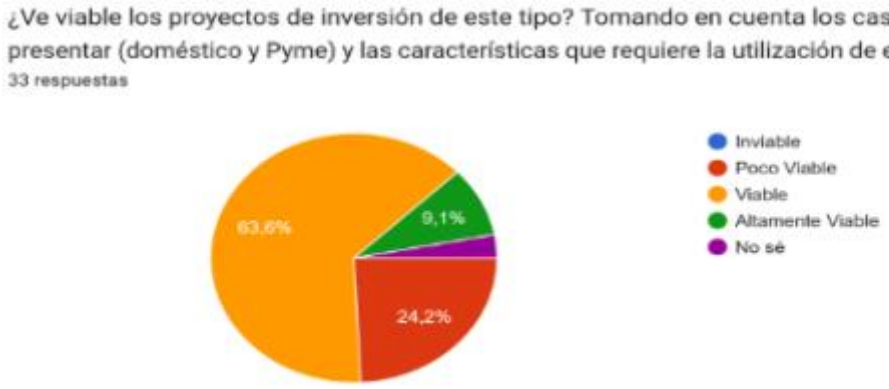
Regarding technical aspects, significant concern was registered over specialized maintenance (54.4%) and the possible progressive degradation of the panels (36.4%). This suggests that operational complexity is viewed as a constant challenge.

Regarding financial conditions, 78.8% of participants reported being unaware of financing tools such as solar leasing or specialized credit lines, which indicates a lack of adequate dissemination and accessible information. In addition, exchange rate variability was identified as a more significant risk than the local interest rate, given that most system components are traded in U.S. dollars. This perception directly influences the sense of economic instability among potential adopters.

Concerning the investment payback period, most participants agreed that recovery is faster for small businesses with high daytime consumption, as solar generation naturally coincides with peak energy demand. This reasoning contributes to a perception of higher relative profitability in commercial contexts.

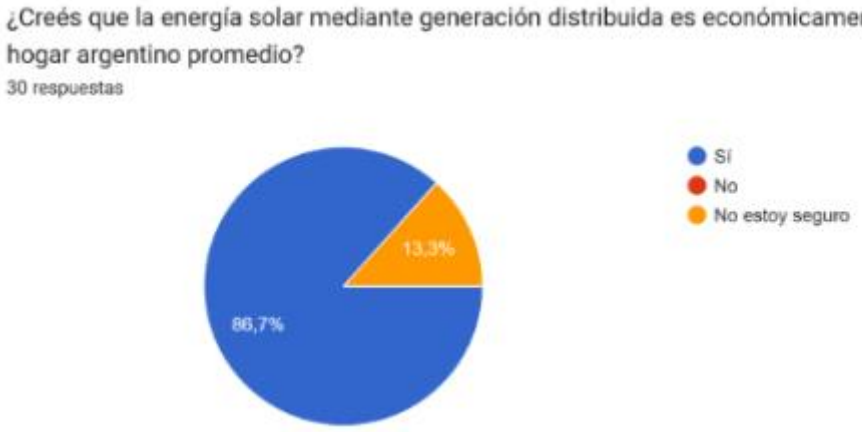
When integrating all these elements, 63.6% of respondents evaluated the projects as viable, although such viability is conditioned by the previously mentioned financial and technical barriers.

Figure 4. Pre-course results on project viability.



Subsequently, the Post-Course Survey revealed a notably positive increase in content comprehension: most participants rated the explanations as clear or very clear. Moreover, the percentage of individuals who considered photovoltaic investment viable increased to 86.7%, demonstrating a favorable educational impact. However, high upfront costs remain the main barrier, influencing decisions to implement these systems over medium- to long-term periods.

Figure 5. Post-course results on project viability.



Finally, the solar kit market analysis enabled the classification of different generation ranges and the estimation of associated costs, facilitating a comparative evaluation of alternatives according to each user's consumption level and specific energy needs.

4. DISCUSSION.

Pre-Course Survey Discussion.

Three main problems perceived by participants regarding the adoption of distributed generation (DG) projects were identified: high initial costs, the need for specialized maintenance, and the capacity and durability of components (panels and batteries).

