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Multi-Level Governance and Policy Design in Nuevo Leon

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Institutional Implementation of In-Kind Subsidies for Distributed Generation: Multi-Level Governance and Policy Design in Nuevo Leon

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Abstract

This article develops an institutional implementation model for a public policy aimed at replacing traditional residential electricity subsidies with in-kind schemes through the delivery of solar photovoltaic systems. Using a multilevel governance approach, the technical, legal and financial capabilities of federal, state and local stakeholders are analyzed, as well as the conditions that are necessary to articulate this policy with existing public programs in Mexico. The study proposes a scalable institutional design, based on public-private partnerships, competitive bidding mechanisms and progressive financing schemes. Enabling regulatory instruments are identified and territorially focused implementation routes are proposed, taking the state of Nuevo Leon as a baseline case. The article concludes with operational recommendations for effective coordination among government branches and presents a duplicable operational model for other regional contexts.

Keywords: Energy governance; distributed generation; multilevel coordination

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Résumé

Cet article présente un modèle de mise en œuvre institutionnelle d'une politique publique visant à remplacer les subventions électriques résidentielles traditionnelles par des dispositifs en nature, à travers la distribution de systèmes solaires photovoltaïques. En s'appuyant sur une approche de gouvernance multiniveaux, l'étude examine les capacités techniques, juridiques et financières des acteurs fédéraux, étatiques et locaux, ainsi que les conditions nécessaires pour articuler cette politique avec les programmes publics déjà existants au Mexique. L'étude propose une conception institutionnelle évolutive, fondée sur des partenariats public-privé, des mécanismes d'appel d'offres concurrentiels et des schémas de financement progressifs. Des instruments juridiques habilitants sont identifiés, et des trajectoires de mise en œuvre territorialisées sont formulées, en prenant comme étude de cas l'État de Nuevo León. L'article se conclut par des recommandations opérationnelles pour une coordination efficace entre les différentes branches du gouvernement et présente un modèle opérationnel duplicable dans d'autres contextes régionaux.

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

Introduction

Mexico faces a bottleneck when it comes to electricity generation in strategic municipalities with high industrial investment, especially in the context of nearshoring. The saturation of the existing electrical infrastructure limits the capacity for regional economic growth and threatens to slow the relocation of key industries. Faced with this scenario, conventional solutions —such as the construction of new generation plants— require deadlines that are incompatible with the urgency of the scenario.

In this context, Fuentes et al. (2025) propose an innovative strategy: redesigning the residential electricity subsidy to finance, by means of a fiscally neutral scheme, the massive installation of photovoltaic systems on the roofs of urban homes, prioritizing municipalities with increasing pressure on the grid. This model would make it possible to free up distribution infrastructure capacity, move towards a more equitable and sustainable energy matrix, and strengthen regional industrial competitiveness.

Considering that proposal, this article develops an institutional, legal, operational and financial implementation model to put this policy into practice. Based on a multilevel governance approach, the conditions needed to structure a scalable distributed generation program financed with in-kind subsidies are analyzed. The document also proposes bidding schemes, progressive financing mechanisms and territorialized implementation routes, taking the case of the state of Nuevo Leon as a starting point.

1. Literature review

Energy subsidies have played an important role in Latin America's social policies, but they often show distributional inefficiencies. Several studies have documented that generalized subsidies tend to disproportionately benefit higher-income households, as they concentrate more energy consumption and, therefore, receive a greater volume of the subsidy through artificially low prices.

In addition to their regressive effects, energy subsidies impose a considerable fiscal burden. In recent years, they represented around 3.7% of GDP in Mexico (and up to 7.4% in Argentina), equivalent to approximately USD 315 per capita per year in the Mexico (Hancevic et al., 2023). This pressure on public finances, in addition to poor social targeting, has motivated the debate on the need to reform existing support schemes towards more progressive and efficient models (Vietites et al., 2022). In this context, exploring alternative mechanisms such as in-kind subsidies is of utmost importance, through the delivery of home photovoltaic systems, which can enhance the welfare of vulnerable households without reproducing the distortions of the traditional scheme.

The promotion of distributed generation, particularly through small-scale solar photovoltaic systems, has been consolidated as an emerging public policy aimed at expanding access, improving equity and advancing energy sustainability. Globally, distributed solar energy is reducing costs and democratizing access to electricity, allowing households and communities to generate their own energy, which strengthens their autonomy from centralized grids and reduces dependence on fossil fuels (Azhar & Warren, 2024).

In Latin America, since 2015, there has been an accelerated growth of renewable distributed generation, driven by the falling costs of solar technology and the creation of specific regulatory frameworks and incentives. By 2019, regional installed capacity exceeded 4.4 GW, with an annual growth rate of 125%, evidencing rapid adoption (Romero, 2020). However, literature indicates that this growth may be concentrated in households with greater economic capabilities, which reinforces the need to design mechanisms that guarantee equitable access to these technologies, particularly for lower-income sectors.

At the same time, the energy transition poses institutional governance challenges. Literature on energy policies stresses the importance of having multilevel governance structures that effectively articulate the different government levels —federal, state and municipal— as well as relevant non-state actors. Conceptually, multilevel governance refers to the distribution of functions and coordination mechanisms between interdependent levels in the formulation, implementation and supervision of public policies. When it comes to energy, this approach has been adopted in several jurisdictions as a way to scale up the transition to clean matrices without losing territorial adaptive capacity (Del Río Benítez Landa, 2022).

Comparative experiences illustrate different models. In the European Union, for instance, regions and local governments have assumed climate commitments aligned with national and community goals, institutionalizing vertical coordination schemes. In federations such as Germany and the United States, state governments have served as laboratories of innovation, adopting more ambitious policies at the subnational level that complement, or even surpass, federal efforts. In the case of Mexico, an effective energy governance framework will require strengthening vertical coordination mechanisms, clarifying concurrent competencies, and fostering inter-institutional learning so that state initiatives can be coherently integrated into the national strategy (van Veldhuizen et al., 2023).

Beyond the institutional design, the viability of a policy that replaces tariff subsidies with in-kind support also depends on its social legitimacy. Acceptance by beneficiary households and their willingness to adopt new technologies are key elements for the sustainability of the program. Historical evidence shows that reforms involving the elimination or transformation of subsidies often face initial resistance, especially if the expected benefits are not adequately communicated (Vietites et al., 2022).

However, various approaches have proven to be effective to increase social acceptance of these measures. On the one hand, communicating the inequities and hidden costs of generalized subsidies in a transparent manner can favor citizen support for their redesign. On the other hand, providing clear information on the tangible benefits of the proposed alternatives —for instance, energy savings, ownership of a long-lived asset, or environmental contribution— helps mitigate perceptions of loss. Experimental studies in Latin America have shown that users respond positively when they understand that new policies can be fairer and more sustainable in the long term (Vietites et al., 2022).

In the specific case of in-kind subsidies through solar panels, the delivery of a physical good reinforces the perception of value: users visualize an immediate and concrete benefit that substitutes for a less visible financial support. This approach has recently been proposed in Mexico by Fuentes et al. (2024), who propose redirecting expenditure on electricity subsidies to finance the massive delivery of photovoltaic systems to residential households. Their estimates suggest that this redesign would make it possible to cover a significant proportion of the expected growth in electricity demand without increasing public expenditure, which offers an opportunity to simultaneously advance distributional equity, fiscal sustainability and energy transition.

2. Objective and scope of the implementation model

The objective of this article is to present an implementation plan to convert a conceptual proposal for the redesign of the electricity subsidy into an executable, technically and fiscally feasible, and socially equitable public policy. Fuentes et al. (2025) proposes the replacement of price subsidies with a quantity-based scheme through direct delivery of solar photovoltaic systems to residential households. This transformation can be carried out without increasing total public expenditure, since it is financed with the resources already allocated to the electricity subsidy, and without increasing household electricity expenditure if properly designed.

