Authors
Rolando Fuentes Bracamontes
Roberto Durán-Fernández
Michele Vittorio
Marcelo Galán González
María Fernanda
García Valaguez

Coordination
Anda David

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Redesigning Electricity Subsidies for Distributed Generation in Mexico:

A Fair Transition Model Applied to Nuevo Leon

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Redesigning Electricity Subsidies for Distributed Generation in Mexico: A Fair Transition Model Applied to Nuevo Leon

Authors

Rolando Fuentes Bracamontes
Tecnológico de Monterrey

Roberto Durán-Fernández
Tecnológico de Monterrey

Michele Vittorio
University of New Haven

Marcelo Galán González
Tecnológico de Monterrey

María Fernanda García Valaguez
Tecnológico de Monterrey

Coordinator

Anda David

Agence française de développement

Abstract

Mexico is faced with a dual energy challenge: to move forward in a transition towards clean sources while meeting the immediate nearshoring demands, calling for a reliable electricity infrastructure. The study presented herein offers a fiscally neutral redesign of the residential electricity subsidy, replacing regressive monetary transfers with in-kind subsidies through the installation of solar panels on residential rooftops. Implementing this proposal to the state of Nuevo Leon, a technical, fiscal and distributive analysis that estimates the potential for distributed generation is developed, based on the redirection of already existing subsidies.

Through geospatial tools and economic modeling, the region is expected to install more than 74,000 residential photovoltaic systems annually, generating between 196 and 262 GWh of electricity per year, which would free up grid capacity for new industrial projects. The study makes an assessment on the different financing schemes, reflecting that it is possible to maintain fiscal neutrality and improve distributive equity via progressive mechanisms. Likewise, it also discusses the operational limits and institutional conditions required to scale up this policy.

As a proof of concept, this work shows the technical and economic feasibility of a modular distributed generation policy aimed at reducing structural inequalities, accelerating the energy transition and strengthening industrial competitiveness in strategic regions.

Keywords: Distributed generation; electricity subsidies; distributive justice; nearshoring;

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Résumé
Le Mexique fait face à un double défi énergétique : progresser dans la transition vers des sources d'énergie propres tout en répondant aux exigences immédiates du nearshoring, qui nécessite une infrastructure électrique fiable. Cette étude propose une refonte fiscalement neutre du système de subventions à l'électricité résidentielle, remplaçant les transferts monétaires régressifs par des subventions en nature sous forme d'installation de panneaux solaires sur les toits des habitations. En appliquant cette proposition à l'État de Nuevo Leon, une analyse technique, fiscale et distributive est développée afin d'estimer le potentiel de la génération distribuée à partir de la réaffectation des subventions existantes.
À l'aide d'outils géospatiaux et de modélisations économiques, on estime que la région pourrait installer plus de 74 000 systèmes solaires résidentiels par an, générant entre 196 et 262 GWh d'électricité par an, libérant ainsi de la capacité sur le réseau pour de nouveaux projets industriels. L'étude évalue différents schémas de financement, montrant qu'il est possible de maintenir la neutralité budgétaire et d'améliorer l'équité distributive grâce à des mécanismes progressifs. Les limites opérationnelles et les conditions institutionnelles nécessaires pour étendre cette politique sont également discutées.
En tant que preuve de concept, ce travail démontre la faisabilité technique et économique d'une politique modulaire de génération distribuée visant à réduire les inégalités structurelles, accélérer la transition énergétique et renforcer la compétitivité industrielle dans des régions stratégiques.

Mots-clés: génération distribuée ; subventions à l'électricité ; justice distributive ; nearshoring

Introduction

Mexico is faced with a dual challenge: to advance its energy transition and to ensure this process is fair and equitable. At the same time, the growing wave of opportunities linked to the reconfiguration of global value chains, or nearshoring, demands reliable and immediately available electricity infrastructure, something that the current limited and highly subsidized system capacity cannot fully guarantee (Durán-Fernández, 2024; Durán-Fernández, 2025).

Recent studies (Fuentes and Vittorio, 2023; Fuentes, Durán-Fernández and Montoya, 2024), have proposed an innovative alternative: taking advantage of the technological advancement of solar distributed generation to alleviate bottlenecks in the electricity grid, freeing up capacity for industry. Inspired by the transformative potential of this technology, even highlighted by The Economist (2024), a redirection of current electricity subsidies — 81.4 billion pesos in 2024 (Government of Mexico, 2023)— towards the provision of residential solar panels as in-kind subsidies is proposed.

This proposal stands out not only for its technological innovation, but also for its institutional design geared towards distributive justice. Unlike schemes that increase public expenditure, here we suggest an efficient reallocation of the existing budget: instead of subsidizing electricity consumption in a regressive manner, this resource becomes a productive investment focused on lower-income households. As a result, neutral fiscal impact is ensured, while promoting a more equitable distribution of energy benefits and strengthening the economic resilience of the most vulnerable sectors.

The study applies that proposal to Nuevo Leon, a state that spearheads the attraction of investments derived from the reconfiguration of global value chains in Mexico, with 287 projects and 68 billion dollars in investment announced between 2021 and 2024 (Bloomberg en Español, 2024). In addition to its economic dynamism, the state has favorable levels of solar irradiation (Global Solar Atlas, 2024), although it faces severe limitations when it comes to electricity infrastructure after the cancellation of strategic projects. These shortcomings, already evidenced in recent grid stress events (Payán, Montes de Oca et al., 2024), threaten to curb growth potential if not addressed promptly.

In order to evaluate this strategy, a pilot study is built based on geo-referenced platforms, which crosses industrial investment data with the potential of residential rooftops to install solar panels. We estimate that, by redirecting the annual electricity subsidy available in Nuevo Leon, about 74,702 photovoltaic systems could be installed per year, generating between 196 and 262 GWh of additional electricity per year. Five years from now, more than 1,000 MW of installed capacity would be accumulated, equivalent to a large-scale but distributed solar power plant.

For this purpose, a 10-year financing scheme is being evaluated from two complementary sources: the federal government's electricity subsidy—brought to present value through a credit mechanism—and a loan to the Federal Electricity Commission (CFE) supported by household bills. Contextualized in a carryover sale energy market, this scheme generates additional benefits to households while creating fiscal space.

This strategy is proposed as a fiscally neutral policy, since it does not increase public expenditure, but rather transforms it into productive investment. At the same time, it seeks to correct the current inequity in the distribution of subsidies, preferentially benefiting low-income and middle-income households.

Although the projected figures may seem ambitious compared to national plans—such as the 27 GW of distributed generation proposed by Plan Mexico for 2030 or the 13 GW of PRODESEN for 2038—, our approach is complementary: it is designed to respond immediately to the bottlenecks that threaten the entry of new industry-related investments. This bottom-up analysis is not intended to replace national planning, but to offer a pragmatic solution that can scale up at a fast pace.

In this sense, this document should be understood as a proof of concept. It explores the technical, fiscal and distributive feasibility of a modular distributed generation policy, offering concrete evidence to rethink electricity subsidy policy and accelerate the deployment of renewables in strategic areas.

1. Conceptual framework

The debate on economic policy interventions aimed at regulating the energy sector has become relevant in the contemporary discussion on how to optimize the use of subsidies. Weitzman (1974) provides a theoretical framework for understanding the effectiveness and challenges of regulatory tools in uncertain environments, which has been applied to environmental and energy policy. It emphasizes the need for innovative approaches that address the specificities of the Mexican energy sector and its infrastructure.

Sovacool (2017) further elaborates on that discussion by stating that subsidies are essential instruments to achieve different policy objectives. He proposes that regulators can, through proactive subsidy design, influence the development of the energy sector to achieve both economic and social objectives. This approach resonates with the ideas of Mazzucato (2021), who argues that the state should play a proactive role in industrial policy, establishing sectoral "missions" to channel public resources towards sustainable initiatives. This dual perspective is especially relevant given the significant number of subsidies at a global level, which reached about $447 billion in 2017, of which at least $128 billion was earmarked for electricity subsidies (Taylor, 2020).

Faced with the challenges of energy transition and climate change, governments are exploring alternatives for financing their energy policies. One innovative option is the widespread installation of solar photovoltaic panels in the residential sector, thus addressing the problems of electricity infrastructure through Distributed Energy Resources (DER). This approach would not only facilitate energy independence for consumers, but can alleviate pressure on distribution grids and improve the efficiency of the energy system as a whole (IEA, 2022).

DER systems allow consumers to meet their energy needs locally, using net metering agreements or feed-in tariffs, which turn users into "prosumers". However, some critics warn about the phenomenon known as the "death spiral" of utilities, in which massive adoption of DER can lead to financial imbalances in these companies (Ford, 1997; Costello et al., 2014). This argument has been the subject of much debate, but studies have shown that the materialization of such a spiral depends largely on the speed of adoption of DER technologies and the adaptability to the new paradigm of energy providers (Muaafa et al., 2017; Laws et al., 2017).

Despite the inherent tensions, DER can help achieve sustainability and renewable energy generation goals. Recent research has demonstrated the great potential of solar roofing systems in different geographical contexts. For example, studies in cities such as Islamabad (Kamran Lodhi et al., 2024) and locations in Peru (Bazan et al., 2018) have found that using rooftops for solar energy can enable a large proportion of local electricity demand to be met and contribute to the reduction of CO_2 emissions.

However, literature dealing specifically with the transition from price-based electricity subsidies to a quantity-based subsidy is scarce, such as the one that would be implemented for the procurement of solar panels. This article proposes a model of in-kind electricity subsidies for Mexico, as a contribution to the debate on how these instruments can be transformed to facilitate the adoption of distributed generation technologies in the context of a fair and effective energy transition. The implementation of this policy would not only address the urgent need to upgrade electricity infrastructure, but could also enhance the development of investments derived from the reconfiguration of global value chains and benefit households financially.

