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Incorporating energy justice into utility-scale photovoltaic deployment: A policy framework

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ABSTRACT

Utility-scale photovoltaic (PV) installations made up 77 GW (6%) of installed capacity in the United States, as of the end of 2021 [1,2]. This will grow to more than 500 GW by 2050 under a mid-case projection or more than 800 GW if solar costs decline more rapidly [3]. While utility-scale PV is projected to grow rapidly, to date, unlike energy efficiency or distributed PV, utility-scale PV has not been used to provide substantial financial benefits to underserved communities, either through ownership, financing of assets, or direct electricity bill reduction.

We assess two mechanisms through which utility-scale PV could benefit underserved communities. We find that while a framework for direct electricity bill reduction can be meaningful to customers, this mechanism falls short of providing restorative justice via wealth creation for minority-owned businesses. In contrast, we find that a framework for procurement of utility-scale PV by public and private entities from PV projects that are financed, owned, and/or developed by minority-owned businesses can provide this restorative justice benefit, and thereby facilitate an equitable energy transition. We conclude with concrete recommendations for new policies and programs to ensure that the benefits of utility-scale PV systems are distributed to underserved communities.

Introduction

Utility-scale photovoltaic (PV) installations made up 77 GW (6%) of installed capacity in the United States, as of the end of 2021 [1,2]. This will grow to more than 500 GW by 2050 under a moderate cost decline projection, or more than 800 GW if solar costs decline more rapidly [3]. Utility-scale PV projects interact with communities in many ways, including, project siting, and the provision of direct electricity bill-reduction benefits. Because of these direct effects, the growth in utility-scale PV provides an opportunity to address energy justice.

Research on the distribution of benefits from other types of solar deployment has focused primarily on distributed PV and community solar [4,5,6]. Across the distributed PV and community solar domains, researchers have identified inequities in terms of solar access. For example, in the distributed PV market, even when controlling for household income and home ownership, majority-white census tracts have installed more distributed PV than Black- and Hispanic-majority census tracts [4]. Similarly, Barbose et al. 2021 found that in 2019 the median income for households that adopted solar was $113k, compared to $64k for all households [5]. In California, Lukanov et al 2019, found persistently lower levels of distributed PV adoption in the state's disadvantaged communities [7]. Finally, research on community solar policies and programs found that while more than 20 states have a policy to provide incentives or mandates for community solar to subscribe low- and moderate-income consumers, to date, these programs have provided only a small fraction (<1%) of the total community solar market [6]. To date, little is known about how utility-scale PV projects can provide financial benefits to disadvantaged communities.[1] The anticipated increase in utility-scale PV deployment provides an opportunity to both anticipate and mitigate potential disparities and disproportionate impacts, as well as create wealth and economic benefits in historically marginalized communities.

Utility-scale PV differs from other solar deployment types in that individual households do not, as currently structured, receive direct benefits from project deployments, as in the community solar market where individual households can receive a credit on their electricity bill. Nor do households own utility-scale PV, like

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[1] In this paper, we refer to "utility-scale" PV to mean PV projects that are not connected behind a customer's meter. These projects are ground-mounted systems usually above 5 MW.

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they might a distributed PV system, and thereby receive all the direct bill savings benefits. The primary financial benefits of installing utility-scale PV accrue to 1) project developers and financiers, 2) the entire class of ratepayers, and 3) utilities with shareholders that are allowed to own and earn returns on generation assets. Another important distinction between the utility-scale PV market and other solar deployment is the scale of investment needed. For utility-scale PV, profits on hardware, installation labor, construction, and developer overhead are estimated at 5% for a 100 MW PV system and 8% for a 5 MW PV system [8]. At $1/watt, this means that a 100 MW PV system would cost $100 million, and the profits would total $5 million. Similarly, a 5 MW PV system at $1/watt would cost $5 million, and the profits would total $400,000. Directing these profits to companies that represent underserved communities could have enormous impact, given the scale of anticipated investments in utility-scale PV.

