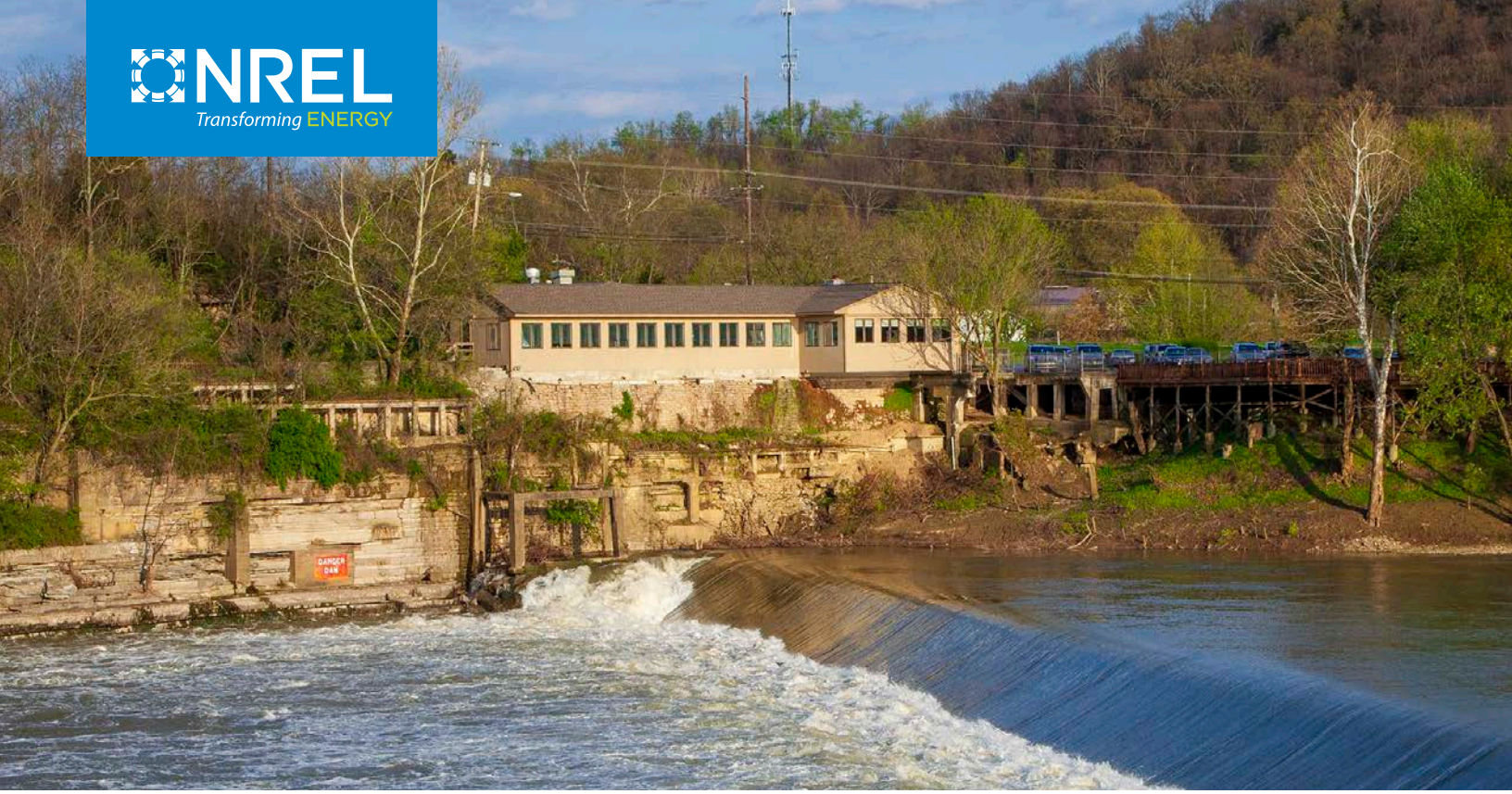

Photo from Gene Burch Photography

A Path to Clean Energy: Cross-Subsidization Concerns From Local Solar Development in Frankfort, Kentucky That Can Apply to Other Communities

Increased Interest in Local Solar Projects Among Municipalities and Public Power Utilities

Thanks to their ongoing cost decreases and technological progress, distributed energy resources (DERs), including renewable energy, have become financially attractive for municipal electric utilities, electric cooperatives, and their customers and members. Recently expanded federal tax credits increase opportunities for cities seeking to meet environmental and sustainability goals and take advantage of the grid and energy resilience benefits of locally sited solar and DER projects. One such city is the capital of Kentucky, the City of Frankfort.