2. National and regional context

2.1. Design and distortions of electricity subsidies in Mexico

The viability of a public policy based on distributed generation cannot be evaluated without considering the particularities of the Mexican electricity system, especially its tariff complexity and the current context of national energy planning. This section briefly describes both elements, which are fundamental for interpreting the scope and limitations of the study.

Mexico's electricity tariff system is notoriously complex, both in its structure and in the way it distributes subsidies. There are multiple levels of subsidization that generate cross-subsidies between types of users, regions and consumption levels, configuring a system that is neither linear nor totally progressive.

At the residential level, the domestic tariff is divided into eight variants according to the average temperature of the municipality: a base tariff (Tariff 1) for temperate zones, six climatic tariffs (from 1A to 1F) for warm zones —with higher subsidies— and the Domestic High Consumption tariff for households that exceed certain consumption thresholds. Each tariff incorporates tiered blocks: the first kilowatt-hours consumed are billed at highly subsidized prices, while excess consumption pays progressively higher rates. Above a certain monthly threshold, the user automatically switches to the Domestic High Consumption tariff, losing subsidies.

Although this structure is intended to be progressive, it introduces distortions in practice. Lower income households that consume less kWh receive higher subsidies per unit, but middle or high income households, if they have low consumption (due to energy efficiency or smaller family size), also have access to the subsidy. In addition, there are strong cross-subsidies between regions: while in Hermosillo a household can consume up to 2,500 kWh bimonthly while maintaining its subsidized rate, in Mexico City the threshold for losing the subsidy can be as low as 250 kWh. This causes significant geographic inequities.

At the sectoral level, subsidies are concentrated in the domestic and agricultural sectors, while the commercial, industrial and service sectors pay unsubsidized tariffs, even incurring cost overruns at times of high demand. This scheme implies that non-residential users subsidize domestic consumption de facto.

For this study, given the complexity and variability of the subsidy according to location and consumption, it was decided to work with weighted average prices and with aggregate estimates of the subsidy applied in the Nuevo Leon region. This methodological simplification is recognized as a limitation, but it is necessary to build a duplicable and evaluable proof of concept at the aggregate fiscal level.

2.2. National energy transition policies and complementary programs

The current federal administration has proposed an ambitious energy transition strategy through two key instruments: the Mexico Energy Transition Plan 2024-2030 and the National Electricity System Development Program (PRODESEN) 2024-2038.

As one of its main goals, Plan Mexico establishes the installation of 27 GW of new distributed generation (DG) capacity nationwide by 2030. This goal responds to broad policy priorities: decentralizing electricity production, reducing transmission losses, strengthening energy sovereignty and expanding equitable access to clean sources.

Similarly, PRODESEN proposes a more conservative course of action, in which it foresees the addition of approximately 13 GW of distributed capacity by 2038. This difference reflects the different approaches of the two documents: while Plan Mexico has a programmatic and political function, PRODESEN is oriented towards the technical planning of the national electricity system.

Within this framework, the federal program called Sol del Norte represents a concrete public policy that shares the principles of energy justice and distributed generation. Initially focused on Mexicali, it seeks to reduce electricity costs for vulnerable households by up to 70% through the subsidized installation of solar panels. In addition to relieving pressure on the electricity system at peak hours, the program avoids the use of storage technologies for cost reasons, and constitutes a direct and rapidly implemented redistributive measure.

The study presented here, although focused on the specific scenario of Nuevo Leon, offers a complementary perspective. It proposes a replicable model that assesses how to redirect existing electricity subsidies towards distributed generation, which can simultaneously contribute to energy transition, fiscal sustainability and social equity. By estimating the number of residential photovoltaic systems that could be financed with the current subsidy, this work provides a useful proof of concept for sizing whether national targets are achievable under different progressive financing schemes.

In this sense, it should not be interpreted as a closed national proposal, but rather as an analytical tool that seeks to inform and enrich the implementation of existing public policies, such as Sol del Norte, and accelerate their deployment in strategic regions, in line with federal planning objectives.

3. Methodology

In order to estimate the technical, economic and fiscal potential of redirecting electricity subsidies towards the installation of solar panels in homes in the Monterrey Metropolitan Area and in strategic municipalities for nearshoring, an exercise was developed based on geospatial analysis, technical modeling of photovoltaic systems and aggregate fiscal estimates.

The first step was to identify the area potentially available for the installation of residential rooftop photovoltaic systems. Using Geographic Information Systems (GIS) platforms, a grid of 10x10 meter cells was built over the Monterrey Metropolitan Area, excluding unhabitable areas such as waterbodies, roads and non-residential industrial parks. This resulted in 6,638 million square meters available (see the Annex for a more detailed discussion). To focus the analysis on housing, the ENVI 2020 database was used, which estimates the percentage of land destined for housing use. Applying this ratio, it was calculated that approximately 139 million square meters correspond to residential rooftops.

Subsequently, the subregion comprising municipalities with an industrial vocation more directly linked to nearshoring was delimited. Repeating the above procedure, we obtained an available residential roof area of 105.5 million square meters in these municipalities.

Based on this available area, the installation capacity was modeled considering an average 2 kW photovoltaic system, whose standard technical footprint is estimated at 11 square meters. Dividing the total area by the area required per system, a technical maximum of approximately 9.6 million installable systems in the selected municipalities was estimated.

In terms of costs, a market price of 37,172 Mexican pesos per complete 2 kW system, including panels, inverters, mounting structure and installation labor, was assumed. According to this reference, installing all of the identified systems would cost a total of approximately 356,506 million pesos.

The next step was to cross-reference this technical potential with the available public budget. According to the Federal Expenditure Budget 2024, approximately 3,674 million pesos are allocated to electricity subsidies in the analyzed region. Using these resources and the estimated cost per system, it was calculated that around 98,826 systems could be financed in a single year. However, in order to build more conservative and realistic scenarios —considering possible technical or social constraints—, the main model was based on the installation of 74,702 systems in one year.

The expected energy production per system was estimated within a range of 1,200 to 1,600 kWh per kW installed annually, according to regional solar irradiation data. This implies that each household equipped with a 2 kW system could generate between 2,400 and 3,200 kWh per year. For the total systems financed, the aggregate annual generation is between 179 and 239 GWh, although in the operational analysis it was rounded to a range of 196 to 262 GWh, incorporating technical improvement margins based on orientation, tilt and efficiency.

Comparing this production with the estimated total electricity demand of the prioritized municipalities —approximately 2,850 GWh per year—, the program would cover between 6.9% and 9.2% of the electricity consumption of the region that was analyzed. This participation, although limited, is significant considering that it would be achieved without the need to build new power plants or broaden the transmission grid.

One of the underlying assumptions of the study is that the installation of photovoltaic systems in residential homes frees up capacity in the electricity grid, which indirectly benefits the industrial sector. It is important to note that hourly dispatch of electricity is not modeled, so it is not asserted that every kWh generated by residential distributed generation must be physically transferred to a specific entity. Rather, it is assumed that, during the solar generation periods —generally coinciding with peak industrial activity—, the decrease in residential demand reduces the load on the grid, allowing greater availability of energy for industrial users connected to the same nodes or substations. This logic starts from a basic premise of the electricity system: since energy is not stored in mass, all generation must meet simultaneous consumption. By reducing the load of households during the day, the dispatch of energy from power plants to the industrial sector is facilitated, a phenomenon documented in electricity systems with high penetration of distributed generation (IEA, 2023).

Regarding the intermittency of solar power generation, distributed generation cannot replace firm capacity or guarantee nighttime supply. Therefore, the study does not propose a one-to-one substitution between installed solar capacity and industrial demand, but rather focuses on quantifying the additional annual generation and its average impact on the residential consumption profile. Given the match between solar generation and industrial demand peaks in the region, this partial load shifting is considered to effectively contribute to alleviating electricity bottlenecks.

Another relevant aspect is the deliberate exclusion of storage technologies, such as domestic batteries. Although their costs have decreased in recent years, they are still not competitive for a massive public policy strategy at the residential level. Integrating storage could improve the efficiency of the proposal, but would substantially increase its costs, so this limitation is explicitly recognized and discussed in the recommendations section.

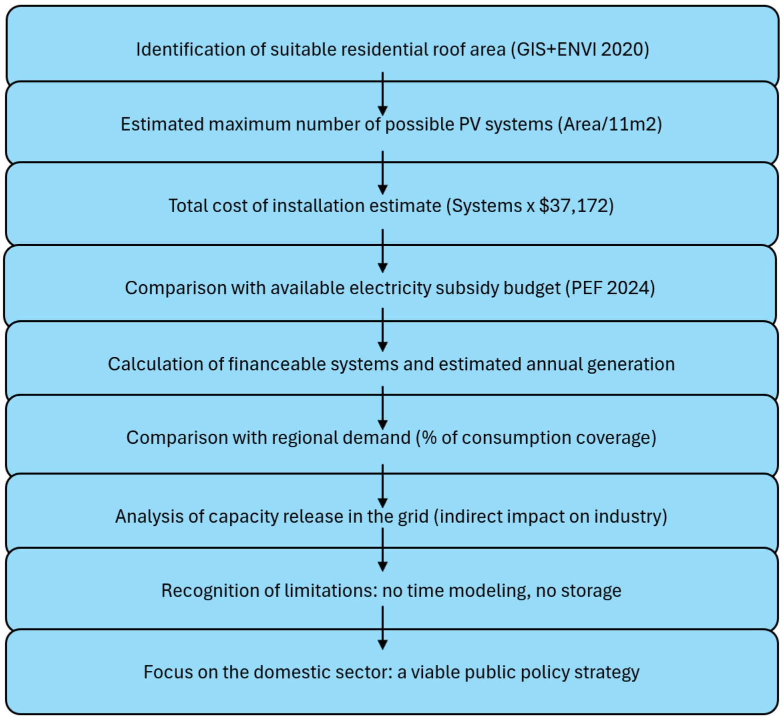
Finally, the decision to center this study exclusively on the domestic sector responds to strategic, political and operational reasons. Households are the main recipients of electricity subsidies in Mexico, so they represent the segment where a significant structural transformation can be achieved by redirecting these subsidies towards productive investments. In addition, the current regulatory framework limits distributed generation to systems smaller than 500 kW, which makes households, rather than industry, the intended beneficiaries of this policy. From a policy standpoint, a residential solar panel program has greater social viability and can strengthen the energy justice narrative. While this effort does not replace large-scale industrial infrastructure needs, it helps to free up critical capacity in the short term, serving as a complement to more conventional expansion strategies.