Beyond being a short-term solution, this policy contributes to long-term structural objectives. By freeing up part of the burden represented by subsidized residential consumption, available energy can be redirected to strategic industrial sectors, while promoting the progressive decarbonization of the energy matrix. The model thus responds to both immediate capacity challenges and the need for a fair energy transition.

The program is aligned with the National Development Plan 2025-2030 and with the principles of energy sovereignty with equity, territorial justice and efficiency of public expenditure. It is conceived as a modular instrument, territorially focused on the first phase, with the potential for national expansion. This article focuses on outlining the institutional, regulatory, technical and social conditions necessary to effectively implement this first stage.

To make this vision a reality, the design and gradual deployment of a new nationwide federal program is proposed, focused on progressively replacing the traditional electricity subsidy with a model of public investment in solar distributed generation. This article focuses on outlining the institutional, technical, financial and social conditions needed to execute an initial territorially targeted phase, based on the case of the state of Nuevo Leon, and on establishing the foundations for its future expansion to other regions of the country.

While factors such as social acceptance, access to financing and technical capacity condition its execution, the government retains a high degree of control over the pace of deployment. The speed with which the program expands can be designed in a strategic and gradual fashion, depending on institutional capabilities, budgetary availability and technological conditions, which makes it possible to manage risks and adjust implementation without compromising its structural objectives.

2.1. Approach

The article presented herein is a conceptual exercise that evaluates the possibility of redesigning the electricity subsidy so that, instead of being applied as a discount on tariffs, it is used as a source of payment to finance the installation of residential photovoltaic systems. The analysis was constructed under a deliberately conservative and technical methodological approach, and its objective was not to develop a public policy operational model, but to demonstrate the financial and distributional viability of this transformation in aggregate terms.

This study 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 alternative schemes were evaluated: the delivery of 2 kW photovoltaic systems financed with the accumulated value of the subsidy; the allocation of smaller capacity equipment (500 W) adjusted to the subsidized consumption; and a model in which households receive a complete 2 kW system, continue to pay their usual electricity bill, and the surplus energy generated is injected into the grid. The valuation of the surplus injected should be driven by regulatory criteria defined by the Energy Regulatory Commission (CRE), and a technical reference tariff or competitive market mechanisms could be established to guarantee certainty for both CFE and participating households.

Due to its technical, financial and operational feasibility, the implementation model is based on the latter scheme, which leverages existing flows, maintaining the user experience and generating surpluses that strengthen the program's fiscal sustainability.

This model is based on three key assumptions: (i) fiscal neutrality, that is, the policy does not require new public resources, but reuses those already allocated to the electricity subsidy; (ii) distributional neutrality, understood as the condition that no household will pay more for its electricity after the change; and (iii) social acceptance, under the assumption that households will value receiving an asset that replaces the subsidy without generating additional costs. In addition, technical stability is assumed: the photovoltaic systems will operate adequately for at least the duration of the financing, without the need for major investments or adaptations to the electrical grid.

However, the translation of this conceptual proposal into a real public policy implies facing multiple limitations and conditions in a comprehensive manner:

Governance and institutional framework: The model does not address how the State should be organized to implement this policy. There is no analysis of which public entity would lead the implementation, how the different levels of government would coordinate, or what legal instruments would be required to effectively redirect the subsidy.

Legal and regulatory feasibility: The subsidy as a source of payment in a financing scheme has no clear operational precedents. Budgetary rules, CRE guidelines and possibly CFE provisions on interconnection and billing agreements would have to be modified.

Progressive scaling and temporality: The analysis assumes that it is possible to achieve full coverage, and the limiting variable in achieving this full coverage is the tax and distributional neutrality objectives themselves. It does not consider that deployment in practice will be gradual, subject to administrative, operational, budgetary and industrial equipment supply capabilities. The optimal sequence and territorial targeting strategy are dimensions yet to be defined.

Impact on the power grid: Although the analysis considers the technical feasibility of the systems, it does not incorporate the cumulative effects that a high penetration of distributed generation could have on the stability of the electricity system, including surplus management, congestion in local grids and the need to reinforce transmission and distribution infrastructure.

Measurement: Unlike traditional net metering schemes, households do not receive direct compensation for the surplus energy injected in this model, nor is a net settlement made against their consumption. On the other hand, the carryover energy is deemed to be property of the system and is used as a source of payment for the financing structured by CFE. Therefore, this scheme does not require modifications to the individual service agreements, but it may require the creation of a specific operational tariff category or a technical injection registry mechanism, defined by the CRE, enabling its monitoring and independent valuation.

Behavioral risks: No scenarios are modeled in which households refuse to participate, sell equipment or fail to perform proper maintenance. The cost or feasibility of the supervision and sanction mechanisms required to prevent operational deviations is also not evaluated.

Additional operating costs: It does not include a breakdown of long-term maintenance costs, insurance, monitoring, or awareness campaigns. Additional costs such as the administration of the financial structure are not contemplated either, including the constitution of reserves, trustees, fees, credit ratings, among others. This assumption is valid for a limited scale pilot program. However, it should be more explicit for the design of a regional or national program.

Social acceptance and perception of value: Although the model ensures that electricity costs do not increase, receiving an asset does not necessarily compensate, from the household's perspective, for the cessation of an automatic subsidy. In some cases, it may be necessary to design complementary monetary, fiscal or in-kind incentives to encourage participation, which could break fiscal neutrality.

Limited horizon: Finally, it is important to reiterate that this initiative does not replace the structural needs of the national electricity system. It does not solve problems such as the need for firm generation, tariff heterogeneity, storage or nighttime demand coverage.

This section seeks highlight that the theoretical analysis should be understood as a reference model, beneficial for informing policy decisions, but it needs to be translated, adjusted and enriched through an institutional, legal, financial and operational implementation plan. This is the purpose of the sections below.

2.2. Stakeholders and institutions map

The implementation of a public policy of this dimension calls for a solid institutional architecture, where different levels of government, private sector stakeholders, international development agencies and civil society operate jointly. The following is a functional map of the key players, their current responsibilities and the role they could play in the implementation of the program.

Federal Government: The Mexican government, through its agencies, has a structural role in the design, financing, regulation and supervision of the program. SENER will lead the strategic definition, establishing the technical, territorial and social prioritization guidelines. SHCP will be responsible for redirecting the resources of the electricity subsidy as a source of payment of the financing, signing multi-year budget agreements and coordinating the participation of development banks and other financial stakeholders. SEMARNAT will contribute with environmental guidelines, sustainability criteria and possible synergies with other climate policies.

CFE will fulfill multiple roles within the program, whose implementation is based on the reinjection of surpluses generated by photovoltaic home systems. As the technical operator of the distribution grid, it will be responsible for assessing the feasibility of interconnecting PV systems, ensuring the quality of supply and safely integrating distributed generation. As a public company, it will have to adapt its operating flows to the reduction of residential load related to self-consumption, and redirect this freed-up capacity towards more profitable sectors, such as industrial and commercial.

In addition, CFE will assume a core financial role in the model. One option is to structure and grant complementary financing to cover part of the cost of the photovoltaic systems, supported by two sources of payment: the constant flow that households will continue to pay through their electricity bill, and the income generated from the sale of surplus electricity injected into the grid.

Another option is for CFE not to be the institution that directly assumes the loan, but contributes the described payment sources to the payment of a loan contracted by a third party. This is the most viable option since it is neutral with respect to CFE's finances.

State and municipal governments: State governments can assume a key role during the expansion of the program, particularly in the regional deployment phases. They will be able to collaborate in the identification of beneficiaries, grant permits and licenses, assist in territorial impact assessment and promote social acceptance at the local level. In specific cases, they could even operate decentralized installation schemes under agreements with the federal trust. Municipal governments will be key players in the logistics of implementation, urban planning, physical access to households and community coordination.