In 2021, Frankfort's city council passed a resolution to meet 100% of city government electricity loads with renewable energy by 2023 and 100% of all customer electricity loads by 2030.[1]

To make progress toward these goals, the City of Frankfort has been working with the National Renewable Energy Laboratory (NREL) to study the feasibility of two distribution-tied, single-axis tracking solar photovoltaic (PV) projects that would together produce 11.54 MW_{ac}.

There are several additional drivers behind the push for solar in Frankfort, including rising electricity prices and a heavy reliance on aging coal infrastructure with an uncertain future.[2] New provisions under the Inflation Reduction Act of 2022 also make it easier for Frankfort—and similar communities across the country—to use federal tax credits to reduce the cost of developing local solar projects (see text box on Expanded Federal Tax Credits for Clean Energy Projects).

Expanded Federal Tax Credits for Clean Energy Projects

The Inflation Reduction Act of 2022 modifies and extends the federal tax credits for solar and storage projects:

- A 30% base investment tax credit (ITC) is available for qualifying projects that meet prevailing wage standards and workforce development requirements.
  - Production tax credits (PTCs) paid out for 10 years are available in lieu of the investment tax credit. PTCs are calculated based on the system's electricity production.
  - Most tax-exempt entities are expected to take the immediate ITC payment to defray upfront capital costs more immediately.
- In addition, several bonus tax credits (adders) may be stacked on top of the base credit, if qualified:
  - The Energy Community Bonus provides an additional 10% for projects located on a brownfield or an area with unemployment due to fossil fuel industry decline, or in a community with a coal mine closure after 1999 or retirement after 2009.
  - The Domestic Content Bonus provides an additional 10% for projects that use a qualifying percentage of steel or iron products that are mined or produced in the United States.[3]
  - The Low-Income Communities Bonus provides an additional 10% to small projects in communities designated as low- to moderate-income and on Native American lands; an additional 20% is available for low-income residential building projects or economic benefit projects. This bonus is subject to an annual cap nationwide.[4]

The elective pay (aka direct pay) provision within the IRA makes the above credits available to tax-exempt entities, which can help local governments, public power utilities, and nonprofit organizations develop local solar. See www.energy.gov/eere/solar/federal-solar-tax-credits-businesses for more information.

Although the analysis for Frankfort did not consider any IRA tax incentives, other NREL resources indicate how Frankfort can use federal tax credits to meet its resolution to be 100% renewable by 2030. The Screening Tool for Equitable Adoption and Deployment of Solar (STEADy Solar) overlays eligibility for the low-income and energy community tax credit bonus adders onto other data, such as solar economic potential and building counts, at a census tract level. Visit www.nrel.gov/docs/fy24osti/88243.pdf to learn more.