These findings suggest that financial evaluation, specifically through the Net Present Value (NPV), must be a priority analysis axis, since results indicate that despite the high initial investment, the economic return can be positive in the medium term.

The data show that the perception regarding maintenance and durability may be overestimated by respondents, as technical evidence indicates that maintenance costs for photovoltaic systems are considerably lower compared to other DG sources, such as wind or internal combustion engines. Likewise, the estimated useful life of panels (25 years) and batteries (10 years) suggests that durability should no longer be considered a critical barrier.

In a context of sharp tariff increases, dissemination strategies should emphasize not only the reduction of operating costs but also the advantages in terms of security and stability of the energy supply offered by photovoltaic DG. The perception of project viability holds up beyond purely technical or financial aspects, reinforcing the need for a training dimension focused on regulatory and normative knowledge (like Law 27.424).

Financial Issues.

The low level of knowledge (78.8%) about financing models among respondents represents a significant information gap that could hinder the adoption of photovoltaic

technologies. This deficit may be linked to the fact that specialized financial advice often involves a cost, limiting users' ability to perform detailed economic analyses.

Furthermore, it is observed that exchange rate variability (TC) is a greater concern than the local interest rate. This perception is explained because the Argentine economy largely operates under a bimonetary dynamic, and exchange rate fluctuations directly affect the purchasing power of components (which are priced in dollars). Consequently, training sessions should explicitly address macroeconomic risks and exchange rate implications in DG projects.

Optimism is evident regarding the investment recovery period, especially in small businesses with high daytime consumption, suggesting that the economic return is perceived as faster in these commercial cases than in average residences. This result implies that the user profile can determine the viability of adoption differently.

In summary, although relevant barriers were identified, the data indicate that the adoption of DG projects via PV energy is still considered viable even before the training, reinforcing the hypothesis that the perception of profitability is present even without specialized technical, regulatory, or financial information.

Post-Course Survey Discussion.

After the training, a high level of unfamiliarity persists regarding current legislation (Law 27.424). The high initial cost remains the foremost perceived obstacle.

However, it is noteworthy that a larger proportion of participants (86.7%) consider DG viable and express the intention to implement or recommend it. This indicates that the course succeeded in reinforcing the perception of viability and increasing the intention for

adoption. These findings underscore that training and dissemination activities can play a key role in the transition toward a more robust DG market in Argentina.

5. CONCLUSION.

The study results indicate that it is necessary to strengthen the diffusion of financial and normative knowledge related to photovoltaic distributed energy generation. This is a key factor for boosting the adoption of microgeneration projects in residential and commercial spheres.

The findings reveal that PV investment projects are perceived as economically viable even before the training intervention. The educational activities demonstrated a positive and significant effect on understanding economic viability. The training included explanations of Law N° 27.424, differentiated consumption scenario analysis (residential and SME), component lifespan, production profiles, and fundamental financial indicators such as NPV, IRR, and the Investment Recovery Period (PRI) (or DPBP), in addition to available financing options. These contents appear to have contributed to a better understanding of the long-term economic return and benefits associated with PV installation.

However, the study presents certain limitations:

1. The sample size was small (approximately 30 surveys).

2. The representativeness of participants may be biased, as some respondents were close contacts of the involved students.

3. The analysis of consumption scenarios was based on a limited set of observations (one SME and ten residential cases), and production cost data came from a single reference source.

Despite these limitations, the results support the hypothesis that photovoltaic DG possesses high adoption potential, conditioned primarily by access to quality technical, economic, and regulatory information. Consequently, strengthening dissemination and training strategies is necessary, integrating knowledge on financing, the normative framework, and profitability analysis.

In terms of practical implications, investments in distributed Microgeneration projects allow residential and commercial consumers to adopt more strategic attitudes regarding energy use, contributing to national energy security and the decarbonization of the electric system. Improving the social perception of these benefits will enhance public confidence in their profitability and sustainability, and promote higher levels of investment.

For future research, it would be convenient to expand the sample size and diversity, improve the accuracy of consumption scenarios and cost data, and refine the economic evaluation models. This would allow for the development of more robust comparative analyses to assess the real impact of promotion policies and changes in the macroeconomic context on the viability of photovoltaic DG in Argentina.

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