Private sector and financial system: The private sector will be a key operational partner in the program. Equipment suppliers must comply with defined technical standards and participate in competitive procurement processes. Certified installation companies will be responsible for executing the works under clear and traceable contractual conditions. Development banks, led by Banobras, will act as trustees and main financial agents of the program. Its role will include managing the trust, structuring credit lines and channeling resources to the operators.

Multilateral and bilateral development banks and international green funds can provide timely payment guarantees and technical assistance to strengthen the financial soundness of the scheme. Commercial banks could participate in later phases of the program, especially if space is made available for mixed financing schemes or industrial expansion of the value chain.

An attractive alternative would be for households to be given the option of paying CFE the proportional value of the unsubsidized panel with resources from an INFONAVIT loan. In this way, households could amortize the total value of the panel, stop paying for their self-consumption and reinject carryovers into the grid that would be credited as future consumption (households cannot receive cash payments for the sale of carryovers). The implementation of this scheme would be independent of the financial structuring, since the household would be the one acquiring the credit with INFONAVIT, so that the financial structure would only see an early amortization of the panels of such household.

There is also the possibility of channeling resources through the stock market, through debt issues backed by future payment flows from households and income from the sale of energy surpluses. This mechanism would allow for the diversification of financial sources, take advantage of the company's credit profile and facilitate the scalability of the program in the medium term.

Households, civil society and academic community: Beneficiary households are at the core of this policy. Not only do they receive the equipment, but must take an active role in its use, maintenance and connection with the program objectives. Social acceptance and ownership of the system will be critical to its sustainability. Civil society organizations will be able to contribute as allies in citizen monitoring, dissemination of energy rights and community accompaniment. Universities and research centers, both public and private, will provide technical evidence, impact assessments, innovation in technological solutions and specialized human capital training. The academic sector can also contribute to the identification of opportunities for the development of local productive capabilities related to equipment manufacture or assembly.

Jointly, this network of stakeholders constitutes a distributed institutional framework that requires state leadership, intergovernmental coordination, collaborative governance and citizen participation. The challenge is to design a technically sound policy and build the agreements, capabilities and cooperation channels needed to turn this proposal into a transforming reality.

2.3. Legal and regulatory aspects

The redesign of the electricity subsidy in a public policy based on distributed generation implies not only operational and financial transformations, but also a progressive regulatory adjustment to enable the new institutional architecture of the program.

The proposed program involves important changes in the way electricity subsidy flows are organized, executed and supervised, as well as in the functions of several public entities, from SHCP and SENER to CFE and development banks. It also proposes the possible creation of new operational, fiduciary or executing units, with specific mandates in energy, financial and territorial matters. These changes must be legally supported, both to ensure institutional security and to prevent competition conflicts or responsibility gaps.

Therefore, the deployment of the program is suggested to be accompanied by a cross-cutting regulatory strategy from the outset, with the aim to comprehensively review existing regulatory instruments, identifying possible restrictions and designing legal mechanisms to enable implementation without creating uncertainty.

Similarly, it is recognized that, as the program evolves and scales territorially, new regulatory needs will arise in relation to land use, interconnection rules, subsidy administration, fiduciary governance, protection of beneficiary households, technical liability regime, or even public procurement under emerging market conditions. In this regard, it will be essential to ensure permanent legal support, combining technical capacity and strategic vision.

3. Stakeholders, capabilities and institutional alignment

3.1. Institutional design and implementation modes

The viability of this proposal, as demonstrated in this report, depends to a large extent on the institutional design adopted for its implementation. A policy of this dimension requires an operational structure capable of coordinating different government levels, managing agreements, overseeing financial flows, articulating the private sector and ensuring equitable results. The way in which responsibilities are distributed among public and private actors, as well as the governance mechanisms that are established, will profoundly condition the program's performance. Four possible implementation schemes are presented below, with a qualitative assessment of their strengths, risks and implications.

a) Centralized model: A first option is to keep the execution of the program centralized in the Federal Government, particularly through SENER, in its leading role in energy policy, and CFE as the technical operator. This alternative would allow greater institutional and political control over the program's design and leadership, ensuring alignment with the government's strategic objectives and minimizing the risk of territorial fragmentation. Additionally, CFE already has logistical structures and technical expertise that could be used for the installation and maintenance of photovoltaic systems. However, this model also represents important limitations: centralized execution could generate operational rigidity, overburden the federal administration and limit the ability to respond to diverse local realities. At the financial level, this scheme might require explicit guarantees from the State to support the structuring of the credit, and limit the possibility of participation of private financial stakeholders that could bring efficiency or innovation.

b) New federal entity: A second alternative is to delegate implementation to a new specialized public entity, such as a state-owned company or a deconcentrated agency, whose specific mandate is distributed electrification using renewable technologies. This model would offer greater administrative flexibility and operational capacity, allowing for more agile contracting schemes, attracting specialized technical personnel and coordination with different government levels. As an institution created for a single purpose, it would also facilitate resource tracking and accountability. Nevertheless, the creation of a new public entity implies relevant administrative shortcomings, as well as the challenge of higher fiscal cost and duplication with functions currently performed by CFE. In addition, it would be necessary to provide this entity with robust institutional capabilities and oversight mechanisms to avoid problems of capture or dispersion of objectives.

c) Collaboration with state governments: A third option is to implement the program in partnership with state governments. In this model, the Federal Government would define the general guidelines, provide financing and establish the regulatory frameworks, while state governments would be responsible for the territorial deployment of the program, the selection of beneficiaries, supervision activities of equipment and, eventually, the maintenance of the systems. This option would allow a more precise adaptation to the social, economic and technical realities of each state, as well as greater local ownership of the program. However, decentralization also entails risks: there are large asymmetries in technical and managerial capabilities among the states, which could lead to disparate results. A federal monitoring and evaluation system should also be designed to ensure the program's coherence at the national level, without undermining its territorial flexibility.

d) Partnership with the private sector: The fourth mode anticipates partnering with the private sector, under a model in which the government retains strategic leadership, control over financial flows and the definition of public objectives, delegating to the private sector only those functions where it can contribute the most value: installation, logistics, technological innovation, specialized maintenance or operational management of large volumes. This form of collaboration recognizes the existing capabilities of the country's entrepreneurial ecosystem, but avoids falling into a logic of passive outsourcing to the public sector.

Including the private sector under this scheme requires establishing clear contractual frameworks, homogeneous technical standards, independent evaluation schemes and an institutional architecture that ensures the alignment of incentives. The objective is not to replace public action, but to complement it, recognizing that the private sector can perform certain tasks in a more agile and efficient manner, provided that the purpose of the policy is well defined and institutionally safeguarded. In order to achieve this, the design must incorporate collaborative governance principles, social impact-oriented performance metrics and fair risk and benefit sharing mechanisms.

This approach is aligned with the perspective of "public missions" developed by Mariana Mazzucato, who argues that the State should not limit itself to correcting market failures, but should actively lead innovation processes and structural transformation with clear social objectives. Based on this logic, the State defines a direction for change —in this case, moving towards a fairer, cleaner and more distributed energy matrix— and mobilizes the private sector as a strategic partner, not as a subordinate contractor or hegemonic actor. This type of models has already been proposed and adapted in sectors such as health, mobility or urban transformation, whereby it has been demonstrated that it is possible to build mission-based public-private platforms with high standards of equity, efficiency and transparency (Mazzcuato, 2018a; Mazzucato, 2018b; Mazzucato, 2019; Mazzucato, 2021; Mazzucato, 2023).

From this perspective, we believe that it is possible to apply a mission-driven innovation approach also in the field of energy policy, specifically in the redesign of residential electricity subsidies. This approach aligns the program's social, economic and environmental objectives within a coherent strategy of structural transformation. In the Annex, we outline a preliminary proposal to adapt the ROAR (Routes, Organization, Assessment, Risks and Rewards) methodological framework to the case of distributed generation in Mexico, with the aim to strengthen the governance, impact assessment and long-term sustainability of the Mazzucato program (2023; Mazzucato, et al, 2020).