With respect to distributional impacts, scholars have highlighted the potential of utility-scale wind development to adversely impact indigenous communities and other marginalized groups [9]. In this way, the potential challenges of utility-scale PV resemble the challenges that utility-scale wind development has encountered internationally. In essence, these types of projects require a substantial footprint, and therefore may give rise to siting and other social and environmental concerns. Utilizing an energy justice-focused approach to utility scale PV development, which engages communities in every aspect of project development, and which also provides significant opportunities for community-based economic impact, can mitigate some of these concerns [10].

This paper will focus on the distributive and restorative energy justice components of utility-scale PV (Table 1).[2] Distributional energy justice considers the equitable distribution of the benefits and costs of the energy system. Restorative energy justice focuses on rectifying the injustice that has occurred because of previous energy decision-making [11–13]. Restorative energy justice has been explored in the context of energy efficiency and weatherization; Lewis, Hernández, and Geronimus (2021) argue that weatherization and energy efficiency upgrades are needed to address the history of racist policies that have led to poor housing conditions among African Americans [14]. These energy justice aspects of utility-scale PV adoption are unexplored in the existing literature [15].

Procedural and recognition justice in the creation of solar policy has been studied (Si and Stephens 2021) found that low-income households were underrepresented in regulatory processes in the state of Massachusetts [16].

This paper makes three novel contributions to the literature:

1) Describing the equity potential of utility-scale PV deployment;
2) Establishing a framework to understand the ability of utility-scale PV to benefit underserved communities through ownership structures, direct bill reduction, job creation, and other tangible financial benefits; and
3) Providing case examples and recommendations on policy and program changes to enable equitable deployment of utility-scale PV.

Utility Bill Reduction via Utility-Scale PV Programs

Equitably distributing the benefits of utility-scale PV should include consideration of how disadvantaged populations can receive financial savings from those projects. Customer bill savings comprise one component of a range of pathways to equitable distribution of benefits. Other pathways include, among other things, ownership of projects, control of where projects are sited, and local job creation for underrepresented groups.

[2] Not addressed specifically in this paper is the role of procedural or recognition justice in the deployment of utility-scale PV. We leave this topic for future research.

Table 1
Energy Justice Principles and Applications for Utility-Scale PV.

	ENERGY APPLICATION	UTILITY-SCALE PV APPLICATION
DISTRIBUTIVE JUSTICE	Equitable allocation of benefits and burdens	**Minority/diverse business** participation in the utility-scale PV industry Consumer bill discounts or other **financial compensation for** utility-scale PV
RESTORATIVE JUSTICE	Addresses issues of past harms	**Wealth creation** via ownership or financing of utility-scale PV assets
PROCEDURAL AND RECOGNITION JUSTICE	Fair access to process and acknowledgment of and respect for all peoples	Disadvantaged communities engaged with project **siting** decisions and creating **new utility program designs**

Source: Adapted from [9,13].

Utility bill reduction programs for low-income consumers are not new. The federal government has supported reducing low-income electricity bills, through the Weatherization Assistance Program (WAP) and the Low-Income Home Energy Assistance Program (LIHEAP), for decades [17]. WAP provides savings through energy efficiency measures, with average investments of $4,695 per household and $283 in annual energy cost savings. Energy cost savings are through both heating and electric, with electric savings at 7%, on average, and heating savings at 15% [18]. LIHEAP was authorized to spend $8.25 billion in Fiscal Year 2021, primarily to pay energy bills of low-income households [19]. This section reviews how policymakers, regulators, and utilities could use utility-scale PV to provide bill savings to disadvantaged customers.