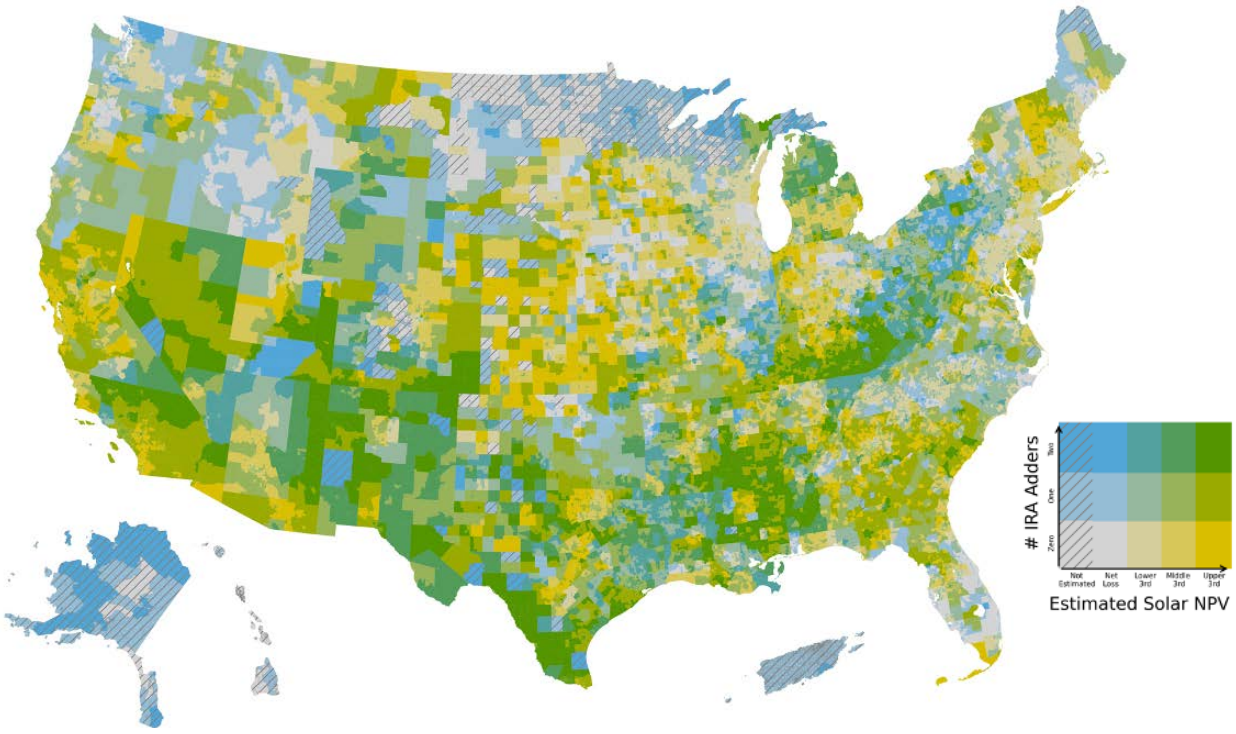

Figure 1. Clean energy projects may be eligible for a 30%–70% federal tax credit. The Screening Tool for Equitable Adoption and Deployment of Solar (STEADy Solar) shows eligibility for tax credits and solar economic data at the census tract level to help communities with solar siting decisions: Look up your community eligibility at data.nrel.gov/submissions/238. *Image by NREL*

Does Locally Sited Solar Lead to Cross-Subsidization?

Effective policymaking, equitable distribution, and stakeholder buy-in depend on understanding how the allocation of costs and benefits of a potential solar project are distributed across affected entities and stakeholders, including municipal utilities, power suppliers, and their customer bases. In some cases, the generation from a solar project may be designated for certain customers through a specific utility program. This gives rise to uncertainty around cross-subsidization, or how nonparticipating customers may be impacted by the utility offering such an option to only a subset of customers (see text box on Cross-Subsidization and Its Types).

In the case of Frankfort, the cross-subsidization question manifested in both a local and regional context: How would the development of the City of Frankfort's solar system financially impact Frankfort Plant Board (FPB) customers and customers of other municipal utilities that obtain electricity from the same supplier? This form of solar cross-subsidization is applicable to hundreds of regions across the country that are served by electric cooperatives and municipal utilities.

With technical assistance from the National Community Solar Partnership (see text box on Community Solar), community activist stakeholders in Frankfort set out to determine how the city's solar development might impact the costs of other customers in the region. Using a detailed model, they elucidated how costs and revenues of the entities that provide electricity generation and transmission services would change if a portion of Frankfort customers' demand was met through the proposed 11.54-MW_{ac} local solar resource. The results of the study indicate that a local solar development in Frankfort could be implemented without negative financial impacts to nonparticipating stakeholders, particularly in an area with low solar PV penetration.[6]

Cross-Subsidization and Its Types

As defined by the University of Minnesota's Center for Science, Technology, and Environmental Policy, "Cross-subsidization occurs when the revenue that one consumer [or class of customers] generates in relation to the costs they are responsible for on the system is disproportionate to other consumers within the same resource pool."[5] Cross-subsidization can occur:

1. Between customers or members of the same utility, such as between those who have solar or access to solar and those who do not.
2. Between customers or members of one utility or entity and those of another utility at the same level or another level (such as energy supplier and distributor) with which it uses a shared infrastructure.