In future phases, the model could be extended to collective schemes, small companies or industrial parks. However, this first exercise is intentionally limited to validating the technical and fiscal feasibility of the proposal in the residential sector as a proof of concept.

The following figure is a summarized scheme of the methodological flow followed in this study.

As mentioned above, the analysis begins with the identification of the area available for the installation of residential photovoltaic systems, using geospatial tools. Based on this area, the maximum number of possible systems and the total cost of installation is estimated and contrasted against the available public budget derived from current electricity subsidies. Based on this, the number of financeable systems, their potential energy generation and their coverage of regional electricity demand are calculated. Finally, the indirect impacts on capacity release in the grid are discussed, as well as the main methodological limitations, highlighting the strategic focus on the domestic sector as a feasible way for a rapid and socially equitable implementation.

Figure 1. Methodological flow for estimating the potential of distributed generation financed by redirecting electricity subsidies in Nuevo Leon.



4. Results

4.1. Projected deployment and energy benefits

The results from the methodological exercise allow a comprehensive evaluation of the technical, economic and fiscal viability of redirecting electricity subsidies towards the installation of solar photovoltaic systems on residential rooftops, as a strategy to alleviate electricity bottlenecks related to nearshoring in Nuevo Leon.

The geospatial analysis described in the Methodology section above determined that there are approximately 105.5 million square meters of residential rooftops available for photovoltaic installation in the priority industrial municipalities. Assuming a requirement of 11 square meters per 2 kW system, the maximum technical potential would be 9.6 million systems, as mentioned above. Installing this full capacity would imply an investment cost somewhere in the neighborhood of 356,506 million Mexican pesos.

Considering the existing subsidy budget, estimated at 3,674 million pesos per year for the region analyzed, it was calculated that it would be feasible to finance around 98,826 photovoltaic systems in a single year. For conservative purposes, the operational model works with a base of 74,702 annually fundable systems.

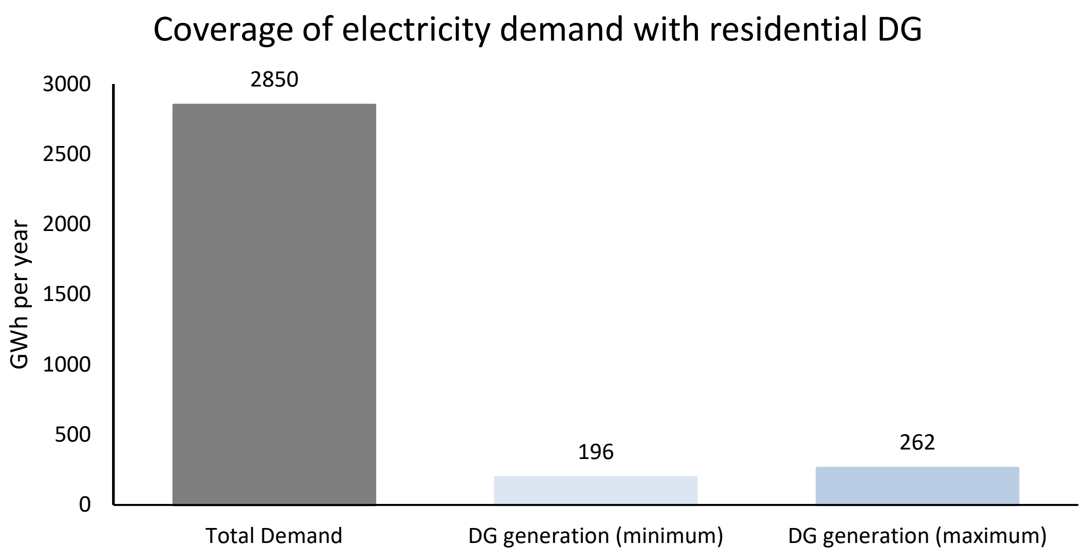
In terms of electricity generation, the installation of these systems would produce between 196 and 262 GWh per year, covering between 6.9% and 9.2% of the total electricity demand of the prioritized municipalities, estimated at 2,850 GWh per year. These results confirm that, although the strategy would not replace the need for large-scale power system expansion, it would free up a significant fraction of capacity in the short term. From an operational perspective, this distributed generation would alleviate the residential load during peak solar power production hours.

The economic analysis suggests that each household could achieve an average annual savings of 10,000 Mexican pesos, allowing the public investment to be recovered in a period of 2.8 to 3.7 years. Were the program to be implemented for five consecutive years, Nuevo Leon could accumulate more than 1,000 MW of installed residential rooftop solar capacity, the equivalent of a large-scale solar power plant. While acknowledging limitations —such as the lack of storage— the results suggest that the program would be a pragmatic and rapidly deployable tool to respond to the electricity challenge of nearshoring.

Below are a series of illustrations of the main findings of the study. These figures show the magnitude of the savings generated for households, the growth rate of installed capacity, the potential coverage of regional electricity demand, as well as the differences in costs between technological alternatives. It also highlights the structural change involved in redirecting electricity subsidies from a current spending scheme to productive investment in distributed generation.

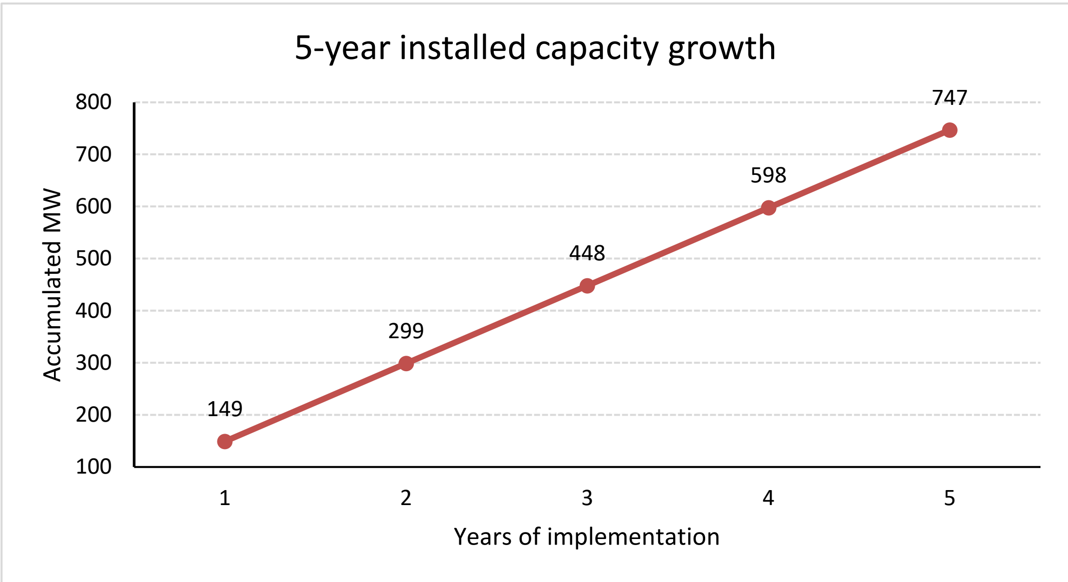
The following figure shows the estimated annual electricity generation that would be achieved by installing photovoltaic systems financed by redirected subsidies, compared to the total electricity demand of the strategic municipalities for nearshoring.

Figure 2. Electricity demand coverage with residential distributed generation



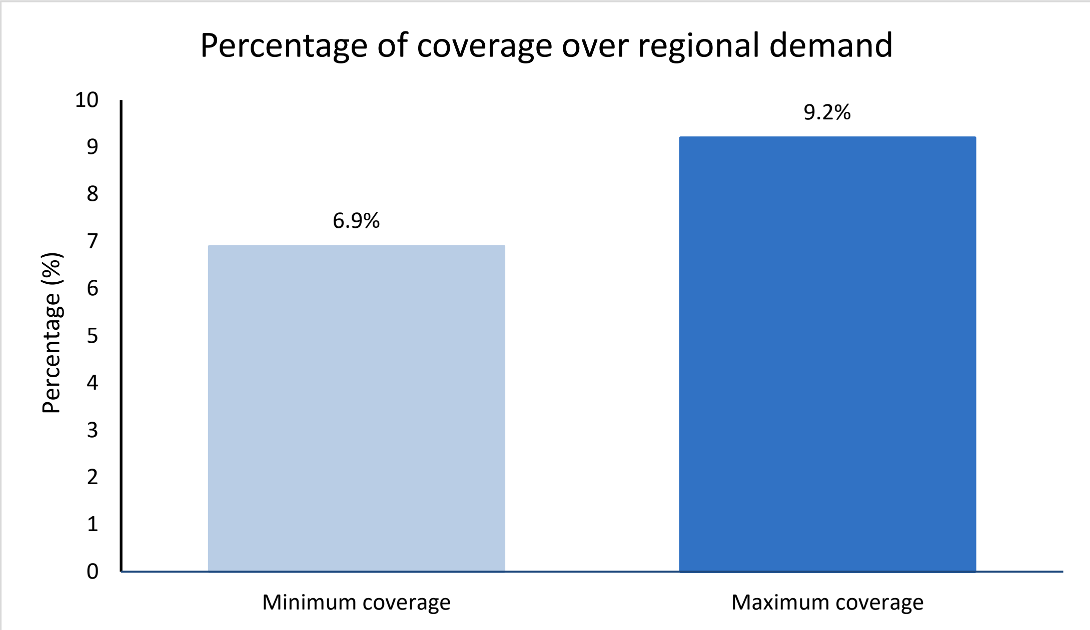
The following graph illustrates the cumulative capacity in megawatts (MW) that could be achieved if the program is maintained for five consecutive years.