Historically, bill savings opportunities from solar have been limited to rooftop PV systems. Rooftop PV can provide customer savings, under certain market conditions. Sunrun, a residential solar service provider operating in in 22 states, Washington D.C., and Puerto Rico, serving more than 500 thousand customers, notes that average customer first year savings from rooftop PV range from 5% to 45%. Typical contracts are for 20 or 25 years and have an annual increase of 2.9% [20].

Newer community solar programs also offer bill savings to subscribers, and community solar subscriptions have had a positive net present median value since 2016. In 2020, for example, the median net present value was $0.26/W, which suggests an overall economic benefit to community solar participants [21]. The addition of state policies providing credits for community solar and/or low-income access of community solar can result in greater bill savings for customers. Low-income customers in Massachusetts could reduce their energy burden from 16.5% to 13.3% (Figure 1), an estimate that accounts for the state's incentives for both community solar and low-income subscriptions [21]. On an electricity-only basis, annual estimated savings to low-income subscribers are about 35% (reducing annual electricity expenditures from $1,180 to $770). State incentives provide added value to low-income customers (at or below 60% of area median income).

Note: LI means "low income". The LI adder applies to income brackets 0-60% of Area Median Income. CSS means "community shared solar".

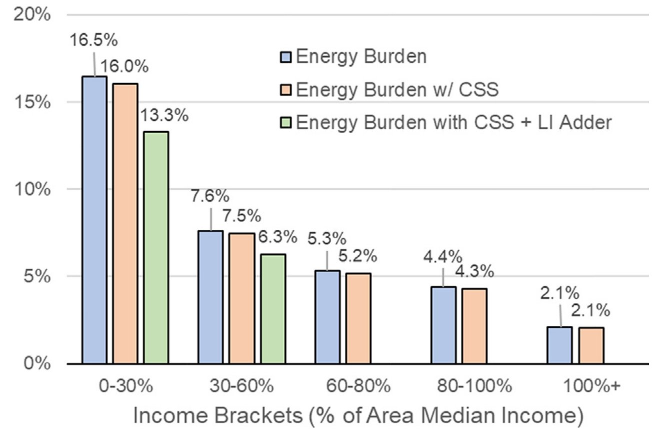

Fig. 1. Modeled Energy Burden Reduction by Community Solar in Massachusetts

Bill savings from existing efficiency and PV programs are summarized in Table 2. These programs demonstrate that, even providing additional incentives for LMI customers, customer savings are not higher than 45%, meaning that some LMI customers may still have a higher-than-average energy burden. Sections 2.1 and 2.2 will describe ways that utility-scale PV could provide bill savings, however, we conclude that these levels of savings are not enough to provide restorative justice to LMI or other disadvantaged populations.

Dedicated Low-Income Solar Access Ratepayer Programs

Dedicated solar access ratepayer programs can provide tangible financial benefits to low-income ratepayers, at a similar scale to existing weatherization efforts. Similar to community solar projects, these efforts can provide on-bill benefits to customers. In 2019, Imperial Irrigation District, a public power utility providing electricity to more than 150,000 customers [22] in southern California, created a solar program dedicated to providing bill reductions for its low-income electric customers. The program will serve more than 12,000 customers (about 8% of its total customers). The program will source from a 30 MW solar facility, developed by Citizen's Energy under a 23-year power purchase agreement with Imperial Irrigation District.

The savings achieved by purchasing utility-scale PV will be passed on directly to all of the utility's income qualified electric customers, via an additional discount on their electric bill. The utility touted the program as one that can "reach thousands more customers" than their rooftop PV program [23].

Florida Power & Light, an investor-owned utility, launched its SolarTogether program in 2021. While marketed as a "community solar" program, the program sources from utility-scale PV projects nearly 80 MW in size, above what many consider to be "community-scale" in nature [24]. None-the-less, the program provides 37.5 MW of capacity reserved for about 10,000 low-income customers. As of August 2021, the program was fully subscribed. Low-income customers are estimated to save about $1,300 each over the life of the program and will never pay more for their subscription than the credits they receive [25].