This study focused on investigating the potential for cross-subsidization between Frankfort Plant Board (FPB) customers and between other all-requirements municipal utility members of the Kentucky Municipal Energy Agency (KYMEA).

Local Community Solar Offers Meaningful Benefits to Customers

Approximately 50% of households and businesses in the United States do not have access to local solar because they are unable to host rooftop systems. This can be for a number of reasons, from not owning the roof to insufficient roof space to being unable to afford the upfront expenses of installing rooftop solar panels.[7] As such, community solar has emerged as one type of clean energy project that can help households, businesses, governments, and nonprofits procure affordable and local solar energy. Community solar projects share the benefits of one or more solar project(s) with multiple customers within a defined geographic area. As of 2023, there were over 1,600 community solar projects nationwide, with 22 states providing regulatory guidance to support their development.[8]

The National Community Solar Partnership (NCSP) is a coalition of over 1,500 community solar stakeholders working to expand access to affordable community solar to every American household: www.energy.gov/communitysolar/national-community-solar-partners. The goal of the partnership is to power the equivalent of five million households using community solar by 2025 and create $1 billion in energy savings for subscribers. NCSP is an initiative led by the Solar Energy Technologies Office within the U.S. Department of Energy, in collaboration with the National Renewable Energy Laboratory (www.nrel.gov) and Lawrence Berkeley National Laboratory (www.lbl.gov). To learn more and join the NCSP community, visit www.energy.gov/communitysolar/join-national-community-solar-partnership.

To access no-cost technical assistance for your solar projects, visit www.energy.gov/communitysolar/technical-assistance.

The full technical report is available at research-hub.nrel.gov/en/publications/cost-effectiveness-of-local-distribution-tied-solar-within-kymea.

Although the results presented in this case study are specific to Frankfort and the electricity contracts in place at the time of the analysis, the study shows how the question of cross-subsidization can be addressed quantitatively, with the goal of increasing transparency and buy-in across stakeholder groups and entities. Other regions with low solar PV penetration might employ similar methods to investigate the impact of local generation projects on different stakeholders. If a project is found to be beneficial in general, even if it may result in undesired cross-subsidization under the status quo contracts and tariffs, this study can provide a framework for considering adjustments. These adjustments, in turn, can restore fairness and bring about the benefits of a solar project without the unwanted consequences to other customers or customer classes.

How Does Cross-Subsidization Apply to Frankfort's Local Solar Proposal?

Electricity customers in Frankfort are served by FPB, a municipal electricity distribution utility. FPB is one of eight municipal utilities in the region that purchase generation from Kentucky Municipal Energy Agency (KYMEA), a joint public agency that acquires and delivers generation to meet the needs of its member utilities. Under an all-requirements (AR) contract, FPB must purchase all the power for its customers through KYMEA. KYMEA relies on payments from FPB and the other member utilities to cover the expense of its contracts with electricity generators and transmission providers. Likewise, FPB relies on revenues from electricity sales to recover its operating costs.

> If Frankfort customer demand for electricity is reduced by local solar projects within the city, the concern is that both FPB and KYMEA might not sell sufficient power to recover their operating costs. As such, the question of cross-subsidization revolved around whether deploying a local solar project in Frankfort would ultimately increase costs to FPB customers and KYMEA's municipal utility customers.

NREL supported Frankfort civilian stakeholders in modeling the impact that changes in Frankfort's load would have on KYMEA's generation purchases and network charges due to the construction and operation of a solar energy project interconnected to the Frankfort distribution system. This provided valuable insight into the financial impact that the solar project could be projected to have on KYMEA, FPB, the City of Frankfort, and KYMEA's other municipal utility members with all-requirements contracts.