Figure 3. Five-year growth in distributed generation installed capacity



Finally, Figure 4 shows the percentage of regional electricity consumption that could be covered by the distributed generation resulting from the program.

Figure 4. Coverage percentage of regional electricity demand by distributed generation



4.2. Comparison with conventional expansion and national generation goals

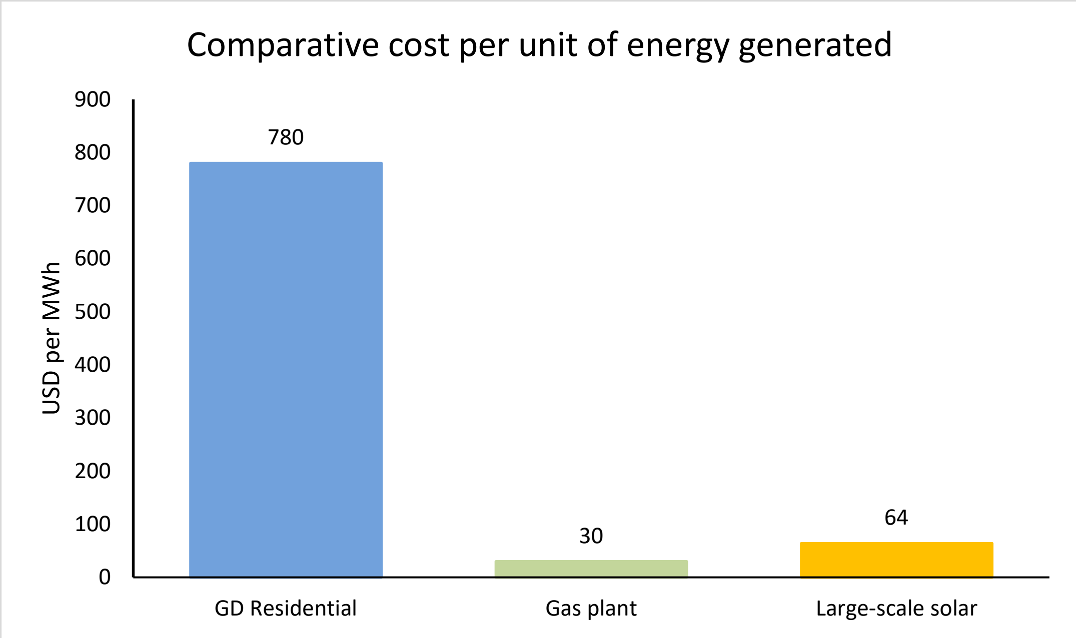
A comparison between the proposed modular distributed generation program and the construction of conventional plants allows an evaluation not only of the energy or economic efficiency of each alternative, but also their relevance in terms of the specific challenges faced by Mexico, particularly the bottlenecks that limit the reception of new productive investment related to the nearshoring phenomenon.

Despite reaching a cumulative capacity of 747 MW in five years, its effective power generation would be considerably less than that of a conventional gas or solar utility-scale plant[1]. It is estimated that, over the same period, distributed generation would produce barely 4.6% of the energy of a gas plant equivalent in capacity, and only 12.8% when compared to a large-scale solar power plant. Furthermore, the cost per unit of energy generated is significantly higher, estimated at more than $780 per megawatt-hour (MWh) versus approximately $30 for gas plants and $64 for centralized solar plants.

Figure 5 shows the differences in electricity generation cost per MWh between residential DG and traditional centralized gas and solar plants.

[1] The term utility-scale is used for photovoltaic installations capable of producing energy for more than one residence or building.

Figure 5. Comparison of the cost per unit of energy between distributed generation and conventional alternatives



The main advantage of the distributed generation program is its immediate impact. While a conventional plant, whether gas-fired or large-scale solar, requires at least five years to complete its planning, licensing, construction and grid connection cycle, the contribution of distributed generation begins as soon as the first solar power system is installed. This feature is especially relevant in industrial areas where the lack of electrical capacity represents a critical barrier in the short term. In this sense, the modular program not only provides clean energy, but does so when it is most needed.

In addition, the modular nature of the program allows for progressive scalability. Its design can be adapted to budgetary conditions, local installation capacity and changing demand on a yearly basis, while large-scale projects require high initial investments and do not offer benefits until they are fully operational.[2] Likewise, distributed generation produces electricity at the point of consumption, reducing transmission losses, relieving pressure on the grid and increasing energy resilience, especially in densely populated urban areas or areas with vulnerable infrastructure.

From a social and political perspective, this scheme has the virtue of materializing with clarity and speed tangible benefits for citizens. Each of the systems installed represents a visible asset in a household, which strengthens the legitimacy of the program and its redistributive impact. By replacing regressive electricity subsidies with investments in installed capacity, a current expense is transformed into a structural solution with positive fiscal and distributional effects.

These results should also be contrasted with the goals established by the federal government. The Mexico Energy Transition Plan 2024-2030 sets a target of 27 GW of new distributed generation capacity by 2030 at the national level, while PRODESEN 2024-2038 foresees a more conservative scenario of 13 GW by 2038. Although the scale of this study —focused on the strategic municipalities of Nuevo Leon— is significantly smaller, its findings allow us to measure the practical feasibility of reaching these goals.

With a targeted effort, redirecting only the current subsidy earmarked for tariffs in this region, it would be possible to install more than 74,000 photovoltaic systems in a single year, generating

[2] While it would seem reasonable to think that large power plants could be built in stages to accommodate demand growth, in practice, this is not always feasible for a number of reasons. There are technical, financial and operational constraints that hinder modular solutions for these technologies.

between 196 and 262 GWh of new clean electricity annually. Over five years, cumulative installed capacity would exceed 1,000 MW, proving that a modular deployment can scale quickly if the right fiscal, operational and regulatory incentives are aligned.

This study, therefore, is not intended to validate or replace national electricity expansion plans, but rather to provide a practical proof of concept that can complement, accelerate and enhance the strategies already defined. Based on a bottom-up approach aimed at solving local bottlenecks immediately, modular distributed generation represents an additional piece in the puzzle of the Mexican energy transition. It does not compete with large-scale projects, but serves as a strategic bridge to ensure that nearshoring is not frustrated by the lack of timely electrical infrastructure.

5. Scenarios and fiscal viability assessment

Given that the previous analysis has demonstrated the technical feasibility of replacing part of the residential electricity consumption with distributed solar generation, this section examines whether such a shift can be sustained under a responsible tax framework and with no compromise on equity. This chapter explores the feasibility of redesigning the residential electricity subsidy in Mexico by partially replacing it with solar photovoltaic systems, without increasing public expenditure and maintaining distributional equity. Based on a technical approach by income decile, three complementary schemes are being evaluated: the delivery of 2 kW photovoltaic systems financed with the accumulated value of the subsidy, the allocation of smaller capacity equipment (500 W) based on subsidized consumption, and a model in which households receive a complete system and continue to pay their usual electricity bill, while the surplus generated is sold to the grid at market price.

The results show that, with a ten-year financing, it is possible to achieve fiscal and distributional neutrality under different cost scenarios. As for 500 W panels, the higher cost per kilowatt forces a reallocation of subsidies from higher income households, and even so universal coverage is not achieved. In turn, the scheme with the sale of surpluses has a positive net present value for all deciles and price ranges, which opens up the option of redistributing the benefits to reinforce its progressive nature.

As a whole, the analysis suggests that an orderly transition from electricity subsidies to a scheme based on distributed generation is both technically and financially feasible. If coupled with an appropriate institutional architecture and progressive allocation mechanisms, this strategy can become a powerful tool to simultaneously advance fiscal sustainability, social equity and energy transition.

5.1. Fiscal neutrality by income decile: cost-benefit analysis

As a first exercise, we analyze, at the household level, how many years of subsidy would be necessary to finance the purchase of a solar panel system whose energy production would allow the household to keep its electricity expenses constant. The methodology consists of estimating, by income decile, the annual amount of subsidy received by a household, its equivalence in electricity consumption[3] and how many panels would be needed to generate the same amount of energy. Finally, the cost of these systems is calculated for different price ranges (low, medium and high).

[3] The CFE applies tiered rates based on the level of consumption. Given the average consumption, households in deciles I to VII consume exclusively within the lowest tariff limit; those in deciles VIII and IX consume exclusively within the threshold of the second lowest tariff; and only those in decile X reach the consumption levels subject to all tariffs. In all cases, the subsidy is mainly applied to the lower tariff, so it can be considered as an equivalent monetary transfer. This allows a direct estimate of how many kilowatt-hours the subsidy received by each household represents.

This exercise is performed for each of the ten income deciles. The results are presented in Table 9. As illustrated in the table, in the low panel price scenario, households in the middle and lower deciles would require between 10 and 15 years of the current subsidy to fully cover the cost of an equivalent system. In the higher deciles, this requirement exceeds 15 years. If high panel prices are considered, the years required increases significantly.

Due to the way it was constructed, this exercise is fiscally neutral: the government does not incur more expenditure than it already spends on the electricity subsidy. The analysis shows that, at least in principle, it is possible to redirect these resources to finance the purchase of solar panels without households facing an increase in their electricity expenditure, and without the government increasing its fiscal effort. However, it also reveals that this scheme cannot be fully implemented in a single year. The policy would require multi-year programming, with subsidy commitments equivalent to several cumulative years.

Table 1. Investment in panels whose energy production allows households to keep their electricity expenditure constant between the subsidy in the initial year (cost of the panels divided by the subsidy in year zero).