Community Benefits Programs

Providing bill credits to residents located near utility-scale projects has not historically been implemented; however, New York's Accelerated Renewable Energy Growth and Community Benefit Act of 2020 requires that the Public Service Commission (PSC) consider a "Host Community Benefit Program". The Program will provide

Table 2
Summary of Bill Savings Opportunities for Low- and Moderate-Income Customers in the United States.

PROGRAM TYPE	ELECTRICITY BILL SAVINGS	DETAILS
LMI ENERGY EFFICIENCY	7%, on average	Electric savings resulting from investments by the U.S. Department of Energy's Weatherization Assistance Program [18]
ROOFTOP PV (ALL CUSTOMER TYPES)	5% to 45%	Range of customer savings from installer Sunrun [20]
LMI COMMUNITY SOLAR	35%	Estimated savings from a targeted low-income community solar program in Massachusetts

direct bill credits to utility customers in communities that host utility-scale wind and solar projects. The Act clearly defines ratepayers as program beneficiaries and not entities like city governments.

New York PSC's final order determined that for utility-scale solar projects, developers will pay $500/MW for a period of ten years. The funds will be disbursed by the utilities to residential ratepayers located in the community where the project is sited, minus a 0.5% administrative fee. The Order made clear that the funds will go to residential ratepayers only, under the theory that they are the ones living by the utility-scale project and therefore deserve the compensation [26].

The amount of compensation per ratepayer will thus depend on the number of residential ratepayers located near the utility-scale solar project. The geographic region is defined as the town(s) or city(ies) where the project is located. Some stakeholders suggested a mile radius definition, but utilities were concerned that they could not automate a billing process using this definition. As an example, the median city population in New York State is 2,818. Using this median population figure, a 50 MW solar project would provide residential customers an $8.87 annual benefit (or $0.74 per month), for 10 years.

Recommendations

To increase opportunities for utility-scale PV programs to benefit underserved communities, including low-income households and environmental justice communities, policymakers, regulators, and utilities can turn to existing examples of low-income support programs. These exist both in the electric sector, as described, but also in other areas such as water utilities. For example, the City of Philadelphia piloted an income-based billing program for water, wastewater, and stormwater services. The program provides a targeted assistance program that charges customers a predictable amount each month, based on their household income, ranging from 2% to 4% of total household income [27].

Moreover, how customers are compensated for utility-scale PV on their bills will greatly influence the level of savings that a utility-scale PV program will provide. For example, rooftop PV and community solar typically credit customers at a retail rate or a value of solar rate. An equitable utility-scale PV bill credit program would take into account the full range of benefits (for example, environmental, social, reliability benefits) provided by the project and credit rate payers accordingly.

Regardless of how bill credits are handled, because bill savings from utility-scale PV is likely to be limited to a portion of a consumer's electric bill, the savings will not be enough to address historic energy injustice. To provide greater energy equity from utility-scale PV, efforts can be taken to pair utility-scale PV programs with other programs related to energy efficiency and weatherization. For example, in Colorado, a program providing community solar to low-income households required that the home first be weatherized, or if it had no, then apply for future weatherization services [28].

Asset Ownership and Financing of Utility-Scale PV

To provide greater savings, utility-scale PV programs could also be paired with programs to address the larger inequities in the solar market concerning asset ownership and financing. The existing system of ownership and finance for utility-scale PV provides an unequitable distribution of the financial benefits of utility-scale PV. This is driven by the way that systems are typically financed in the United States. Projects are financed via a mix of debt and equity, and reliance on the federal investment tax credit, which provides a 26% tax credit for utility-scale PV systems. Most projects rely on tax equity financing, where tax equity partner will take a portion of an equity investment in exchange for the right to claim the tax credits [29]. The tax equity market consists of large players, for example banks and public corporations. Wealthier individuals mostly likely benefit from investments in public companies, in fact, more than 80% of all U.S. stocks are owned by the wealthiest 10% of the population [30].