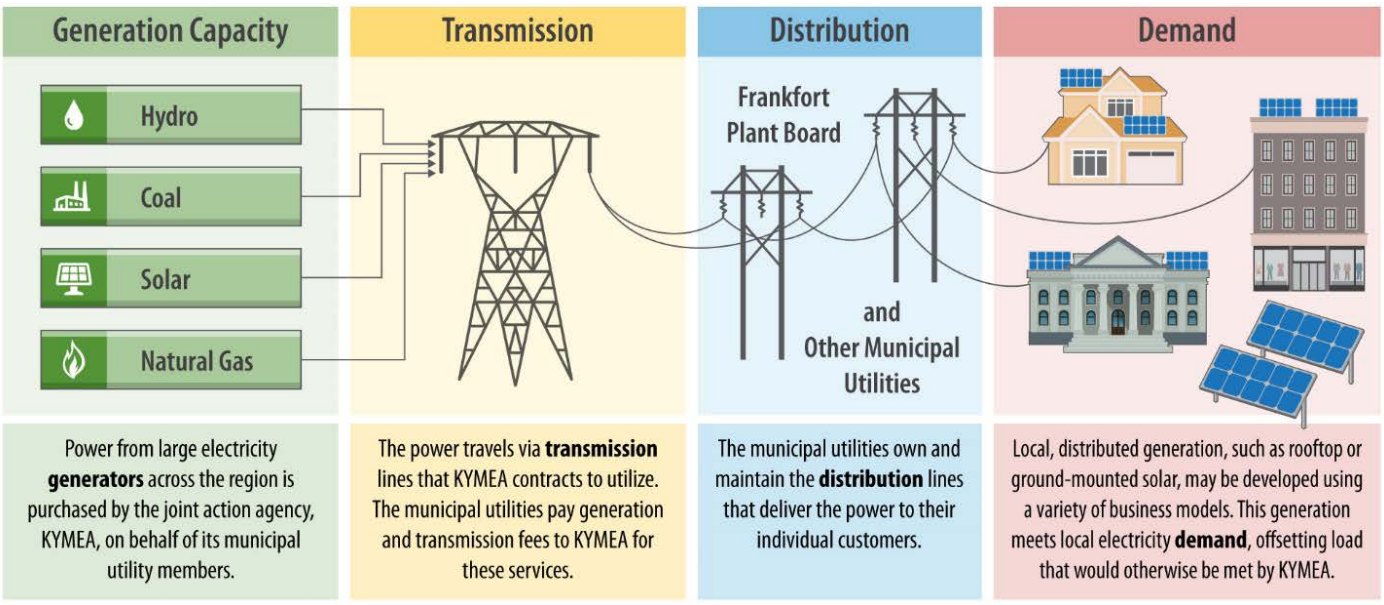

Figure 2. Electricity generators across the region have contracts with KYMEA to provide electricity to meet the demands of KYMEA's eight all-requirements member utilities. KYMEA coordinates the delivery of electricity to the member utilities via the Louisville Gas and Electric Company and Kentucky Utilities transmission system. Member utilities, including Frankfort Plant Board, maintain their own distribution systems over which they deliver the electricity to their customers. Under their all-requirements contracts with KYMEA, member utilities may own and operate small amounts of local solar generation on their distribution systems.

Modeling Results and Cross-Subsidization Findings

Reyling on publicly available data on KYMEA's generation and transmission service contract costs, a Frankfort model was developed that looked at two scenarios:

1. **Business as usual (BAU)**, which modeled a dispatch profile of KYMEA's energy system in 2023 to determine the agency's current annual energy and network services costs.
2. **Frankfort's distributed energy resource (DER)**, which analyzed KYMEA's energy and network services costs when a portion of Frankfort's demand was met through 11.54 MW of solar production.

Comparing KYMEA's operating costs between the scenarios, the results showed that Frankfort's solar production was projected to decrease the agency's total annual expenses by $1.17 million.[9] This difference in annual expenses can be attributed to Frankfort's solar production **decreasing KYMEA's aggregate peak demand**, both on an annual and daily basis. This is projected to reduce the variable expenses KYMEA will pay in transmission fees and power purchases from its suppliers to meet customer load.

In areas where there is not significant solar PV penetration, new solar projects are likely to lead to operational savings; however, as solar penetration increases, the savings for the next solar projects will be sequentially lower. Pairing solar with storage technologies like lithium-ion batteries has been shown to help mitigate the decreasing marginal value of additional solar projects, but even then, new projects might still result in higher electricity costs, because storage technologies have decreasing marginal returns as well.[10] These developments, however, vary significantly by region and depend on a variety of factors, such as the existing market structures for valuing the contribution of renewable and storage assets to the grid.[11]

KYMEA and FPB, however, are also expected to face declines in their power sale revenues from the implementation of Frankfort's solar PV facilities, as their production will be used to meet local demand. Despite these decreased power sales, careful financial planning through the reorganization of KYMEA's and FPB's tariffs can leave each stakeholder financially whole in the pursuit of developing local solar energy.