	Low	Medium	High
I	4.12	5.10	8.92
II	6.24	7.73	13.52
III	7.49	9.28	16.22
IV	8.73	10.82	18.92
V	9.98	12.37	21.63
VI	11.64	14.43	25.23
VII	13.31	16.49	28.83
VIII	15.39	19.07	33.34
IX	18.71	23.19	40.55
X	25.78	31.95	55.87

5.2. Allocation models: 2 kW, 500W panels and carryover sale

The above exercise raises the possibility of establishing financial mechanisms that can anticipate the investment in solar panels and recover the costs through future subsidies. A viable model would be a financing scheme where the electricity subsidy functions as a source of payment. This design has important advantages: first, the subsidy has historically grown above inflation and GDP, suggesting that, even with conservative real growth assumptions, the source of payment would expand over time. This would allow contracting higher financing amounts and accelerate program deployment. Details of the financial structure are discussed in the following section.

In addition, projected GDP growth is in line with the behavior of tax revenues, which reinforces the macroeconomic viability of this strategy.

In short, a financing scheme supported by future subsidies would make it possible to reconcile distributional objectives with fiscal neutrality, facilitating the transformation of current spending into public investment.

5.2.1. 2 kW equipment

For low- and middle-income households, the current subsidy amount is not enough to cover the cost of a complete photovoltaic system in a single year. Therefore, an aggregate financing scheme is proposed, structured through a public trust that receives the subsidy flows as a source of payment. This trust, supported by the federal government, might arrange financing with development banks to purchase and install photovoltaic systems.

The distribution of the systems would follow a progressive criterion, prioritizing the lowest income deciles first. In other words, panels would be assigned sequentially, starting with decile I, then decile II and so on, until resources are exhausted. With this approach, distributional neutrality will depend on the financing term, the cost of the panels and the interest rate applied. The operational details of this structure are discussed in the implementation plan.

The table below presents the program coverage to replace electricity subsidies with photovoltaic systems, expressed as the percentage of households that could maintain their electricity expenditure constant under different combinations of financing terms (3, 5 and 10 years) and panel costs (low, medium and high). Coverage is shown both at the aggregate level and broken down by income decile. The financing parameters are presented in the annex and the operational details in the following section.

Table 2. Program coverage by decile while maintaining fiscal neutrality

	Financing term								
	3 years			**5 years**			**10 years**		
	Panel cost			**Panel cost**			**Panel cost**		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
I	100%	100%	100%	100%	100%	100%	100%	100%	100%
II	100%	100%	100%	100%	100%	100%	100%	100%	100%
III	100%	100%	100%	100%	100%	100%	100%	100%	100%
IV	100%	100%	100%	100%	100%	100%	100%	100%	100%
V	100%	100%	84%	100%	100%	100%	100%	100%	100%
VI	100%	100%	0%	100%	100%	100%	100%	100%	100%
VII	100%	98%	0%	100%	100%	52%	100%	100%	100%
VIII	93%	0%	0%	100%	100%	0%	100%	100%	100%
IX	0%	0%	0%	100%	100%	0%	100%	100%	98%
X	0%	0%	0%	92%	3%	0%	100%	100%	0%
Total	**79%**	**70%**	**48%**	**99%**	**90%**	**65%**	**100%**	**100%**	**90%**

As can be seen, coverage improves significantly as the term of the financing is lengthened and the cost of the equipment is reduced. In the best-case scenario (10 years and low cost), the program can reach 100% of households in all deciles, thus achieving distributional neutrality: no household sees its expenditure increase and no reallocation of subsidies between deciles is required.

In contrast, in scenarios with shorter terms and higher costs, coverage is lower, especially in the upper deciles. This indicates that, under these conditions, resources are redistributed from higher-income households to lower-income households, prioritizing the most vulnerable. For example, in the 3-year high-cost scenario, only 48% of households can be covered, and coverage disappears completely for deciles IX and X.

This exercise demonstrates that, even without increasing fiscal expenditure, it would be possible to reconfigure the current electricity subsidy into a progressive policy, provided that an appropriate financing mechanism is designed. The key is to take advantage of the continuity of subsidy flows as a source of repayment and to prioritize the most vulnerable households in the allocation of the systems.

This exercise is based on the use of 2 kW photovoltaic systems per household, which poses a challenge to the fiscal neutrality of the program. For lower-income households, the current electricity subsidy is equivalent to much lower consumption than the energy that can be generated by a system of that capacity.

For analytical purposes, a theoretical calculation is performed to estimate what fraction of the 2-kW system would cover the consumption equivalent to the subsidy, also assuming that its cost is proportional. In practice, however, photovoltaic systems cannot be split, so this approach is not viable: the entire system would have to be installed, even if the subsidy does not justify it, which would imply higher public expenditure than the current one and would therefore break with the principle of fiscal neutrality.

Despite this limitation, the exercise is beneficial for it shows one possibility: if the surplus electricity generated could be valued —either because the household consumes it additionally or because it is returned to the grid and remunerated—, and if that value covers the part of the system that exceeds the subsidy, then the scheme could be sustained without increasing public expenditure.

5.2.2. 500 W equipment

Since households with lower consumption cannot justify the installation of 2 kW photovoltaic systems without breaking fiscal neutrality —since the subsidy they receive is equivalent to a fraction of that capacity— a more adjusted alternative is proposed: the use of 500 W equipment. This second exercise seeks to improve the alignment between the current subsidy and installed capacity, although it introduces new challenges in terms of costs and coverage.

However, these smaller units have a significant economic disadvantage: their cost per kilowatt installed is up to 45% higher than that of 2 kW systems. This is because the economies of scale associated with larger systems are lost (e.g., the cost of installation and ancillary components does not reduce proportionally with the size of the equipment).

In order to maintain fiscal neutrality, that is, not to spend more than what is already allocated to the electricity subsidy, it is necessary to compensate for this higher cost. This is achieved by reducing or eliminating the subsidy currently received by higher income households (high deciles) and reallocating those resources to the most vulnerable households (low deciles), who would now receive the photovoltaic equipment.

Additionally, since 500 W panels cannot be split, a discrete allocation of panels per household is defined, based on the average consumption of each decile: 1 panel for deciles I and II, 2 panels for deciles III to VI, 4 panels for deciles VII to IX and 10 panels for decile X.

Even with this distribution, the electricity generated is on average 30% higher than what households originally obtained with the subsidy, which means they are better off in terms of energy. But to ensure that this does not involve additional expense for the State, the subsidy to higher income households must be removed.

Finally, the results show that even with 10-year financing it is not possible to cover 100% of the households. The higher deciles lose their subsidy in its entirety, while the lower deciles are fully benefited. This reveals a highly progressive policy (improving the poorest at the expense of the richest), although with operational limitations: universal coverage is not achieved without breaking fiscal neutrality.

Table 3. Program coverage by decile while maintaining fiscal neutrality. Direct assignment with 500 W equipment

	Financing term								
	3 years			**5 years**			**10 years**		
	Panel cost			**Panel cost**			**Panel cost**		
	Low	**Medium**	**High**	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
I	100%	100%	100%	100%	100%	100%	100%	100%	100%
II	100%	100%	100%	100%	100%	100%	100%	100%	100%
III	100%	100%	61%	100%	100%	100%	100%	100%	100%
IV	74%	3%	0%	100%	100%	53%	100%	100%	100%
V	0%	0%	0%	100%	19%	0%	100%	100%	100%
VI	0%	0%	0%	30%	0%	0%	100%	100%	37%
VII	0%	0%	0%	0%	0%	0%	100%	34%	0%
VIII	0%	0%	0%	0%	0%	0%	62%	0%	0%
IX	0%	0%	0%	0%	0%	0%	0%	0%	0%
X	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total	**37%**	**30%**	**26%**	**53%**	**42%**	**35%**	**76%**	**63%**	**54%**

5.2.3. 2 kW equipment with carryover sales

While smaller capacity panels allow for more accurate allocation, their high cost per unit limits total coverage, even with long-term financing. Therefore, the third exercise proposes a different solution: maintaining the delivery of 2 kW equipment to all households, but taking advantage of the value of surplus energy as a complementary source of financing, preserving the user experience and strengthening the financial viability of the scheme.

Under this exercise, the household self-consumes all the electricity generated by the panel and continues to pay its electricity bill as it did before. That is, it continues to pay the unsubsidized portion at the current rate, and receives the benefit of the subsidy implicitly by consuming locally generated energy. This arrangement allows maintaining the subsidy logic without modifying the user experience.

Given that previous exercises have shown that, over a 10-year term, the financing is fiscally and distributively neutral, the same time horizon is adopted. A conservative lifespan of 10 years is also assumed for the solar energy system, although in practice it could be extended with proper maintenance, generating additional long-term benefits.

In this scheme, financing is structured with two complementary sources. On the one hand, the federal government provides the net present value of the subsidy in advance that it would have transferred to the household during those 10 years. These resources are obtained via a structured loan through the financial engineering described in the following section.

On the other hand, the unsubsidized part of the panel generation has two intended uses. A portion is self-consumed by the household, but it continues to pay CFE for such self-consumption at the rate it was paying, so that its total bill remains unchanged. On the other hand, the carryover is reinjected into the grid and sold by CFE to the industry at market price. These resources are supplied as a source of payment to finance the purchase of the panels. Since the source of payment of such loan is the CFE's tariff, the credit risk would be expected to correspond to that of CFE itself, equivalent to the cost of financing its debt issuances at a similar term.

The analysis of the proposed scheme shows that it has a positive Net Present Value (NPV) in all the scenarios that were considered, both in the three panel cost ranges and in all income deciles. This indicates that, in financial terms, the model is viable even under less favorable conditions.

Specifically, the NPV of the scheme equals about 86% of the total that the household would pay to CFE over the lifespan of the system in the low panel cost scenario, about 76% in the medium cost scenario, and about 39% in the high-cost scenario. This suggests that, depending on the cost of the equipment, there is a margin to apply an additional discount on the household bill, since the surplus energy injected into the grid —which is not consumed directly by the household— is sold at market price, and generates enough resources not only to cover the loan, but also to provide an additional benefit.

Likewise, the NPV is higher for households in higher deciles, given that their consumption is higher and, in many cases, they receive two 2 kW units, which increases the volume of surplus generated. However, this additional value does not necessarily remain tied to the household that generates it. In a design with equity criteria, this surplus could be redistributed as a cross transfer between deciles, which would make it possible to construct a more progressive policy.