Alternative ownership and finance structures exist but have not been widely used. For example, public utilities and electric cooperatives, where the ratepayers also own the utility, could provide more equitable ownership of renewable energy assets. However, in the U.S., investor-owned utilities provide the bulk of electricity services to U.S. customers [31]. In addition, as publicly held business entities and non-profit entities, these utilities cannot benefit directly from the federal investment tax credit; they forgo the credit or work through a third-party developer who can take the investment tax credit. The predicted scope and scale of utility-scale PV development in the United States provides an opening to explore alternative business models and approaches to development that broaden the spectrum of benefits available to non-traditional market players, such as public power providers, electric cooperatives, and community-based organizations.

In this section, we focus on how existing ownership and finance structures could be reformed, while acknowledging that more work could be done to create new ownership and finance structures. We present case examples in Sections 3.1 and 3.2 of projects and policies. These programs can grow the pool of minority business enterprise (MBE) developers in their markets, ultimately creating companies that can expand to markets that do not offer a program dedicated to MBE development. We provide examples of both public sector (state and national) and private sector procurement designs (Table 3) which vary in their scale, timing considerations, and flexibility.

Table 3
Procurement Considerations for Public and Private Sector Support for MBE Utility-Scale PV Deployment.

PROCUREMENT CONSIDERATION	PUBLIC SECTOR	PRIVATE SECTOR
SCALE OF PROCUREMENT	Large (GWs)	Small to Medium (100s of MW)
TIMING TO DEVELOP PROCUREMENT	Slow to develop new regulations	Fast to implement a new program, with corporate leadership support
FLEXIBILITY TO CONSIDER NON-FINANCIAL PURCHASING CONSIDERATIONS	Limited by legislation	Limited by corporate leadership
EXAMPLES	Renewable Independent Power Producer Program (South Africa) Offshore wind procurement (Maryland, U.S.)	Environmental justice power purchase agreement (PPA) (Microsoft)

Private Sector Support for Minority-Owned Businesses ("Energy Justice Power Purchase Agreement")

Corporations are large purchasers of solar power to meet their sustainability, carbon reduction, and cost savings goals, and can leverage their private sector dollars to support a more equitable energy future. In 2020, the contracted utility scale solar pipeline was 69.3 GW, with corporations representing 19% (13.2 GW). Other large non-investor-owned utility purchasers of power generated from utility-scale PV included cooperatives (7%, 4.9 GW) and community choice aggregations and municipal utilities (17%, 11.8 GW) [1].

Corporate purchasers are beginning to purchase renewable energy in ways that go beyond buying the cheapest option. Historically, corporate purchasers were involved with creating renewable energy certificates (REC), which allows for verification that purchasers are receiving the environmental attributes of renewable energy. REC purchases, particularly when purchased separately from the underlying electricity ("unbundled"), have been viewed with skepticism by some stakeholders, particularly when unbundled REC pricing was very low [32]. Corporate purchasers continue to evolve their purchasing strategies, with a focus on lowering cost and providing additional "value" [33]. Developers are also tackling more questions related to corporate sustainability goals of environmental impact, jobs creation, social justice, and employee diversity [1].

Corporate purchasers have more flexibility than governments to create unique purchasing structures to accelerate equity. In 2021, Microsoft signed an agreement with Volt Energy, a national African American owned solar PV development company, what they term an "environmental justice power purchase agreement." Microsoft contracted for 250 MW of solar PV. The Microsoft and Volt Energy agreement is unique in that: 1) it sources renewable energy developed by a minority-owned business and 2) a portion of the profits will be used to develop renewable energy projects in underserved communities [34]. While data on the status of minority-owned solar developers does not exist, SEIA notes that in 2019, 88% of senior executives are white and 80% are men [35]. Additionally, it has been noted that Black ownership of any kind of clean energy business is low [36].