Thus, even though KYMEA was projected to experience a $1.37 million decrease in power sale revenue from FPB, it would only see a negative operating difference of approximately $200,000, as its operating expenses would have been reduced by $1.17 million. A similar cash-flow analysis for FPB revealed that the municipal utility could have reduced its payments to KYMEA by an estimated $1.37 million but would have also experienced a $2.06 million decrease in its power sale revenues from Frankfort customers. This would have left FPB with a potential negative operating difference of approximately $690,000. The City of Frankfort, meanwhile, would have reduced its electricity payments to FPB by about $2.06 million annually. Consequently, Frankfort could afford to allocate an estimated $890,000 from the city's $2.06 million in reduced electricity payments to offset KYMEA's and FPB's operating losses and use the remaining $1.17 million to pursue building the solar PV facilities without triggering cross-subsidization. In this way, residents could stand to save on their electricity bills while the city meets its renewable energy targets and lowers its carbon footprint, provided that the cost of constructing and operating the solar PV facilities equates to less than $1.17 million a year or $53.33 per MWh produced.

FPB could also be in a better position to reliably serve demand in Frankfort. The solar PV systems could be upgraded for islanded operation, involving additional local generation, batteries, or both in addition to other system assets and controls. The utility could use power from this enhanced system to sustain critical loads, potentially enhancing regional grid resilience for local customers.

Modeling KYMEA's Generation and Transmission Services in Engage™

This case study employed Engage™, an accessible and free-to-use energy system modeling web application developed by NREL. Inputs to the model included:

- **Customer load data** from the relevant communities
- **Generation profiles** for renewable resources like hydro and solar
- **Cost metrics** on energy services, including but not limited to generation and transmission.

Learn more about Engage at www.nrel.gov/state-local-tribal/engage-energy-modeling-tool.html.

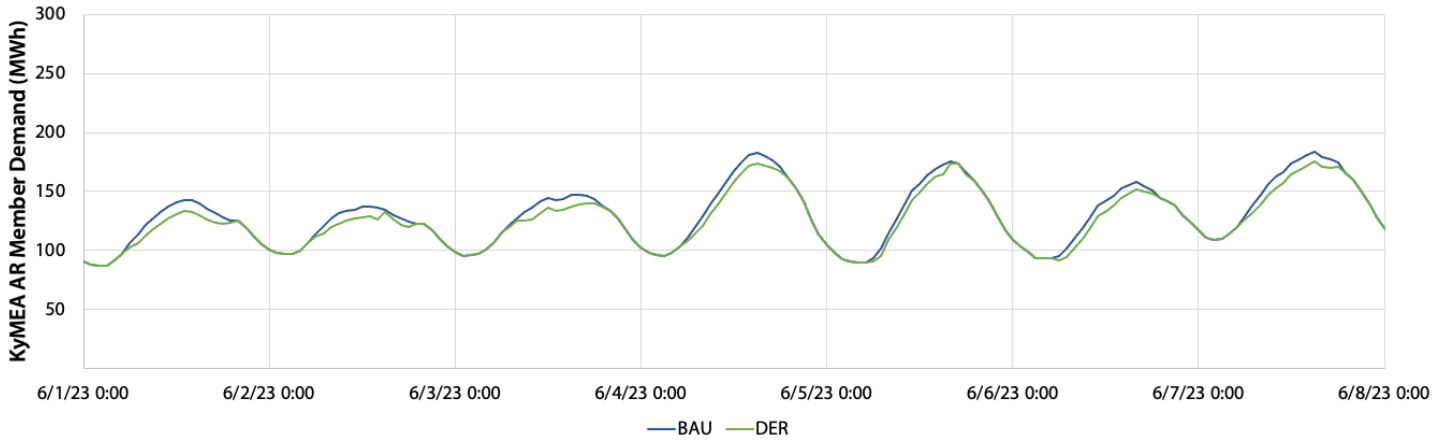

Figure 3. Demand curves for KYMEA, before (blue) and projected after solar construction in Frankfort (green), showing lower aggregate demand for KYMEA after DER implementation.