Table 4. Net Present Value of the Scheme divided by Present Value of Household Payment to CFE/1

	Panel Cost Scenario		
	Low	**Medium**	**High**
I	72%	59%	9%
II	79%	68%	24%
III	83%	74%	39%
IV	84%	72%	26%
V	88%	79%	47%
VI	91%	82%	49%
VII	83%	74%	39%
VIII	96%	89%	59%
IX	89%	79%	43%
X	93%	87%	64%
Average	86%	76%	40%

/1 The Net Present Value (NPV) of the scheme is calculated by dividing the present value of all benefits (including the sale of surplus energy) by the present value of the payments that the household would make to CFE without panels. A positive NPV indicates that the revenue from the sale of surplus energy covers the cost of the solar panels and generates an additional economic benefit, which could be transferred to the household. If the result is close to 100%, it means that the income generated by the panels would be sufficient to cover the entire household electricity cost.

It should be noted that the scheme is sensitive to the price of surplus energy. The baseline exercise assumes that it is sold at $0.80 per kWh, which corresponds to the low range of the industrial tariff. However, tariffs can be as much as double that value, which would imply an even higher NPV and open up room for further redistribution or additional benefits to households.

Taken together, these results suggest that the model is not only fiscally and operationally sustainable, but that it can generate positive net returns for households and create additional fiscal space if the value of the energy surplus is properly exploited, which would allow for more progressive policies.

This model makes it possible to move towards a technically robust, financially viable solution that is operationally compatible with the current system, while maintaining fiscal neutrality and strengthening incentives for distributed generation.

5.3. Discussion and limitations

This exercise is based on several assumptions that should be discussed in order to contextualize the results in a correct fashion.

5.3.1. Optimal subsidy

To begin with, it is not assumed that the current electricity subsidy is optimal in economic terms. According to welfare theory, an optimal subsidy is one whose marginal social benefit is equal to its fiscal cost. The current subsidy in Mexico could be higher or lower than that level. However, this analysis does not seek to determine the optimal level of subsidy, but rather to explore whether it is possible to redesign its use without increasing public expenditure —a relevant constraint in a context of limited fiscal space. The definition of the optimal subsidy level and its evaluation within the framework of fiscal sustainability is beyond the scope of this report.

5.3.2. Distributional neutrality

From a broader perspective, even the optimal subsidy analysis could be expanded to estimate a desirable level per income decile. However, this approach is based on purely economic criteria. A government may have different normative distributional objectives, for instance, based on principles of equity, inclusion or universal rights. Under this logic, defining an "optimal" distribution of the subsidy is much more complex, since it will depend on the political priorities at the moment.

This exercise, therefore, does not prescribe a new subsidy structure, but rather identifies the conditions under which a policy of in-kind subsidies (solar panels) can be fiscally neutral (the state does not spend more) and distributively neutral (no household pays more for its electricity).

The results indicate that, with sufficiently long financing terms, the policy can simultaneously meet both conditions. However, the time frames for this duration may be technically unrealistic. The effective lifespan of solar panels can be limited by factors such as wear and tear, need for major maintenance or technological obsolescence. Financing equipment beyond the horizon in which its performance is guaranteed jeopardizes the sustainability of the scheme.

Therefore, shorter terms are more consistent with actual operating conditions. In these scenarios, if panel costs are in the medium or high ranges, it is not possible for all households to keep their electricity bill constant without redistributing resources. In other words, in order to achieve fiscal neutrality without affecting the lowest deciles, it is necessary to transfer part of the subsidy currently received by higher income households to the most vulnerable.

This result has considerable public policy implications. It shows that, even without increasing public expenditure, it is possible to redesign the electricity subsidy so that it corrects its current regressive bias and becomes a progressive instrument of energy equity. The key lies in the combination of three elements: structured financing, progressive allocation and appropriate territorial targeting.

5.3.3. Additional incentives

Although this exercise is constructed under the criterion of distributional neutrality —i.e., that households do not face a higher expenditure in their electricity bill—, it should be noted that this condition may not be sufficient to guarantee the social acceptance of the policy. From a household perspective, replacing an automatic rate subsidy with a photovoltaic system may be perceived as an additional burden, due to maintenance responsibilities, use of physical space, or simple frictions in the day-to-day experience.

Even when a valuable asset, such as a solar panel with resale value or long-term use, is being transferred, the incentive may not be clear or immediate for all households. In this sense, it may be necessary to supplement the policy with an additional incentive (monetary, fiscal or in-kind), which would have implications on the fiscal neutrality of the scheme. Under the carryover sales scheme, the additional value generated by the scheme could be redirected as an additional incentive to households.

Likewise, there are operational risks that must be considered during the implementation phase, such as oversight of the proper use of the systems or the possible informal resale market. These issues do not affect the financial viability of the scheme, but do affect its practical effectiveness, and should be addressed through institutional oversight, monitoring and sanction mechanisms, same of which are discussed in the following section.

5.3.4. Use of subsidy after amortization of the panels

On the other hand, the exercise opens the way for discussion on the future use of the subsidy once the financing has been amortized. If the credit term is shorter than the lifespan of the panels, fiscal resources could be freed up for several years. These resources could be used to renew equipment, expand the program or finance new public priorities. Even if part of the subsidy is required to be preserved for maintenance or partial replacement, the magnitude of the expense would be significantly less than the initial investment. In this sense, a fiscally neutral policy in the short term could generate net fiscal benefits in the long term.

Overall, this exploratory exercise demonstrates that the redesign of the electricity subsidy towards a distributed generation policy is conceptually feasible under market conditions and can become a powerful instrument to advance simultaneously on three fronts: fiscal sustainability, social equity and energy security.

5.3.5. Contribution

It is important to emphasize that this proposal should not be understood as an integral solution to the challenges of the national electricity system. Its scope is limited both in scale and nature: it does not replace the need for investment in firm generation, it does not solve structural transmission problems, nor does it address tariff heterogeneity in its entirety. Likewise, the analysis is based on conservative assumptions about costs, the lifespan and subsidy growth rates, which may vary in practice. Aspects such as energy storage, surplus management, major impacts on the transmission grid, and social acceptance of the program are also not taken into consideration. For the above reasons, the results should be interpreted as a proof of concept that illustrates the partial feasibility of redesigning the electricity subsidy with more progressive criteria, but not as a substitute for comprehensive energy planning or broader structural reform. The proposal explored here may be a complementary piece within a broader set of tools, the success of which will depend on operational, institutional and political factors beyond the scope of this study.

This approach offers a promising way to address one of the structural paradoxes of the Mexican electricity system: the existence of public subsidies that, in practice, disproportionately benefit higher-income households. Without increasing fiscal expenditure, the proposed redesign suggests that these resources could be used more equitably and productively. Although it does not solve the underlying challenges by itself, it does provide a concrete tool that could simultaneously contribute to three national objectives: advancing distributive justice, accelerating the energy transition and strengthening industrial competitiveness. More than a problem of technical or financial feasibility, this type of policy now poses a challenge of political decision-making.

The annexes section analyzes the key operational elements for the effective implementation of the proposal, including the required institutional financial structure, the mechanisms for progressive penetration and the governance conditions necessary for its viability. All of this has the objective of demonstrating that a transition from a price-based to a quantity-based electricity subsidy can be carried out without affecting public finances and, under certain parameters, without negatively altering the current distribution of the subsidy among deciles.

Conclusions

This study derives from a specific and urgent problem: the need to free up electricity capacity in the strategic municipalities of Nuevo Leon in order not to miss the opportunity offered by the nearshoring phenomenon. The limited but critical objective is to identify an immediate intervention strategy that, by means of redirecting current electricity subsidies, will alleviate bottlenecks in the residential distribution grid and, consequently, free up space for growing industrial demand.

In addition to its technical and fiscal dimension, the proposed program explicitly incorporates a focus on reducing structural inequalities. The current price-based electricity subsidy policy tends to be regressive: higher-income households receive proportionally more support than lower-income households. The proposal evaluated here proposes to transform this instrument into an in-kind subsidy, providing clean generation assets directly to households. In this way, a structural bias in public policy is corrected, improving distributive equity by giving priority to benefiting low and middle-income sectors that today, despite their vulnerability, receive a smaller proportion of state support.

The proposal is based on a principle of fiscal neutrality: it does not require new budgetary resources, but rather an efficient reallocation of existing expenditure. By transforming flow subsidies —directed to electricity consumption— into in-kind subsidies —oriented to investment in generation—, the fiscal effort is kept constant while the structural impact of the policy is increased. This transformation makes it possible to channel resources to households that, under the current scheme, receive less support from the State despite their greater vulnerability. The progressive design of the proposed schemes ensures that benefits are distributed in proportion to the needs, strengthening the connection between energy policy and social justice.

This study is, as explicitly stated, a proof of concept. It does not model hourly electricity dispatch dynamics, does not solve the need for firm generation, nor does it incorporate storage in its economic analysis. It proposes a complementary, realistic and executable tool that responds to the short-term urgency: freeing up existing capacity in the electricity infrastructure by reducing residential demand during peak hours, while generating a positive impact in terms of social equity.

From this perspective, the implications of the study for the different governmental actors are relevant:

According to CFE, the program represents a strategy that can alleviate immediate pressures on the distribution grid, reducing losses and deferring costly investments in short-term strenghtening. Additionally, it reinforces the CFE's role as a socially responsible company by facilitating equitable access to clean energy.

According to SENER, the results offer a practical way to accelerate the goals of the Mexico Energy Transition Plan 2024-2030, contributing in a tangible way to territorially equitable access to clean energy, without compromising large-scale infrastructure planning.

According to the Ministry of Finance and Public Credit, the redirection of subsidies transforms regressive and structurally inefficient expenditure into productive investment with a positive fiscal return in the medium term, while reinforcing the progressiveness of public policy.