Applied to the case of distributed generation in the electricity sector, this would imply for the State to define the priority areas, select the beneficiaries according to social criteria, manage the financing structure and supervise the quality of the equipment, while the private sector (through competitive bidding and regulated frameworks) would be in charge of executing the technical deployment. Thus, the partnership is not only financially and operationally viable, but also politically consistent with a progressive vision of development. Far from representing an abdication of public office, this mode can be a powerful way to expand state capabilities, accelerate implementation and ensure that the benefits of the energy transition reach those who need it most first.

To avoid operational duplication, the technical functions of the program — including equipment procurement, installation and territorial deployment— can be delegated to the federally defined implementation mechanism. This guarantees a clear separation between CFE's financial responsibilities and the logistical operation of the program, optimizing resources and ensuring institutional efficiency.

Table 5. Assessment of advantages and risks in operational execution alternatives
Source: The authors

Execution mode	Advantages	Challenges or risks
Centralization in the Federal Government	Centralized control; strategic alignment; use of existing CFE capabilities.	Operational rigidity; administrative overload; low local adaptability; limited private participation.
New specialized public entity	Operational flexibility; agile contracting; traceability and focused accountability.	Political-administrative time for its creation; risk of institutional duplication; need for legitimacy and control.
Partnership with state governments	Territorial adaptation; greater local ownership; integration with state policies.	High asymmetries between state capacities; risk of fragmentation; need for robust federal oversight.
Partnership with the private sector (mission approach)	Efficient execution; use of private sector technical capabilities; possibility of technological innovation.	Need for strong agreements and control mechanisms; risk of loss of state control if poorly designed; requires clear collaborative governance.

3.2. Financial structure

The implementation of a national program to replace electricity subsidies with photovoltaic systems requires a dual and robust financial structure, capable of coordinating both the mechanisms managed by the Federal Government and those led by CFE. The main objective is to ensure that the scheme works without generating additional pressures on public finances, taking advantage of the resources currently earmarked for subsidies as a source of payment, and mobilizing complementary financing to accelerate the deployment of infrastructure.

3.2.1. Financing with subsidy as source of payment (Federal Government)

The first component of the scheme is based on rechanneling the electricity subsidy currently received by beneficiary households. The core mechanism is a public trust (defined purpose vehicle) constituted by the Federal Government as trustee. This trust would have the resources rechanneled by SHCP as assets, equivalent to the subsidy that households would no longer receive as part of the program, as well as contingency financial reserves, which must be created to absorb operating fluctuations and ensure credit servicing in adverse scenarios. A timely payment guarantee, potentially provided by an international development finance institution with sovereign backup, would also be included.

The trust would be managed by Banobras, in its capacity as trustee, and would be governed by a Technical Committee comprised of high-level representatives from SHCP, SENER and other federal agencies. This committee would be responsible for defining annual investment goals, approving the general conditions of the program and authorizing the use of financing. To ensure a smooth and specialized operation, an executing unit will be set up within the trust itself, responsible for managing the relationship with the program operators, verifying compliance with the installation goals and reporting to the Technical Committee on a regular basis. This separation between strategic and operational functions seeks to streamline execution and reduce administrative bottlenecks.

The financial operation consists of contracting a credit by the trust, using as a source of payment the flows from the rechanneled subsidy. Once the financing is approved, the resources are transferred to the program operator, who is responsible for the purchase and installation of the solar panels. On a monthly basis, SHCP deposits in the trust the resources corresponding to the subsidy that would have been allocated to the households already included in the program, allowing the trustee to service the loan on a timely basis. In the event of insufficient cash flows, financial reserves are activated first as an operating buffer, and ultimately the guarantee of timely payment. These mechanisms form a financial stabilization system that makes the scheme robust in the event of possible contingencies.

Additionally, the program must be supported by a multi-year commitment from SHCP, which guarantees the transfer of the corresponding subsidy to each household throughout the loan. However, it is recognized that these types of policies are exposed to political and fiscal risks, so the guarantee of timely payment plays a critical role as a mitigation instrument in the event of an eventual interruption in budgetary flows.

Regarding financial and operational monitoring, Banobras, as trustee, is expected to be responsible for conducting early audits to detect relevant deviations in the program's progress or in the fulfillment of financial goals. These audits would function as an early warning system, triggering adjustment mechanisms by the Technical Committee or the program operator. Indicators to be monitored include the number of households incorporated, the effective installation rate, the frequency of subsidy deposits and the consistency of debt service.

3.2.2. Financing with invoicing as source of payment (CFE)

The second component is managed directly by CFE, within the framework of the model with reinjection and sale of surpluses. These revenues are valued at market price, and are accounted for within the financial scheme of the operating trust.

In this case, households continue to pay their electricity bill as they did in the past. The difference is that they self-consume the energy generated by the photovoltaic system now and the surplus is injected into the grid, generating an additional income valued at market price. It should be noted that, unlike a net metering scheme, households do not receive the monetary value of the surplus energy, so there is no direct commercial relationship between the user and the electricity market, and billing remains within the traditional model.

This combined flow allows CFE to structure a financing scheme without direct budgetary support. One option is for CFE to set up its own financial instrument, such as an operating trust or portfolio structure, which would receive monthly payments from the households and the incomes from the carryover sale, and with them the credit associated with the purchase and installation of the photovoltaic systems. This mechanism may be managed directly by CFE headquarters as part of its regular financial operations.

However, a simpler option is for CFE to simply contribute these resources as a source of payment to the trust set up by SHCP, which will then contract the complementary part of the credit. The financing would have the resources provided by CFE as a source of payment, so the financial cost could be equivalent to that faced by the company.

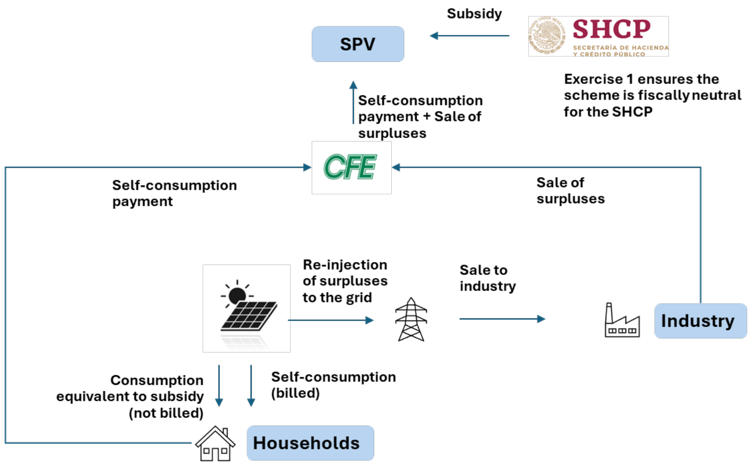
The financial calculations of the model assume that the financing is structured under the same risk conditions under which CFE makes the contracts, i.e., without the need for additional explicit guarantees, since the source of payment is supported by its own billing flow. However, complementary guarantee or hedging mechanisms —by development banks or multilateral institutions— could be considered to reduce the perceived risk and improve financing conditions.

In parallel, logistical functions —including equipment procurement, installation and monitoring— can be delegated to the federal program operator, thus ensuring a clear separation between financial management and technical execution, and avoiding operational duplication.

This model ensures a stable and recoverable source of payment, and also allows CFE to improve its operating position. Energy that was previously intended for subsidized consumption may be redirected to more profitable sectors, such as industry and commerce, where rates are not subsidized. Redistributing this load optimizes the use of installed capacity, reduces technical losses and strengthens the company's financial profile.