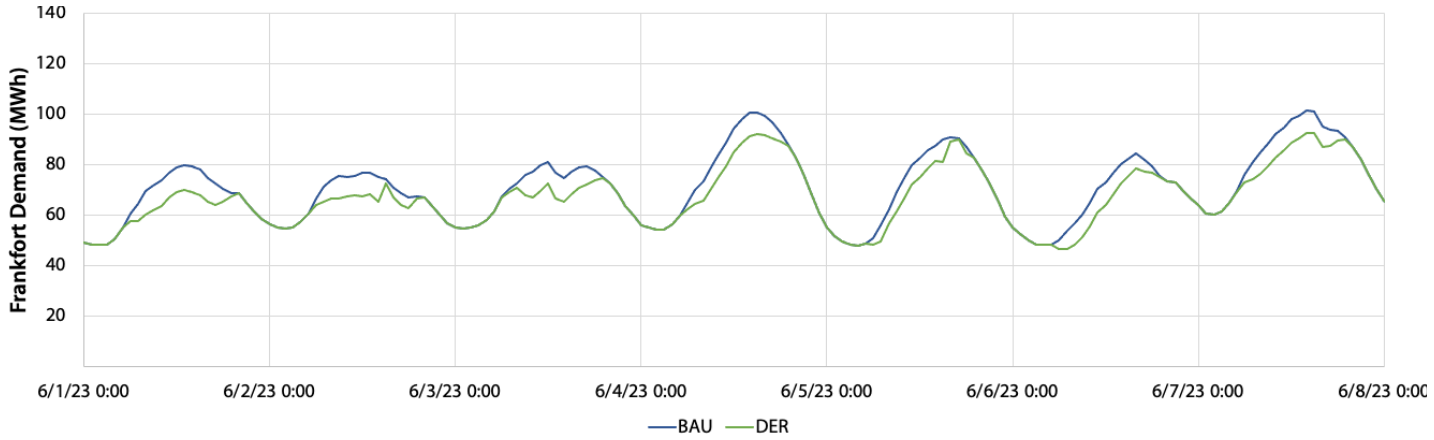

Figure 4. Demand curves for FPB, before (blue) and projected after solar construction in Frankfort (green), showing lower aggregate demand for FPB after DER implementation.

Stakeholder	Objectives	Impact
City of Frankfort	• Capture IRA incentives through solar generation • Achieve 2023 and 2030 renewable energy targets.	Frankfort can pursue its clean energy goals by compensating KYMEA and FPB for their differences in operating revenues with $1.17 million left over to cover capital and operating expenses for the city's solar projects.
Kentucky Municipal Energy Agency (KYMEA)	• Meet local electric power needs of all-requirements members • Recover operating costs through all-requirements sales contract.	The proposed solar capacity could improve KYMEA's economic efficiency by decreasing the agency's reliance on expensive generators and increasing the compensation it receives from selling power into the Midcontinent Independent System Operator (MISO). With an estimated $200,000 reimbursement, Frankfort's solar energy would maintain KYMEA's financial integrity with the potential to reduce future capacity requirements.
Frankfort Plant Board (FPB)	• Reliably serve demand in Frankfort • Comply with all-requirements sales contract.	FPB's operating revenues can remain balanced if the utility receives an estimated $690,000 from the City of Frankfort if it constructs the solar PV facilities. If battery storage, additional generation, and controls equipment are added for islanded operation, these solar systems are a potential first step to bolstering grid resilience for local customers, bringing a potential power source during outages.
KYMEA's All-Requirements Members	• Maintain all-requirements sales contract • Avoid increases in electricity costs from KYMEA tariff.	Because KYMEA would be able to fully recover its operating expenses under the new arrangement, KYMEA's other all-requirements members would not be financially affected by Frankfort's solar PV facilities.