According to the Ministry of Economy, the program strengthens the narrative of sustainable and inclusive nearshoring, conveying the message that Mexico can respond nimbly to the demand for international investment infrastructure while promoting more equitable growth in strategic territories.

In short, the study confirms that modular distributed generation financed through redirected subsidies does not compete with the national energy expansion strategy; it complements and strengthens it. It is a pragmatic bridge to unlock electricity capacity in critical areas, at the time when it is most needed, while correcting historical distortions in the distribution of public subsidies and promoting a fairer energy transition model.

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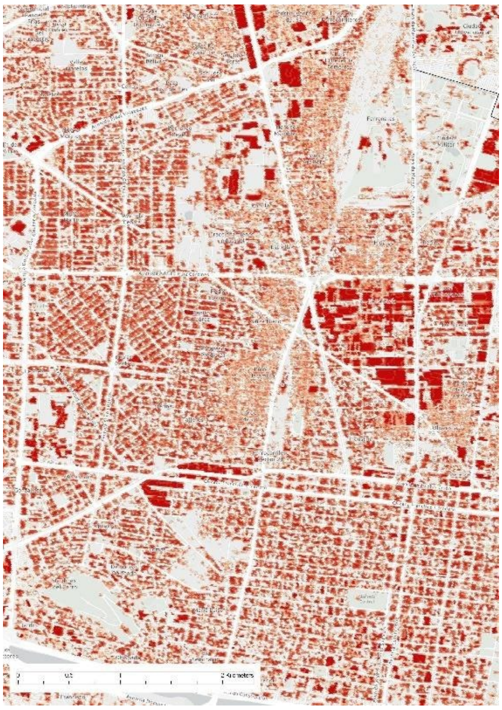
ANNEX

1.1. Methodological Details

1.1.1. Mosaics and rooftops identification

Applying zonal statistics within the geostatistical software, a total of 6.9 billion square meters of rooftops were obtained for the Monterrey Metropolitan Area.

Figure 8. Methodology applied to the case of Monterrey, Nuevo Leon, Mexico.



1.1.2. Delimiting study areas

The State of Nuevo Leon has 51 municipalities, of which 36 reported having industrial production in the most recent Economic Censuses. From this cut-off, a search for investment announcements by municipality from the beginning of 2023 was developed as a way of understanding which municipalities are capturing the most capital under the nearshoring trend. This search reduced the total number of municipalities to 14, as can be seen in the following table.

Table 6. Selection of municipalities based on their industrial production

#	Municipality	2019 industrial production (Mill. MXN)	Industrial production, %	2020 Population	Population, %
1	Apodaca	214,380.08	28.81%	656,464	11.35%
2	San Nicolás de los Garza	125,689.25	16.89%	412,199	7.13%
3	Santa Catarina	83,618.88	11.24%	306,322	5.30%
4	Guadalupe	77,404.22	10.40%	643,143	11.12%
5	General Escobedo	51,863.97	6.9%	481,213	8.32%
6	Garcia	39,374.43	5.2%	397,205	6.87%
7	Pesqueria	24,738.67	3.3%	147,624	2.55%
8	General Zuazua	14,968.11	2.0%	102,149	1.77%
9	Salinas Victoria	5,932.28	0.80%	86,766	1.50%
10	Marin	2,957.91	0.40%	5,119	0.09%
11	Cienega De Flores	2,482.98	0.33%	68,747	1.19%
12	Cadereyta Jimenez	2,433.51	0.33%	122,337	2.11%
13	Juarez	2,192.77	0.29%	471,523	8.15%
14	El Carmen	1,748.70	0.24%	104,478	1.81%
	TOTAL	**649,785.76**	**87.13%**	**4,005,289.00**	**69.26%**

1.1.3. Area estimation

Applying the geostatistical analysis methodology detailed above, it is possible to estimate the available roof area in 6,509 million square meters. As mentioned above, this methodology does not distinguish between residential and non-residential rooftops.

Figure 9. Methodology applied to the municipality of Cadereyta Jimenez, Nuevo Leon.

1.1.4. Estimation of residential rooftops

We used the ENVI 2020 database, reported by INEGI through its National Housing Survey (2020), which estimates that there are 35,259,433 housing units nationwide, of which 1,661,415 are in Nuevo Leon. Due to the fact that INEGI reports the square meters of construction by ranges, a weighted average of 92.74 square meters is obtained for housing in Nuevo Leon. Multiplying this figure by the number of housing units allows us to estimate the total area of residential rooftops in Nuevo Leon, as well as for each of its municipalities.

Table 7. Housing Units in Nuevo Leon by size

Total of housing units in Nuevo Leon	Up to 45 m^2	From 46 to 75 m^2	From 76 to 100m^2	From 101 to 150 m^2	More than 150 m^2	Not specified
1,661,415	209,235	432,045	416,057	318,378	266,740	18,960
	12.6%	*26.0%*	*25.0%*	*19.2%*	*16.1%*	*1.1%*

Table 8. Nuevo Leon weighted average housing units' size and total roof area

Concept	Value	Units
Weighted average	92.75	square meters
Weighted average	0.000093	square kilometers
Total residential rooftops	154.10	square kilometers

Table 9. Total available residential roof area by municipality in the evaluation area

Municipality	Total of housing units	Available area in m^2
Apodaca	181,637	16,846,746.89
Cadereyta Jimenez	37,325	3,461,876.31
Cienega De Flores	20,451	1,896,820.69
El Carmen	30,033	2,785,546.72
Garcia	114,866	10,653,767.83
General Escobedo	131,655	12,210,939.74
General Zuazua	29,627	2,747,890.41
Guadalupe	182,399	16,917,422.03
Juarez	134,383	12,463,960.46
Marin	1,440	133,559.33
Pesqueria	43,650	4,048,517.11
Salinas Victoria	25,418	2,357,507.62
San Nicolás de los Garza	121,707	11,288,267.39
Santa Catarina	82,871	7,686,246.53
Total	1,137,462	105,499,069

1.1.5. Estimated CAPEX (solar panels)

Based on this available area, the installation capacity was modeled considering an average photovoltaic system of 2 kW, whose standard technical footprint is estimated at 11 square meters. This size was determined based on the work of Lagar (2021). Dividing the total area by the area required per system, a technical maximum of approximately 9.6 million installable systems in the selected municipalities was estimated.

In terms of cost, a market price of 37,172 Mexican pesos per complete 2 kW system was assumed, based on a quotation from a solar panel company. The cost of the system includes panels, inverters, mounting structure and installation labor, whose breakdown is shown in the table below.

Table 10. Residential rooftop solar panel installation breakdown taken as a basis for scenarios

Concept	Amount in MXN
Price of panels (6 units, MXN)	16,974.74
Inverter price (1 unit, MXN)	19,844.21

Electrical material price (MXN)	9,750.00
Labor cost (MXN)	5,610.00
Price per type of structure (MXN)	9,154.20
Total before taxes (MXN)	61,333.15
Installed capacity (kW)	3.30
Price per 3.3 kW installed (MXN/kW)	18,585.80
Price per 2 kW installed (MXN)	37,172

1.1.6. Estimated subsidy

For a proposal seeking alignment with the reality of the public budget, we estimate the financial resources available for its implementation, which derive from the federal electricity subsidy to households. For this, the proportion of the federal electricity subsidy that is exercised within the municipalities of analysis is calculated, as indicated in the Federal Expenditure Budget 2024.

Table 11. Proportion of federal electricity subsidy corresponding to the analyzed municipalities

Concept	2010	2020	TMAC	2024
Housing nationwide	28,614,991	35,233,462	2.10%	38,291,290
Housing in municipalities with nearshoring	809,804	1,137,462	3.46%	1,303,247
Proportion of housing nearshoring	-	-	-	3.40%
Federal Electricity Subsidy	-	-	-	$81,581,400,000
Nearshoring housing subsidy	-	-	-	$2,776,629,583

1.1.7. Estimated power generation

Two approaches are used. The first method collects information from the ENIGH 2022 regarding average quarterly expenditure on electricity by income decile. Considering this information it is possible to obtain the annual expenditure on electricity for the entire decile. The second method uses NASA's City Night Lights Project database, where the color of the pixel represents the kWh energy consumption in a year.

Figure 10. Electricity consumption by 2019 by municipality in the assessment area derived from night lights.

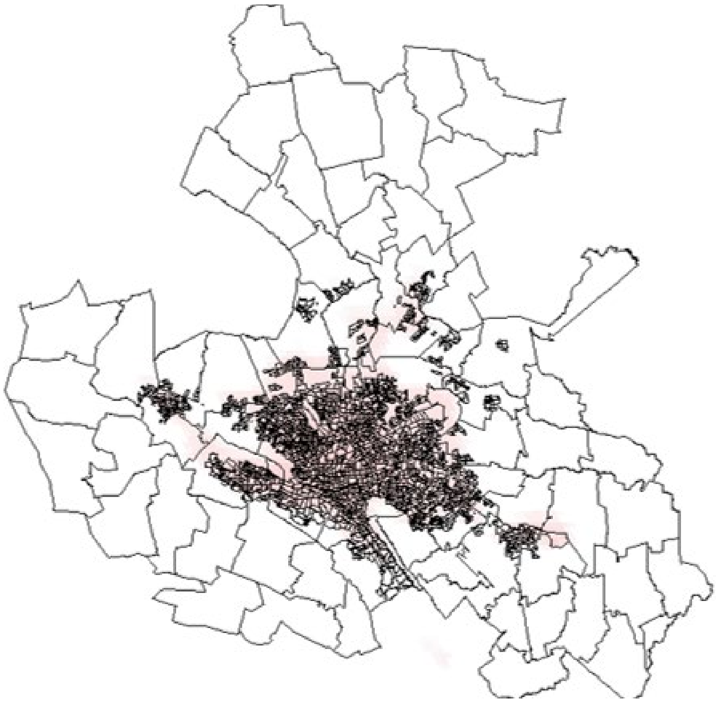


Table 12. Energy consumption by municipality derived from night lights

Municipality	kWh per year
Apodaca	513,746,136.91
Guadalupe	504,369,744.37
General Escobedo	373,210,013.62
San Nicolás de los Garza	336,893,175.50
Juarez	279,121,032.77
Santa Catarina	238,734,080.84
Garcia	212,728,922.54
Cadereyta Jimenez	128,272,088.43
El Carmen	57,510,459.06
Salinas Victoria	53,903,636.71
Pesqueria	45,331,443.01
General Zuazua	44,967,321.36
Cienega De Flores	41,639,556.43
Marin	4,343,462.69
TOTAL	**2,834,771.07**

1.1.8. Offset

Having established that installable systems can generate between 196 and 262 GWh per year and with estimated consumptions of between 2,830 and 11,600 GWh per year for the analyzed municipalities and the state of Nuevo Leon, respectively, the relief from distributed generation to energy consumption is condensed in the following table.

