

Increasing Access to Grid- Tied Distributed Photovoltaics for Low-Income Populations: Considerations for Developing Countries

Governments around the world are under immense pressure to promote inclusive economic growth, reduce budget deficits, and promote sustainable development goals. In developing countries, such goals may potentially be addressed through public policy approaches to encourage the use of distributed photovoltaic (DPV) systems¹ among low-income electricity customers.²

At the same time, low-income customers face numerous barriers to DPV deployment, including lack of access to capital and financing, lack of awareness about the technology, lower levels of homeownership, and insufficient economic incentive because of lower retail tariffs, among others. As a result, low-income customers are often the least likely in developed and developing countries to deploy solar [1].³ Not only do lower income customers face barriers to adoption, under some tariff designs and regulatory frameworks, they may potentially cross-subsidize

solar installed on the roofs of higher income households (see “What is Cross-Subsidization?”).

However, under the right conditions, low-income grid-tied DPV programs can offer beneficial outcomes for governments, customers, utilities, and the environment, enabling a “just” clean energy transition. The concept of distributive energy addresses the distribution of benefits and burdens of the energy system and considers whether the burdens disproportionately affect historically marginalized communities.⁴ In practice, few such low-income DPV policies and programs exist in the developing world, but there is increasing interest in this topic and a need for replicable and scalable pilot projects and programs.

This brief informs decision makers in developing countries as they explore ways to promote equitable access to solar energy in their communities. We provide an overview of the drivers of low-income solar programs, typical program design approaches, and several case studies of how low-income DPV programs have been implemented around the world as well as guiding questions to assist in designing a low-income DPV policy or program.

How Are Low-Income DPV Programs Beneficial?

Low-income DPV programs can serve customers and society in numerous ways. For one, they can more equitably expand access to solar and, by doing so, build broader support for clean energy transitions. If more low-income households

What is Cross-Subsidization?

Cross-subsidization refers to the phenomena in which one set of customers pays into the electricity system an amount of money that is less than the cost incurred by the utility to serve them, which in turn leads to one or more sets of customers paying more than their cost-of-service to make up the difference. Cross-subsidization is common within and between rate classes—a practical necessity of ratemaking, given that each unique customer has their own unique cost-of-service. In the context of DPV, cross-subsidization occurs when customers adopting DPV reduce their financial contributions to the power system below their cost-of-service, leaving non-adopting customers to make up the difference with increases in electricity tariffs.

adopt DPV, the benefits will be spread more evenly across all ratepayers.⁵ Moreover, low-income DPV programs, especially when paired with energy efficiency interventions, can reduce the energy burden for low-income customers by reducing their share of income dedicated to energy expenses. Low-income DPV programs can also be a means for repurposing ongoing electricity subsidies. Many developing countries provide electricity to low-income customers free of charge or heavily subsidized to cover basic needs. A low-income DPV program can redirect ongoing subsidies into direct DPV investment subsidies with the goal of reducing electricity subsidies over time.

1. Distributed PV systems are connected to the distribution system of an established, centralized utility system, smaller in scale, typically connected “behind the meter” of a retail electricity customer, and typically, but not always, owned or operated by a distribution utility.

2. The definition of low-income varies by country and region. See Table 1.

3. Either standalone rooftop systems or shares of jointly owned, shared, or “community” solar arrays.

4. Other aspects of energy justice include Procedural and Restorative Justice, see [2].

5. However, DPV adoption by lower income households will not reduce potential cross-subsidies from nonadopters to adopters. Nonetheless, at low levels of DPV deployment, this issue is minimal and part of the broader “cross subsidization” at play with general ratemaking.

How Are Low-Income DPV Programs Typically Designed?

Low-income DPV programs typically take one of the following two approaches:

- Increasing credit and financing options to low-income communities for DPV installation

- Providing direct incentives that subsidize all or part of the cost for a DPV system or a share of a community solar system.⁶

In either approach, policymakers must consider how a low-income DPV program will be funded (e.g., ratepayer funding, existing government funds, a development

bank, or private investment) and the pros and cons associated with each of these funding pathways. Other program design factors, such as eligibility, should also be considered (see **Table 1**).