Figure 6. Financial scheme

Source: The authors



3.2.3. Short- and long-term financial synchronization

A critical part of the design is to ensure that loan disbursement and beneficiary incorporation are synchronized, regardless of the source of financing. This principle applies both to the structure of the Federal Government, in which the rechanneled electricity subsidy serves as a source of payment, and to the scheme in which CFE structures its own financing, supported by household billing flows. In both cases, three operational alternatives are expected to coordinate funding with the physical progress of the program:

Total disbursement in advance: The trust contracts full financing in advance and executes it as homes are incorporated. This model requires an open line of credit and may generate unnecessary financial costs if the pace of execution is slower than anticipated.

Short-term bridge loan: A temporary credit facility provides immediate liquidity to the operator to acquire panels, and is subsequently refinanced with the trust's long-term structured loan. This solution improves operational flow, but requires more complex financial management.

Staggered modular financing: The scheme is structured by modules that are only activated when verifiable targets are met, such as a minimum number of households with signed agreements and an installation stage validated by an independent third party. This alternative significantly reduces the risk of requesting more financing than is required and allows the program to be adjusted in a progressive and controlled manner.

In summary, the financial structure proposed here is designed to combine budgetary security, operational flexibility and institutional control, allowing for an orderly and fiscally neutral implementation of the program. Its success will depend on effective coordination among the different public actors involved, on the technical quality of its verification processes and on the State's ability to sustain the multi-year commitment to a new generation of public policy.

3.3. Deployment plan and expansion timeline

The transformation of the electricity subsidy into a policy of investment in residential solar energy systems requires a progressive implementation, designed with flexibility and realism. Instead of a rigid timeline, this plan is presented as a conceptual map with three staggered phases, the timing and scope of which may be adjusted as operating experience evolves.

First stage: It corresponds to a territorial pilot program, with an expected duration of up to two years, focused on the Monterrey Metropolitan Area. This region was chosen for its strategic relevance: it combines high pressure on the electricity system with growing industrial demand. The pilot program will validate the financial structure, test the institutional operation and gather evidence on the social acceptance of the scheme.

Second stage: It involves a partial expansion of the program over a two- to three-year horizon. Coverage will still be limited, but significantly greater than in the first stage, prioritizing regions where the program will have the greatest social and technical impact. To define its expansion, a matrix of criteria is proposed: stress on distribution networks, concentration of energy poverty, feasibility of photovoltaic installation, proximity to industrial poles or areas with demand pressure due to nearshoring, and alignment with state energy development policies.

Third stage: To be implemented after three years, it would correspond to a national expansion that progresses towards total or majority coverage. This phase will depend on the accumulated success and the State's ability to consolidate the operational, financial and regulatory model. Gradual progress will be made towards all eligible territories, maintaining criteria of equity and targeting.

In terms of scenarios, the design should provide for differences between low and high penetration contexts. Low penetration (less than 10% of eligible households in five years) allows operating with direct budgetary resources and low impact on the electricity grid, but has lower scale and structural impact. High penetration (over 50% in the same period) accelerates aggregate benefits, but requires greater technical capabilities, surplus control, risk management and structured financing.

The penetration potential of the program will depend on a number of factors such as political will, access to credit, social response and technical aspects. The speed of deployment is not determined solely by external variables, but can be deliberately modeled as of the design of the program. Through phased planning, compatible with institutional and budgetary capabilities, the government can adapt the pace of implementation and maximize the territorial impact of the program.

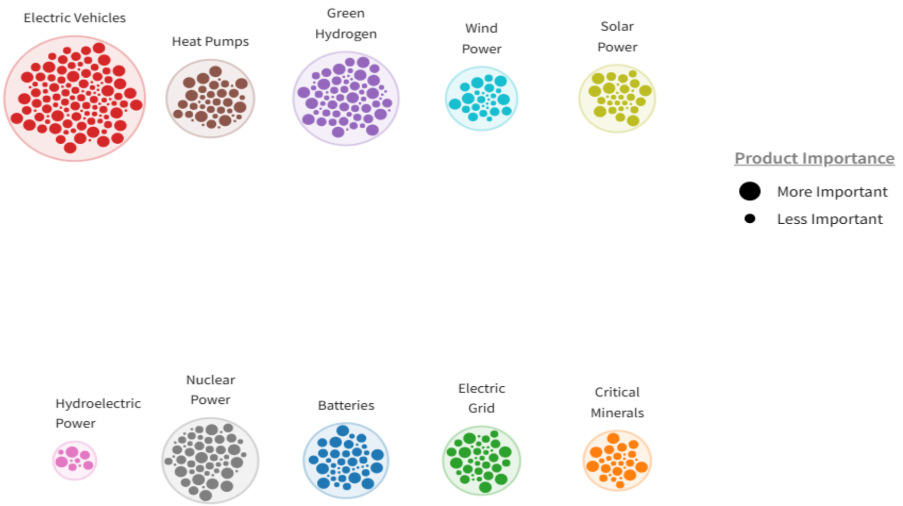
3.4. Procurement, logistics and installation

The implementation of this policy will require a well-structured operational strategy to procure, distribute, install and maintain residential photovoltaic systems throughout the country. The most viable procurement model is a centralized and competitive one, with volume bidding to make the most out of economies of scale. This model can be applied with a phased approach to accompany the territorial progress of the program and adjust prices and conditions according to operational learning.

It will be essential to define approved technical standards for the equipment —panels, inverters, meters— from the beginning, which will facilitate both operation and maintenance, in addition to reducing the risk of incompatibility or poor performance. The installation must be carried out by accredited companies, with subsequent independent technical validation, as a condition for activating the flow of the rechanneled subsidy. Logistics must foresee regional distribution centers, and coordination between suppliers, installers, auditors and operators will be key to scaling up without generating bottlenecks.

Beyond the logistical aspects, the program provides the opportunity to strengthen a national solar energy value chain. Harvard University's Economic Complexity Lab has developed tools to identify the potential of each country to enter highly complex productive sectors, such as clean technologies. According to its estimates, Mexico has an industrial base and technological capabilities that position it favorably to develop key components of photovoltaic systems, such as structures, wiring, transformers and even photovoltaic modules. This policy could, therefore, be articulated with a green industrial development strategy aimed at generating employment, transferring technology and diversifying exports. Although this requires more specific feasibility studies, the potential is documented.

Figure 7. Green value chains and components for Mexico
Source: Greenplexity; Harvard Growth Lab
https://growthlab.app/greenplexity



However, any procurement policy must consider the dominant role that China occupies in the global solar energy value chain. This country controls a substantial part of the global production of inputs and final products in the solar cell and module market, as well as a relevant part of inverter manufacturing. This concentration means that any attempt to close trade with China —for geopolitical or protectionist reasons— would represent a substantial risk to the viability of this policy, particularly in terms of costs and implementation times. The current environment of global trade tensions makes it even more important to have a flexible purchasing strategy that mitigates supply risks without compromising the competitiveness and scalability of the program.

Overall, the operational component of the program must balance procurement efficiency, technical control and industrial vision, so that the energy transition is also a lever for national productive development.

3.5. Evaluation of impacts to the grid and technical aspects

The deployment of large-scale residential photovoltaic systems is not only a financial or organizational issue, but also a direct intervention on the country's electrical infrastructure.

Therefore, it is essential to anticipate its technical effects, especially in distribution, transmission and system stability. The degree of penetration achieved —low, medium or high— will have different implications in terms of risk and operational needs.

In a low penetration scenario, the impact on the grid will be limited and probably manageable with the existing infrastructure. In this case, distributed generation will reduce local loads and may even improve operating efficiency in certain areas. The priority will be to establish basic interconnection protocols, post-installation technical validation mechanisms and functional coordination with CFE Distribution to ensure up-to-date records and secure connections. Investment in grid reinforcement would be marginal and focused.