Comparing production with the estimated total electricity demand of the priority municipalities — approximately 2,850 GWh per year—, the program would cover between 6.9% and 9.2% of the electricity consumption of the region analyzed. This participation, although limited, is significant considering that it would be achieved without the need to build new power plants or broaden the transmission grid.

Table 13. Energy demand relieved by PV systems according to consumption parameters

	Energy consumption (ENIGH)	Energy consumption (night lights)
Offset (MWh per year)	11,415,728.05 - 11,350,303.08	2,638,496.16 - 2,573,071.19
% of consumption	1.69 - 2.25	6.92 - 9.23

1.2. Assumptions, parameters and construction of financing scenarios

This annex describes the assumptions, parameters and procedures used to create the financing scenarios presented in this report. Its purpose is to assess whether the electricity subsidy currently existing in Mexico can be redesigned as a source of payment to finance the acquisition of residential photovoltaic systems. Based on this logic, the aim is to determine whether such a redesign can be fiscally neutral —that is, without requiring additional government expenditure— and maintain the current level of household electricity expenditure at the same time.

In order to answer this question, a technical exercise was constructed to simulate the financial and distributive behavior of a replacement electricity subsidy policy with residential photovoltaic systems. This exercise is based on a representative household approach by income decile: it estimates, for each of the ten deciles, the annual amount of subsidy that a household receives, the equivalent energy that this subsidy allows it to purchase, and the investment required in solar panels to generate that same amount of electricity. Subsequently, it is evaluated whether the accumulated flow of the subsidy over a given time horizon (3, 5 or 10 years) is sufficient to cover the cost of that investment through a fixed-rate financing scheme.

The basis of this analysis is a detailed estimate of the amount of electricity subsidy received per household, with data provided by the Centro de Estudios Espinosa Yglesias. CFE applies tiered rates based on the level of consumption. Given the average consumption, households in deciles I to VII consume exclusively within the lowest tariff limit; those in deciles VIII and IX consume exclusively within the threshold of the second lowest tariff; and only those in decile X reach the consumption levels subject to all tariffs. In all cases, the subsidy is mainly applied to the lower tariff, so it can be considered as an equivalent monetary transfer. Under the assumption —reasonable under this context— that residential electricity demand is inelastic, it is estimated how many kilowatt-hours that transfer represents, i.e., how much electricity.

With this information, the number of solar panels needed to cover the same amount of energy is estimated, using standard market generation factors, already developed in previous sections of this report. It should be pointed out that the starting point is a standardized technical configuration of the photovoltaic systems, for the sake of comparability and simplification, and not a customization per household. Similarly, a range of market prices (low, medium and high) is considered, including the cost of the panels as well as their installation and additional components. Given the massive nature of the proposed program, it is reasonable to assume that effective prices could be close to the low range, due to economies of scale and consolidated purchases.

To finance the Federal Government's investment, a fixed-rate credit scheme is modeled, supported by the State, with 3-, 5- and 10-year terms. The interest rates applied are taken from fixed-rate federal bonds (M Bonds), corresponding to the April 30, 2024 auction, which reflects a sovereign financing cost. Since the source of payment is the subsidy itself, managed by the SCHP, it is assumed that the risk of the scheme is equivalent to the country risk, which justifies the use of these rates as a reference. The rates used are nominal and no present value discounts are applied; instead, the cumulative nominal value of the subsidy over the financing period is compared to the amount of loan required. In this sense, the analysis does not assess the opportunity cost of the subsidy, but rather its effective capacity to cover, in accounting terms, the debt service during the established term.

The exercise of carryover resales considers a financing for the purchase of panels, which has as a source of payment the CFE's charge to households. For this exercise, the CFE's financial cost for 10-year debt issuance is used as the discount rate. Particularly, the CFE 24UX bond is taken as a reference, issued in December 2024 with a 10-year term for an amount of 3,643 million pesos, at a rate of + 128 Udibono basis points (equivalent to a coupon of 6.94%), which represents a placement of 32 basis points below the initial price. This rate reflects the CFE's cost of financing under market conditions comparable to those of the model analyzed. The calculations use the May 6, 2025 10-year UDIBONO rate of 5.27% and a UDI growth rate equal to inflation growth (see next paragraph).

All scenarios assume that the subsidy grows at a real rate of 1% per year— in line with expected GDP growth— plus 3% inflation. This is a conservative assumption, considering that the electricity subsidy has tended to grow above both indicators in recent years. The policy, by design, is fiscally neutral: in no scenario are additional resources used in relation to those already committed under the current subsidy scheme. Also, electricity tariffs are assumed to grow at the same rate as inflation and electricity consumption measured in kWh follows real GDP growth.

In scenarios where the present value of the subsidy is not enough to cover the cost of the systems for the entire population, a progressive allocation rule is introduced: the available resources are distributed starting with households in decile I and advancing sequentially until they are exhausted. In this context, it is calculated, for each decile, whether the investment received under the new scheme exceeds or falls below the subsidy originally received. This difference is reported as a net reallocation: positive if the household receives more investment than subsidy, and negative if it loses part or all of the benefit.

Finally, it is worth pointing out that, although this analysis includes technical assumptions on panel efficiency, lifespan (minimum 10 years), and generation conditions, elements such as energy storage, export of surpluses to the grid, and long-term operating costs are not incorporated. The objective is not to build an operational simulation of a distributed energy system, but to assess whether the redesign of the subsidy is financially viable and whether it can be implemented without affecting households from a distributional perspective. The cost of both 2 kW and 500 W equipment corresponds to market quotations; in a more realistic scenario the equipment could be obtained wholesale through a public bidding process, which could improve these conditions.

In summary, this exercise should be understood as a proof of concept, technically conservative and fiscally neutral, showing under what conditions a policy of transition from electricity subsidy to distributed generation can be financially sustainable and socially equitable.

1.2.1. Analysis unit

The exercise starts with a representative household by income decile. Based on estimates of the electricity subsidy per household (based on figures from the Centro de Estudios Espinosa Yglesias), we calculate how much energy is subsidized annually under the current tariff scheme. For aggregate calculations, the result is multiplied by the total number of households in each decile.

1.2.2. Estimated individual electricity subsidy

We are based on the assumption that the household faces a staggered tariff scheme, in which the first kilowatts consumed have lower prices and increase on a gradual basis. The subsidy is reflected as a reduction in the total payment of the electric bill. The number of kilowatts per year equivalent to this subsidy is estimated, assuming an inelastic demand, which is consistent with the specialized literature on basic services.

Table 14. Average consumption by decile and tariffs

	Tariff	kWh Monthly Consumption
I	Tariff 1	134.90
II	Tariff 1	148.19
III	Tariff 1	174.15
IV	Tariff 1	141.85
V	Tariff 1	181.19
VI	Tariff 1	180.16
VII	Tariff 1	239.23
VIII	Tariff 1A	196.20
IV	Tariff 1A	292.23
X	Tariff 1C	428.21

1.2.3. Equivalent solar production

For each decile, it is estimated how many solar panels are required to generate the electricity equivalent to the subsidy received. A standard market generation factor is used, the technical justification for which is developed in previous sections of the report. A standardized residential system power is considered, not customized per household, to facilitate comparison between scenarios.

1.2.4. Investment cost and market prices

Three solar panel price ranges are used (low, base and high), which include installation and additional components (inverters, wiring, etc.). It is assumed that large-scale implementation could allow access to low range prices. The investment required per household is calculated based on the number of panels required.

Table 15. Cost of equipment

Panel cost	2 kW Equipment	500 W Equipment
Low Cost	$30,000	$10,000
Base Cost	$ 37,172	$13,500
High Cost	$65,000	$17,000

1.2.5. Financing and interest rates

The financing from the Federal Government that has the subsidy as a source of payment considers a fixed-rate credit scheme with 3, 5 and 10-year terms. Interest rates are taken from fixed-rate government bonds (M Bonds) at the April 30, 2024 auction, as a reference for the cost of sovereign financing. Since the subsidy is a source of payment guaranteed by the Ministry of Finance and Public Credit, it is considered reasonable to assume a risk equivalent to that of the sovereign. The rates used are nominal rates, no cash flow discounting is performed.

The CFE's financing considers an over-rate of 128 basis points with respect to the 10-year UDIBONO.

1.2.6. Source of payment: accrued subsidy

The electricity subsidy is assumed to grow at a real rate of 1% per year, consistent with conservative GDP growth, plus expected inflation of 3%. During the financing term, the nominal value of the expected subsidy for each household is accumulated. If this amount is equal to or exceeds the amount of loan necessary to finance the panels, the source of payment is considered sufficient. By construction, the fiscal year is fiscally neutral, since no more resources are used than those already earmarked in the public budget.

1.2.7. Reassignment of subsidy by decile

In these "non-neutral" scenarios, higher-income households may see their subsidy fully or partially reduced, while lower-income households may receive a higher allocation than they currently receive, reflecting a progressive redistribution implicit in the policy structure.

Agence française
de développement
5, rue Roland Barthes
75012 Paris l France
www.afd.fr

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