Table 1. Considerations for Designing a Low-Income DPV Policy or Program

<p>What would the eligibility criteria be for a low-income solar program? What qualifies a customer as “low-income”?</p>	<p>The definition of “low-income” can vary by jurisdiction:</p> <ul style="list-style-type: none"> • Percentage of income—in the United States, the definition is determined by the household income relative to the region’s median income or percentage of the federal poverty limit. • Residential or agricultural rates—in terms of rate class, low-income customers will typically be residential-sector and, sometimes, agricultural-sector ratepayers. However, there can be income variation within each of these customer classes, so policymakers may want to target a subset of a sector. • Low-income or lifeline rates—in some cases, there are already low-income classes (e.g., “lifeline” customers). DPV policy could make use of these special rate classes to streamline verification processes. Some low-income solar programs target customers that already receive government assistance (e.g., electricity subsidies) to reduce other streams of government-supported energy assistance.
<p>How much of a subsidy is needed for low-income households to adopt solar?</p>	<p>Understanding the level of financial assistance that is sufficient for a low-income household to adopt solar informs program and incentive design.</p>
<p>How can low-income DPV be paired with efficiency programs to result in meaningful energy burden reduction?</p>	<p>Energy efficiency and DPV, together, can reduce customer electricity consumption and costs.</p>
<p>What consumer protections are needed to ensure low-income customers are not sold inferior products?</p>	<p>Low-income customers can be unfamiliar with solar products and are often the target of scams and exploitation, making strong consumer-protection measures critical for this population.</p>
<p>Where do low-income customers typically live (e.g., single-family versus multifamily home, rented or owned property) and are buildings suitable for DPV (e.g., roof structure, orientation)?</p>	<p>These characteristics may influence whether an individual rooftop DPV program or community-based shared solar program is more appropriate.</p>
<p>Can a low-income solar program involve large corporate consumers or other entities in supporting low-income communities?</p>	<p>Large corporations and other large energy users may collaborate on DPV projects that benefit low-income customers. These “anchor tenants” can subscribe to a large portion of a community solar project, de-risking the project.</p>
<p>Can low-income solar programs target customers that are most highly subsidized (e.g., residential, low-income, agricultural) in a particular region?</p>	<p>A low-income DPV program can target those who already receive electricity subsidies, converting ongoing subsidies into a one-time DPV investment subsidy.⁷ It is important to explore how customers are subsidized (e.g., by other ratepayers, the state, or both) and how to secure upfront financing.</p>
<p>Is community solar an appropriate model to benefit low-income communities?</p>	<p>Community solar, also known as shared solar or solar gardens, is a DPV deployment model that allows customers to buy or lease part of a larger, offsite, shared solar PV system [3].</p>

6. Sometimes, access alone is sufficient to increase low-income solar adoption because customers can subscribe to small amounts of DPV while taking advantage of the economies of scale.

7. It is important that a solar program not be used to move unsubsidized customers into a subsidized rate. A large energy consumer could install DPV capacity to bring that customer down to a subsidized rate, which increases the burden to the utility.

Low-Income DPV Programs from Around the World

The following case studies demonstrate how low-income DPV programs have been implemented in three countries. These examples demonstrate how low-income DPV programs aim to expand the benefits of solar to low-income communities, reduce their energy burden, and reduce existing government energy subsidies.