In a medium penetration scenario, localized stresses could be observed in areas where low voltage grids were not designed for significant reverse generation. This can lead to voltage quality problems, transformer saturation or the need for replacement of secondary infrastructure. In this case, an ex-ante evaluation of the technical conditions of each deployment area will be necessary, as well as complementary investments coordinated with CFE to prevent bottlenecks. Likewise, it will be necessary to establish a national monitoring system to identify possible real-time saturation or instability points.

Operational risks are amplified in a high penetration scenario. At this scale, solar energy surpluses can become significant during certain times of the day, especially in residential areas with low concurrent industrial demand. Managing these surpluses requires the establishment of safe absorption mechanisms: from distributed or community storage, to backup agreements with CFE for controlled reinjection. It will be critical to define grid injection rules, including limits, pricing or compensation, and to have bidirectional metering infrastructure in place.

Additionally, the stability of the national power system must be protected with new security protocols. This includes technical requirements for inverters, automatic disconnection criteria in the event of faults, coordination with regional control centers and, eventually, the implementation of smart grid technologies. These actions should be led by CFE Transmission and Distribution, in coordination with the regulator and program operators, to prevent distributed generation from compromising system reliability.

Although it is not part of the base design of this proposal, battery storage technology could become a strategic component of the program in the medium term. Its incorporation would allow better management of surplus residential solar energy, temporarily storing the electricity generated during peak radiation hours for later use, which would reduce injection into the grid and mitigate the risk of saturation in high penetration scenarios. This would be especially valuable in areas with low daytime demand or fragile grids, where distributed generation without storage can amplify voltage or frequency imbalances.

In addition, batteries could work as an energy resilience tool for households by providing backup in the event of supply disruptions, or even enable demand management and dynamic tariff schemes if combined with smart meters. Nevertheless, its widespread adoption faces technical and economic limitations. The cost per kWh stored is still considerable for lower-income households, and installation and maintenance require higher technical standards.

In all scenarios, the program design should include an ex-ante technical evaluation that identifies priority areas for investment, defines realistic operational limits and avoids undesirable effects on the grid. As the program scales, the integration among energy policy, grid planning and technology transition will be essential to ensure that the advancement in solar generation does not create imbalances, but rather contributes to a cleaner, more resilient and efficient electricity system.

3.6. Monitoring, control and maintenance

Not only does the sustainability of the program depend on its initial funding and the success of its territorial deployment, but also on the existence of a robust follow-up, supervision and maintenance system that guarantees its integrity over time. This involves ensuring both the correct use of public resources and the continued functionality of the installed photovoltaic systems.

Firstly, financial and technical audit mechanisms must be implemented from the onset of the program. At the financial level, the trustee —in this case Banobras— must establish periodic reports on budget execution, subsidy flows and loan payments, externally audited and shared with the Technical Committee. At the technical level, a system of random and independent inspections must be set up to verify the quality of the equipment, the secure connection to the grid and the operability of the systems. These audits must be conducted by certified third parties, selected by public call, under protocols defined by the Technical Committee and the trust's executing unit.

Secondly, it is essential to monitor the proper use of the equipment. In order to do that, the program must include contractual clauses with beneficiaries that prohibit resale, voluntary disconnection or abandonment of the systems without just cause. Failure to comply with these conditions could result in the cancellation of benefits or even penalties, depending on the applicable legal framework. At the operational level, a remote monitoring system is proposed to detect unusual consumption patterns or sustained failures, activating alerts for field inspections.

Maintenance is another critical axis to preserve system efficiency over time. A technical protocol for preventative and corrective maintenance should be defined, including two levels: a minor one, which can be performed on an annual basis and covered by the operator during the warranty period; and a major one, which includes the eventual replacement of critical components (such as inverters) and can be financed with resources released from the subsidy once the loan has been repaid. These actions should be coordinated with the program operator and CFE Distribution to ensure that the system remains safe and functional within the grid.

Lastly, the program must have a national registry of beneficiaries, managed by the trust's executing unit. This registry will consolidate information on participating households, location of the systems, technical characteristics, installation dates, operating status, maintenance history and contractual compliance. This database will be essential for program traceability, impact assessment and corrective decision making.

Together, these mechanisms will allow maintaining the transparency, functionality and legitimacy of the program in the long term, ensuring that the public investment made translates into sustained benefits for families and for the national electricity system.

3.7. Social acceptance, communication and incentives

The viability of this policy depends not only on its financial or technical structure, but also on its social acceptance. The success of the program will require that beneficiary households not only access the photovoltaic systems, but actively adopt them, keep them in operation and value their incorporation as an effective improvement in their quality of life. To achieve this, it is essential to develop a comprehensive communication strategy, incentives and social monitoring.

The first step is to identify and anticipate cultural, social and logistical barriers that could hinder adoption. These may include distrust of government programs, perception of increased complexity versus automatic subsidy, concern about maintenance, resistance to change, or lack of basic technical information. Logistical frictions may also arise, such as lack of adequate space to install panels, restrictions in multi-family housings, or fear of damaging the home's infrastructure. These barriers must be recognized and addressed starting from the design phase.

As a complement, the program should foresee the possibility of non-financial incentives to reinforce the decision to participate. This may include bonus mechanisms (for instance, additional credits in the bill in case of sustained compliance), preferential access to other social programs (such as energy efficiency, connectivity or drinking water), or certifications that accredit the household as a clean energy beneficiary, with possible advantages in administrative or fiscal processes. The design of these incentives must be sensitive to the territorial and cultural context.

A national public communication and energy education campaign will be essential to build legitimacy and social understanding. This campaign must clearly explain what changes and what remains the same: that the household will not pay more for electricity, that it now receives an asset of its own, and that it is part of an energy transformation with shared benefits. It should incorporate educational content on the use of the systems, the environmental benefits and the role of citizens in the energy transition. Working with community media, schools, social media, local leaders and territorial attention centers is suggested, in order to adapt the message to different audiences.

Finally, establishing a continuous monitoring system for public perception and user satisfaction is highly recommended, coordinated by the program's executing unit. This may include periodic surveys, digital feedback mechanisms, community dialogue tables or participatory evaluations. The objective is to identify areas for operational improvement, as well as to maintain an active link with citizens to strengthen the political and social legitimacy of the program.

Social acceptance is not an accessory component, but a structural condition for program sustainability. The energy transition will only be successful if it is also a policy that is approachable, understandable and valued by the households it seeks to transform.

4. Institutional risks and strategic recommendations

Any large-scale public policy with fiscal, operational and social implications faces inherent risks that must be anticipated, assessed and managed with preventative mechanisms and structured response capabilities. This program, which proposes the redesign of the electricity subsidy through residential photovoltaic systems, is no exception. Although the technical analysis has demonstrated its conceptual feasibility, its implementation poses multidimensional risks that must be addressed through institutional design.

a) Financial and fiscal risks: One of the main risks is the possible interruption of the flow of subsidies rechanneled from SHCP, either due to budgetary changes, political decisions or fiscal impacts. Although the program has a multi-year commitment, it is not immune to macroeconomic pressures. To mitigate this risk, a timely payment guarantee with sovereign or international support is included, as well as contingency reserves within the trust to act as a temporary buffer.

b) Operational risks: The program depends on a complex logistical chain that includes procurement, distribution, installation and maintenance of equipment. Delays in public procurement, technical quality problems or installation bottlenecks could slow progress. In order to mitigate this risk, a specialized executing unit is envisaged to manage and monitor the operating agreements, as well as independent technical audits at each stage. The phased approach also makes it possible to correct faults prior to national extension.

c) Institutional risks: The dispersion of responsibilities among multiple public and private actors can generate governance gaps, overlaps or fragmentation. To avoid this, a clear institutional architecture is proposed: a Technical Committee with strategic functions, an executing unit with an operational mandate, and a trustee with financial responsibility. The traceability of decisions and the existence of a national registry of beneficiaries and systems will make it possible to consolidate cross-cutting control and evaluation.