While corporate purchasers are not setting public policy, they can use their procurement power to create a new market for MBE developers. These developers would then be positioned to take advantage of public sector programs (Section 3.2) that may have greater ability to scale investment.

Public Sector Support for Minority-Owned Businesses

Public sector actors can also support MBEs through their renewable energy auctions or other renewable mandates. In many countries and states, renewable procurement is conducted through a centralized approach, with governments determining bidder qualifications and selection criteria. Through this process, governments can insert their policy priorities into procurement action. For example, in the United States, the Bipartisan Infrastructure Law (H.R. 368), established a clean energy demonstration program for clean energy projects on current and former mine land. The Law directs the Department of Energy to select projects based on a number of criteria, including creation of the greatest amount of jobs and economic development in distressed areas.

There has been a history of policy-oriented renewable energy procurement in South Africa, Europe, and more recently, through off-shore wind procurements in the United States. In some cases, governments have set aspirational goals, while in other cases, minimum thresholds for MBEs have been established. While not all procurements explicitly sourced utility-scale PV, a similar framework could be used for utility-scale PV.

South Africa developed the Renewable Independent Power Producer Program (REIPPP) in 2011 to facilitate competitive procurement of large-scale renewable energy from independent power producers. REIPPP increased the economic development considerations of a bid to 30% of the bid (70% based on price). Traditionally, procurement used weightings for 90% price and 10% economic development [37]. The economic development considerations include shareholding provisions targeted at Black ownership in the selling company, construction contractor, and operations contractor. The REIPPP used a staged approach to selection of bidders. First, qualification thresholds had to be met. The economic develop criteria were related to job creation, local content, ownership, management, preferential procurement, enterprise, and socio-economic development [38]. These criteria included more specific thresholds and targets for local content percentages (40-45% threshold and 65% target) as well as ownership by local communities (2.5% threshold and 5% target) and black people (12% threshold and 30% target).

In terms of success, for solar PV, the local content requirements included a minimum threshold of 45%, with a target of 65%. In the fourth round, the average bid for local content was 62.3%, closer to the target level than bids for all the other renewable energy target types and representing an increase from the first rounds, which saw average bids of 38.4%. Overall, while the economic development requirements were considered controversial and often confusing and expensive, the World Bank (2014) notes that the requirements also helped generate political support for the overall program [38].

In the United States, recent state offshore wind and community solar procurements have included conditions for sourcing from MBEs. In Maryland, the Skipjack and US Wind offshore wind procurements both included a memorandum of understanding for a good faith effort to target minority investors and create MBE participation goals [39].

Another pathway to advance equity for utility-scale PV deployment in the United States could be the expansion of electric cooperatives or municipal utilities into areas that are more diverse. Cooperative and municipal utilities are owned by their ratepayers. Because of this, community-owned utilities serving disadvantaged communities/minority communities will benefit community member owners. Member-owned utilities generally also have more procurement flexibility than investor-owned utilities. In California, Community Choice Aggregations (CCAs), which source the electric supply mix for their local communities, have focused on supplier diversity, including procurement and contracting, workforce development, use of local labor, and other provisions [40]. However, to date, supplier diversity efforts by the CCAs, do not include targeted procurement of renewable energy supply by MBEs.

Local Ownership: Future Research Directions

The discussion of community ownership is most prevalent in reference to distributed resources that supply small amounts of power or in reference to community-owned utilities (e.g. municipal, cooperative, and CCAs in the U.S.). Community ownership of utility-scale PV could enable greater economic benefits for community co-owners by facilitating the distribution of investment returns to community co-owners and facilitate local project control. Co-owned projects which are owned both by a community-based organization or entity and a corporate entity would allow for a project to receive tax credits, as provided under the existing tax code. These types of projects could foster distributive justice through greater distribution of economic benefits to community-based partners. Further, this structure could mitigate potential negative impacts resulting from project siting, while also limiting the transactional costs that can emerge from a lack of community support for a project. Additional research is needed to better understand the pathways to create utility-scale community ownership business models.