As for KYMEA, Frankfort's solar projects could potentially lower the agency's future operating costs by marginally decreasing its contracted capacity. Although a rigorous analysis of potential capacity savings based on the capacity value of PV was not done, estimates from the technical report put the figure anywhere from $300,000 to $770,000 annually.[12]

Applications for Other Communities

The analysis presented in this case study assessed the financial impacts of distributed PV and community solar on multiple key stakeholders under existing contract and tariff structures and estimated what might be required to maintain multiple parties' financial integrity. While a unilateral analysis can be appropriate for evaluating the opportunity for an individual utility customer to implement local solar, the perspectives of all potentially affected entities or classes can be important when large (or large in the aggregate) projects are under consideration. This analysis investigated impacts on the City of Frankfort, FPB, KYMEA, and other customers of KYMEA. The need to ensure the utility's ongoing financial viability and equity among customers makes this type of analysis invaluable as a part of the renewable energy transition.

There are approximately 1,958 publicly owned electric utilities like FPB in the United States, in addition to 812 cooperative electric utilities.[13] While these utilities' customer loads, tariffs, local policies, and contracts will fluctuate on an individual basis, they are all likely to experience similar questions on how to best integrate distributed renewable energy systems into their grids in an equitable and mutually beneficial way. The methodology outlined in this case study presents one novel approach that energy providers and interested communities can take to measure their risk of cross-subsidization and identify collaborative policies and solutions. By addressing shared challenges, stakeholders can collectively lower energy costs, improve grid resilience, reduce greenhouse gas emissions, and contribute to a cleaner, more sustainable future.

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References

[1] https://www.frankfort.ky.gov/DocumentCenter/View/3904/NREL-Phase-1-Final-Report

[2] https://www.nrel.gov/news/program/2023/why-frankfort-set-a-clean-energy-goal-for-the-end-of-2023.html

[3] Although the Internal Revenue Service issued the Domestic Content Bonus Credit Guidance under Sections 45, 45Y, 48, and 48E (Notice 2023-38) in 2023 (https://www.irs.gov/pub/irs-drop/n-23-38.pdf), it is not entirely clear how this will be proven or enforced, because PV projects do not include labels about countries of origin for iron and steel.

[4] The U.S. Department of Energy created a Program Capacity Dashboard to track allocations of all four categories (including the subcategory of Additional Selection Criteria under each) of the Low-Income Communities Bonus Credit Program. For 2023, most categories had more applications than allotments, as shown here: https://eco.energy.gov/ejbonus/s/.

[5] https://static1.squarespace.com/static/62073e030dca05628e9f1926/t/64401c3cce57e41da86f03d4/1681923132515/SEIN+Synthesis+Report+%28final%29.pdf

[6] A higher penetration of solar energy in a community's electricity portfolio can lead to the development of a "duck curve," a phenomenon well-explored in California that shows how solar can create issues of over-generation and ramp-up challenges for dispatchable generators. Currently, the level of solar production that Frankfort's proposed 11.54-MW system would have on the grid would be minimal, because it would be the only solar PV system on the grid (aside from Ashwood when it becomes operational). Nonetheless, this is an important consideration for FPB to monitor and manage as Frankfort progresses toward its goal of achieving 100% renewable energy by 2030, as it will lead to higher levels of solar penetration. To learn more about the duck curve, visit https://www.energy.gov/eere/articles/confronting-duck-curve-how-address-over-generation-solar-energy.

[7] https://www.energy.gov/eere/solar/community-solar-basics

[8] Metrics on shared renewable generation, including community solar, can be found at https://www.epa.gov/green-power-markets/shared-renewables.

[9] For a complete breakdown of cash flows, read the full technical report at https://www.nrel.gov/docs/fy24osti/87697.pdf.

[10] https://esca.epri.com/pdf/Back-Pocket-Insights/EPRI-P201-Decreasing-Returns.pdf#:~:text=Declining%20

[11] Examples of market values for solar and storage include their role in providing grid stability through capacity payments as well as reduced peak demand through time-of-use pricing or net metering.

[12] The technical report highlights two approaches to valuing the capacity contribution of Frankfort's solar PV systems. The first approach, which involved utilizing KYMEA's Member Resource Credit and the solar capacity value by the Southern Electric Reliability Council (SERC), placed the capacity value at $300,000 annually. The second approach looked directly at the cost savings from reducing KYMEA's aggregate annual peak in August by 7.26 MW, which placed the capacity value of Frankfort's solar projects at $770,000 annually. More details on the methodology can be found in the technical report at https://www.nrel.gov/docs/fy24osti/87697.pdf.

[13] https://www.eia.gov/todayinenergy/detail.php?id=40913.

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