d) Social and legitimacy risks: Citizen rejection, low perceived value or reluctance to replace an automatic subsidy with a physical asset may limit adoption. For this reason, an early public communication strategy is established, as well as complementary incentives and satisfaction monitoring mechanisms. It is recognized that, in certain contexts, it will be necessary to adapt the message or redesign program conditions to respond to cultural or logistical barriers.

e) Technical and grid risks: Large-scale distributed generation can disrupt the technical balance of the electricity system. If program penetration exceeds certain thresholds without grid investments or control mechanisms, it could generate instability. Therefore, an ex-ante evaluation by stage, the technical support of CFE and regulators, and eventually the development of storage schemes and smart grids in critical areas are foreseen. While uncertainty about social adoption or the availability of funding may pose risks, one of the most manageable aspects for government is the speed of deployment. Defining clear phases, intermediate goals and feedback mechanisms allows mitigating these risks and adapting the scale of the program according to its performance and operational context.

f) Behavioral and compliance risks: Misuse, abandonment or resale of the equipment could affect the integrity of the program. This possibility is reduced if agreements with beneficiaries, responsible use clauses and remote operation monitoring are provided for. The inclusion of penalties and community surveillance can also limit these risks.

g) Coordination and institutional learning risks: Every pilot program faces uncertainty about its replicability. This plan incorporates a structured learning phase: early audits, external evaluations, regulatory adjustments and, above all, the possibility of progressive adjustment of the model based on accumulated evidence.

h) Risk of non-payment by households: One of the key risks of the scheme is partial or total non-payment by households, a variable that may not be fully captured in the CFE's current delinquency and collection parameters. Although the design is based on the assumption of continuity in the payment of the electricity bill —and considers the cut-off of supply as a deterrent mechanism—, this risk acquires a different dimension when the household already has a photovoltaic system installed. Although the panel is not functional without connection to the grid or an enabled meter, the fact that the household physically owns the asset gives it greater bargaining power in case of conflict, especially if there are forms of collective organization or local social pressure. This may weaken the traditional sanction mechanism associated with service disconnection, especially in areas with a history of tariff conflicts or low institutional collection capabilities. For this reason, it will be necessary to consider contractual or legal mechanisms that enable the recovery of equipment in the event of persistent non-payment, as well as shared responsibility schemes or joint and several guarantees in community contexts. The possibility of reclaiming or relocating equipment can strengthen compliance incentives and reduce the financial risk of the program.

i) Fiscal risk related to the valuation of the surplus: In the proposed scheme, the surplus energy generated by the solar home systems is injected into the grid and valued at market price as a source of payment for the financing structured by CFE. Although this income is not transferred directly to the household, and therefore does not constitute taxable income for the user, it is important to ensure that this interpretation is explicitly recognized by the tax authority. If not clarified, there could be legal risks or misperceptions regarding the treatment of the surplus as taxable income. On the CFE's side, these revenues must be correctly accounted for within the framework of its commercial operations, making a distinction between conventional sales and valuation as a financial guarantee. This issue should be addressed in coordination with the Tax Administration Service (SAT) and the CRE.

Conclusions

The implementation of a distributed generation program financed with the redirection of electricity subsidies represents a concrete opportunity to transform a regressive current expense into a strategic investment with social, fiscal and energy benefits. The implementation model of this report has proven that this transition is not only conceptually viable, but also operationally feasible if articulated on a clear institutional architecture, structured financing mechanisms and an operational model of progressive deployment.

The proposed operational design foresees critical factors for its success: from the selection of priority households and territories, to the definition of procurement schemes, installation, monitoring and maintenance. Additionally, legal, regulatory and social barriers are identified, which require specific attention to avoid frictions in their implementation. The existence of similar programs such as Sol del Norte, and the alignment of the model with the objectives of Plan Mexico and PRODESEN, strengthen its relevance and open spaces for its integration into existing public policies.

A key conclusion is that the model needs to start with carefully designed pilot schemes. These must validate their technical and financial viability, as well as the social acceptance of the scheme, the operational capabilities of the stakeholders involved, and the regulatory coherence with the current regulatory framework. The evidence generated in these pilot programs will be essential for scaling them up in an orderly and effective manner.

Lastly, although the focus of this report has been on distributed generation in residential households, its logic can be adapted to collective schemes, small businesses or industrial clusters in future phases. This flexibility makes the model a platform for structural transformation that goes beyond the short term: it is a proposal to redesign the role of the State in the use of energy subsidies, towards a public policy that is more progressive, resilient and aligned with the challenges of sustainable development.

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ANNEX

1.1. Financial structure of the program

The financial structure of the program is organized through a public trust, designed to channel the electricity subsidy towards the acquisition and installation of residential photovoltaic systems, without compromising fiscal sustainability. The following diagram illustrates the main stakeholders and operational flows:

a) Technical Committee- Governing body of the trust, defines annual goals, authorizes the use of resources and approves lines of financing. Oversees the overall operation of the program.

b) Executing Unit- In charge of technical-operational management. Coordinates with program operators, follows up on equipment and reports to the Technical Committee.

c) SHCP- Reallocates the subsidy resources to the trust that would have been destined to the households brought into the program on a monthly basis. This flow is the source of payment of the financing.

d) CFE- Performs household billing and collections and is responsible for the carryover sales to the industry.

e) Trust- Managed by Banobras, it receives the subsidy resources and channels them to the operator, in addition to contracting the necessary financing to execute the program.

f) Credit- Financial instrument contracted by the trust to finance the acquisition of solar panels. It can be structured by sections or staggered lines. It is supported by subsidy flows and a guarantee of timely payment in case of contingency.

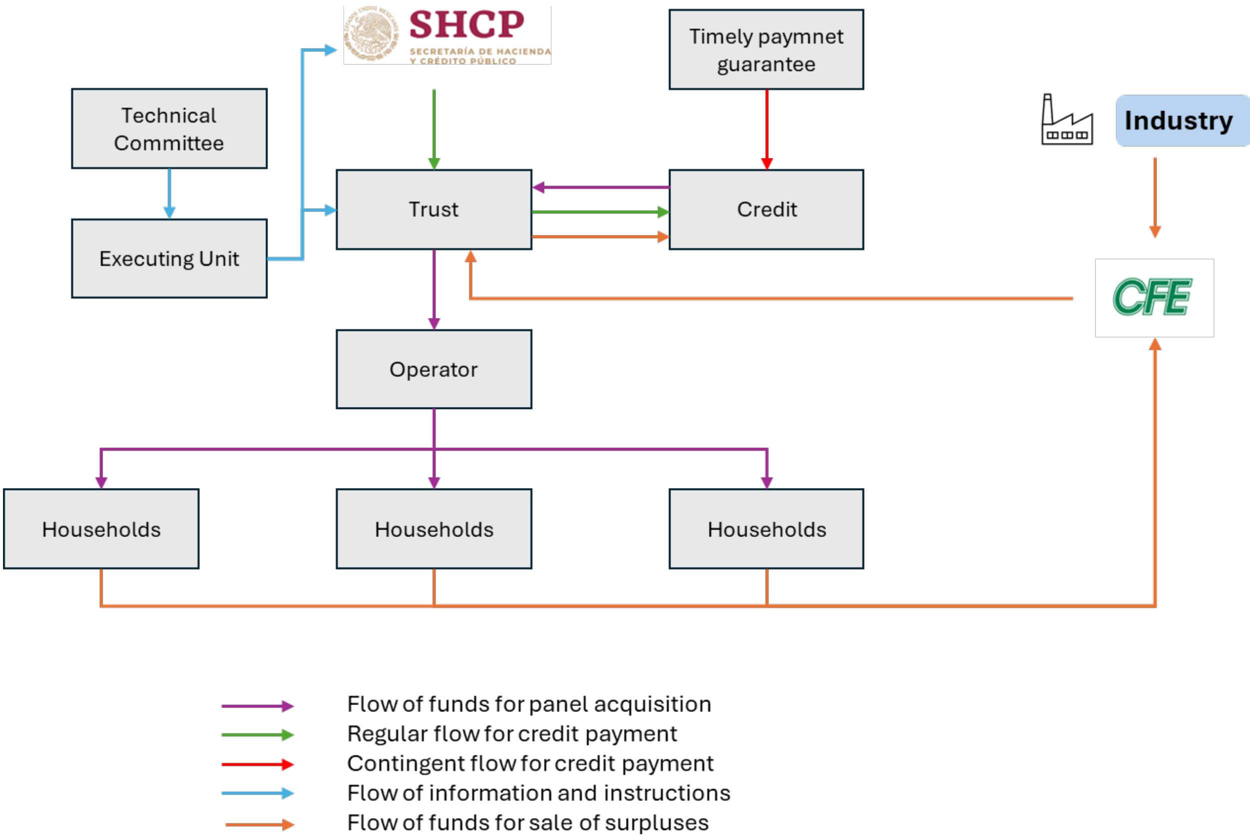
g) Timely Payment Guarantee- Financial coverage provided by an international financial institution with sovereign backup. It is activated only if grant resources and reserves are not sufficient to service the debt.