Recommendations

Private- and public-sector advancements can support MBE development, success, and scale in the realm of utility-scale PV deployment.

First, private sector support can accelerate MBE energy enterprise creation, so that when programs are created, there are enterprises ready to participate. Apple's Impact Accelerator was founded in 2021 supporting 15 Black- and Brown-owned businesses working in green technology and clean energy. The businesses will receive training and access to Apple experts and alumni [41]. In addition to private sector programs, federal programs also exist. The U.S. Department of Energy's Inclusive Energy Innovation Prize was designed to enable clean energy and climate innovation, and entrepreneurship programming and capabilities at colleges and universities that serve large populations of students underrepresented in STEM, Minority Serving Institutions (MSIs), community colleges, and undergraduate institutions. The prize also encourages increased participation in clean energy and climate-smart job training and job placement/hiring, including programs that target participation from disadvantaged communities, including formerly incarcerated individuals and youth transitioning out of foster care. The program will award 10 organizations $200,000 and select 2-3 of those organizations for an additional $500,000.

In order for both public and private sector program to be successful, they need to be designed in a way to support new applicants. Historically, new applicants have faced challenges accessing federal dollars. And while there are a large number of energy justice programs emerging in the United States, most of these programs are led by non-governmental organizations, suggesting that the U.S. governments (federal, state, and local) may not adequately be addressing energy justice [42]. Federal, state, and local programs should be designed with new applicants in mind, keeping applications short and specific, and providing support for application development.

Second, after enterprise creation is supported, the public and private sector can establish procurement policies to incentivize MBE ownership. Part of this should ensuring that MBE designation is not too onerous or time-consuming [43]. Further, to the extent possible, funding programs used to facilitate utility-scale PV development should include credit and financial terms that allow unique solutions for new developers [43]. This could be challenging for both the public and private sector; new designs may need to include an external organization providing guarantees. Finally, policies should, where possible, encourage participation by MBEs by dividing the contracted work into smaller pieces, thus allowing smaller businesses to participate [44].

Lastly, in the United States, where project finance is driven by the federal investment tax credit, making the tax credit refundable would open the market to entities that historically have not been able to access tax equity financing, such as not-for-profit entities and cooperatives. Advocates have made the case that making the federal investment tax credit refundable would allow nonprofit organizations, cooperative utilities, and others without tax appetite an easier pathway to utility-scale PV ownership [45].

Conclusion

The existing energy justice literature examines how renewable energy technologies could be used to create procedural, recognition, distributive, and restorative justice. However, this literature to date has lacked a focus on practitioner application [46]. This paper provides real world examples and applies energy justice solutions to the development utility-scale PV projects and how benefits can flow to underserved communities and businesses. The paper also outlines several interventions for both the public and private sectors.

Electric bill reductions represent an additional, more limited pathway to addressing energy justice in the utility-scale PV market. Given the limitations of providing ratepayer bill savings through utility-scale PV development, policymakers could design programs that are comprehensive and address energy justice issues through rate design, procurement, and creative project ownership models. This includes ratepayer programs that combine multiple value streams, such as efficiency, storage, and water-saving technologies, but also focus on wealth creation through support of MBEs.

Throughout the utility-scale PV value chain, numerous opportunities exist to create a more equitable distribution of project financial benefits. Prices for utility-scale PV include the costs of capital (project finance) as well as the costs of hardware, installation, labor, and contractors. A more equitable utility-scale PV future would include portions of these costs going to MBEs.

Additional research is needed to understand:

1) How equity in utility-scale PV programs could translate to equity in utility-scale wind deployment;
2) What legal or regulatory constraints might exist for public sector programs that create preferential purchasing from MBE companies; and
3) How new utility-scale PV ownership structures could create financial value to disadvantaged communities.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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