Mexico: The “Solar Bonus” To Reduce Total Net Energy Consumption and Government Subsidies

In Mexico, the central government’s Secretariat of Finance and Public Credit heavily subsidizes electricity rates for low-use residential and agricultural customers, creating a financial strain on the national budget and reducing the economic attractiveness of customer-sited solar. Subsidized electricity tariffs are paid by 98% of residential users; on average, they pay 46% of the cost of electricity service. These residential electricity subsidies represent approximately 0.4% of Mexico’s GDP [4]. The proposed “Solar Bonus” [5] mechanism developed by the nongovernmental organization Iniciativa Climática de México (ICM) would provide an upfront financial incentive to customers to install a DPV system to reduce their total net energy consumption with the aim of deploying clean energy, reducing low-income energy burdens, and reducing subsidy payments by the central government. The subsidized customer would still pay an electricity bill, but at a fraction of the cost of their original bills. Essentially, the central government of Mexico would repurpose existing electricity subsidy funding and instead supply that funding upfront for the rollout of DPV systems. According to a study conducted by ICM, avoided monthly electricity subsidy payments would pay back the initial Solar Bonus capital expenditure in approximately 7 years. This concept has not been implemented to date, largely due to challenges securing funding for the upfront incentive.

India: States Experiment with Low-Income Solar Pilots [6]

The Indian state of Andhra Pradesh has two programs dedicated to encouraging rooftop solar adoption among low-income, subsidized domestic consumers whose consumption is between 100 and 200 units of electricity a month. The state distribution utility, Eastern Power Distribution Company of Andhra Pradesh Limited, has proposed one customer-owned rooftop model using net metering and a second developer model using gross metering. Both models were approved by the state regulator in 2020 [7]; implementation began in mid-2021 [8].

Under the customer-owned/net-metering model, the distribution company (DISCOM), on behalf of participating customers, organizes bulk purchasing of PV systems, negotiates with and selects a vendor, while also facilitating access to financing (i.e., bank loans) for the 70% of the capital cost that remains after 30% is covered by capital financial assistance offered by India’s Ministry of New and Renewable Energy. The DISCOM collects monthly loan installments directly from the customer, along with the monthly utility bill, and remits that payment to the bank. By playing this facilitator role, the DISCOM aims to remove barriers to financing and selection of qualified solar installers.

Under the developer/gross-metering model, the DISCOM competitively selects a developer to supply power for 25 years to the DISCOM; customers would be financially compensated for leasing their rooftop space.

United States: Subsidies To Increase Efficiency and Lower Energy Bills

In the United States, federal and state governments manage programs that have been leveraged to deploy solar for low-income populations. Implementation can vary widely by state. Some programs include:

Low-Income Home Energy Assistance Program (LIHEAP)

LIHEAP distributes federal funds to states and federally recognized tribes to help eligible families with costs associated with home energy bills, energy crises, and weatherization. For example, in 2010, California used \$14.7 million in LIHEAP funds, combined with other funding sources, to install nearly 1,500 PV systems on low-income single and multifamily housing as part of its Solar for All California pilot program [9]. Evaluations of the program estimate that low-income households saved from 26%–86% on energy bills after the installation of PV through this program [10].

Weatherization Assistance Program (WAP)

Similarly, WAP, a federal program, enables low-income families to permanently reduce their energy bills by making their homes

more energy efficient. Weatherization improvements (e.g., weather stripping, heating and cooling system upgrades, and insulation) are free for eligible program participants provided they pass a cost-effectiveness test. Some states, such as California and Colorado, draw upon WAP funds (often in conjunction with LIHEAP and other funds) to deploy solar installations for eligible customers at no cost [11]. Other states generate funds for low-income solar programs through dedicated utility bill charges for customers.

Community Solar

States are addressing low-income customer access to solar through community solar programs—a business model in which multiple customers own a portion of a large, offsite solar project and receive bill credits for their share of solar generation virtually (for more information, see NREL’s Community Solar website). In some cases, states require community solar to serve low-income households [12].



Photo by Werner Slocum, NREL 65601

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USAID and NREL are interested in supporting partner countries to develop and evaluate low-income solar programs as part of the technical assistance offered via the Distributed PV Toolkit. If you are interested in partnering, please contact: slawson@usaid.gov.

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