h) Operator- Executes the purchase, installation and technical validation of photovoltaic systems in beneficiary households.

i) Households- They receive photovoltaic systems. As soon as they join the program, their subsidy is transferred to the trust as a source of payment of the loan.

This model makes it possible to maintain fiscal neutrality by using resources already allocated, while transforming a recurrent subsidy into a long-term investment.

Figure 11. Financial structure



1.2. Implementation of the ROAR framework to in-kind subsidy policy for distributed generation mission approach

The transformation of the traditional electricity subsidy into a scheme based on the delivery of residential photovoltaic systems can be interpreted as a public mission of structural innovation, in line with the methodology proposed by Mazzucato, Kattel and Ryan-Collins (2019). To guide this transformation, the proposal is to adapt the ROAR framework, which comprises four key components: direction routes, institutional organization, evaluation and dynamic tools, and risk and reward sharing.

Firstly, the dimension of Routes implies clearly defining an ambitious and transformative mission that guides energy policy beyond correcting market failures. In this case, the mission can be formulated as ensuring equitable and sustainable access to distributed solar energy for the country's most vulnerable households, by means of the progressive redesign of the residential electricity subsidy. This strategic direction requires giving up a passive logic based on reduced tariffs, to move towards a logic of investment in durable assets, energy efficiency and territorial justice. The mission should be explicitly integrated into national planning instruments, such as the National Development Plan, the PRODESEN, and the energy transition commitments assumed by Mexico within the framework of its climate goals.

As for institutional Organization, the success of the mission requires a multilevel, coordinated and adaptive governance architecture. The Federal Government, through SENER, SHCP and CFE, assumes the strategic leadership, normative regulation and financial articulation of the program. State and municipal governments play key roles in territorial implementation, identification of beneficiaries and promotion of social acceptance. Development banks operate as fiduciary agents and financial structuring elements, while the private sector participates in the provision of equipment, installation and maintenance, under technical standards and competitive processes.

The creation of a specialized executing unit within the federal trust fund is proposed, responsible for coordinating the technical operation of the program and reporting progress to the high-level Technical Committee, with inter-institutional representation.

From the perspective of Assessment and measurement, the ROAR approach proposes the need to go beyond the traditional metrics of physical coverage or budgetary efficiency, incorporating dynamic and multidimensional indicators. The evaluation of the program should consider impacts in terms of distributional equity by income level and territorial location, fiscal savings compared to the traditional subsidy scheme, net environmental effects derived from clean generation, and social perception of the value delivered. It should also capture the strengthening of national industrial capabilities connected to the photovoltaic value chain. The integration of simulation and modeling tools, adapted to the energy sector, would make it possible to anticipate structural impacts and improve decision making.

Finally, in relation the distribution of Risks and Rewards, the policy should ensure that the economic and social benefits derived from the program are distributed fairly, and that operational and financial risks are managed in a shared basis. The proposed strategy is based on using the public resources already allocated to the subsidy as a source of payment, avoiding new fiscal pressures. However, the complementary participation of private financing and multilateral organizations is also envisaged, providing guarantees and risk capital on preferential terms. At the social level, the program should ensure that beneficiary households do not face an increase in their electricity costs, and receive a tangible asset that improves their well-being and resilience. To this end, it is necessary to define clear rules on system ownership, maintenance obligations, valuation of injected surpluses and sanction mechanisms for non-compliance. Likewise, a comprehensive communication and energy education strategy will be essential to strengthen the program's political legitimacy and foster citizen ownership.

Taken together, the ROAR framework provides a robust conceptual guide for structuring a mission-driven energy policy. Its application to the redesign of the residential electricity subsidy in Mexico offers a concrete way to move towards a more equitable, resilient and sustainable development model.

1.3. Studies required for implementation

This report is a proof of concept: an exploratory analysis that demonstrates the technical, fiscal and distributional feasibility of redesigning the residential electricity subsidy through the delivery of photovoltaic home systems. However, its conceptual nature implies limitations that must be addressed before moving towards an enforceable public policy. The effective implementation of this program requires a series of additional, more detailed and multidisciplinary studies that delve into strategic, technical, financial, regulatory and social aspects. The following are five key studies that must be developed to move from a conceptual proposal to a comprehensive implementation strategy:

A. Strategic planning and territorial deployment: Design a detailed implementation plan for the program at the national level, including geographic prioritization criteria, expansion schedule and realistic estimates of progressive coverage.
   a. Identification of priority areas according to electricity stress, energy poverty, technical feasibility and proximity to industrial poles
   b. Simulation of deployment routes (low, medium and high penetration)
   c. Evaluation of synergies with other sectoral and territorial policies
   d. Proposal of indicators and short-, medium- and long-term goals

B. Technical and operational feasibility: Evaluate the technical feasibility of the program in different contexts, anticipate impacts on the electric grid and define standards, protocols and operational requirements.

   a. Ex-ante analysis of the impact on distribution and transmission networks
   b. Identification of complementary investment needs in electric infrastructure
   c. Definition of technical standards and protocols for installation, interconnection and maintenance
   d. Exploration of the potential role of emerging technologies such as battery storage and smart grids

C. Financial viability and risk structure: Simulate the complete financial operation of the scheme, identify critical risks and design stabilization, monitoring and adjustment mechanisms.
   a. Modeling of financial flows over time
   b. Detailed calculation of operating and institutional costs
   c. Evaluation of guarantee mechanisms, reserves and contingency coverage
   d. Design of early warnings, internal audits and financial governance schemes

D. Legal and regulatory feasibility: Analyze the current legal framework, identify the necessary adjustments and propose a progressive regulatory strategy to make the program feasible.
   a. Review of applicable budgetary, regulatory and contractual rules
   b. Evaluation of legal requirements to redirect subsidies and set up the trust
   c. Proposal of enabling instruments (decrees, agreements, secondary reforms)
   d. Legal support strategy during implementation

E. Environmental, social and governance impact: Evaluate the environmental and social effects of the program, and design mechanisms to maximize community benefits and ensure inclusive governance.
   a. Estimation of net environmental impacts (emissions reduction, material footprint)
   b. Territorial, gender and accessibility equity analysis
   c. Design of mechanisms for citizen participation, transparency and accountability
   d. Assessment of alignment with international ESG standards (e.g., climate financing)

These studies are part of the bare minimum necessary to ensure a solid, coordinated and legitimate implementation of the program. Its development should be parallel to the institutional and financial design of the pilot program, and serve as a key technical input for its progressive escalation.

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