
*July 1 | Ward 8 | OPC in Your Neighborhood visits grocery stores across the District. Consumer Outreach Specialist Erica Jones is excited to greet a shopper at the Alabama Avenue Giant in Southeast.*

# AGENCY FUNDING

### Source of Funds

Funding for the Office of the People's Counsel is provided through two sources: 1) Appropriated Budget and 2) Assessment Funds. All funds are paid by DC utility ratepayers.

### Appropriated Budget (Operating Funds)

The appropriated budget provides for administrative and general operating expenses for OPC (rent, salaries, equipment) and is authorized by the District of Columbia in the governmental budget review process. OPC's fiscal year 2016 appropriated budget was $7,648,091. Appropriated funds are also used to support such additional activities as: 1) representing the interests of District consumers before the DC Council, Congress, and federal courts and agencies; 2) conducting independent investigations or audits of utility companies; 3) monitoring the implementation of utility rates; and 4) providing technical assistance to community groups. By law, these funds must be reimbursed to the District by the three regulated utility companies and the alternative energy and telecommunications providers according to an established formula, outlined in the Public Utility Reimbursement Fee Act, DC Code § 34- 912(b)(1).

### Formal Case Assessments

Assessment funds are used to pay the costs of litigation and investigations. OPC assesses the affected utility and the utility can recover those costs directly from consumers through rate increase cases.

To fully participate in complex litigation before the Public Service Commission and the courts, the People's Counsel is authorized to retain the professional services of attorneys and expert technical consultants such as economists, accountants, and engineers, as needed, to effectively represent DC utility consumers. By law, the affected utility company is required to pay a special franchise tax to cover the costs of regulatory litigation by OPC. In turn, the law recognizes that the utility may include these costs, as well as its own litigation-related expenses, as operating expenses that can be recovered from consumers through rate increase requests. OPC must adhere to monetary limits in imposing assessments on the utilities. In a rate case, the Office is permitted to assess the utilities no more than a total of one-quarter of one percent of a company's net investments in plant operations, which is referred to as "rate base."

With respect to all other cases or investigations (those not involving the setting of rates), OPC is permitted to assess one-twentieth of one percent (five cents on $100) on a company's rate base during a calendar year. By law, unused money is returned to the utility.

*November 3 | People's Counsel Sandra Mattavous-Frye and OPC staff with DC Counsel staff who received an OPC briefing on utility issues.*

*Assistant People's Counsel Arick Sears briefs DC Council staff on OPC's advocacy and concerns in their ward.*

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*June 17 | Australian Consumer Advocate Chris Alexander visits OPC to learn best practices, with Nicole Sitaraman, People's Counsel Sandra Mattavous-Frye and Deputy People's Counsel Karen Sistrunk.*

*April 22 | Ward 2 | Florescent light bulbs are a big hit at an energy efficiency workshop conducted by Community Outreach Specialist Denise Blackson at the Residences at Harbourside in Northwest.*

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Office of the People's Counsel for the District of Columbia

# Solar Generation Potential and Integration of Distributed Energy Resources in Low- and Middle-Income Communities In Washington, DC

Submitted by:
**Jerome S. Paige & Associates, LLC**
**Economic, Business & Organizational Consulting**

Washington, DC 20012
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## Table of Contents

# Acknowledgements

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# Acronyms

| | |
|---|---|
| AC | Alternating Current |
| ACEEE | American Council for an Energy-Efficient Economy |
| ACP | Alternative Compliance Payments |
| ACS | American Community Survey |
| AMI | Advanced Metering Infrastructure |
| AMI | Area Median Income |
| ARRA | American Recovery and Reinvestment Act of 2009 |
| CBE | DC Certified Business Enterprise |
| CCHP | Combined Cooling Heat and Power |
| CEG | Clean Energy Group |
| Census | U.S. Bureau of the Census |
| CEP | District of Columbia's Comprehensive Energy Plan |
| CHP | Combined Heating & Power |
| Clean CEP | District's Clean Energy Plan |
| CWFA | Clean Water Financing Authority |
| DC | Direct Current |
| DC SEU | DC Sustainable Energy Utility |
| DCHA | District of Columbia Housing Authority |
| DCMR | District of Columbia Municipal Regulation |
| DCOZ | DC Office of Zoning |
| DCRA | DC Office of Consumer & Regulatory Affairs |
| DCSEU | District of Columbia Sustainable Energy Utility |
| DER | Distribute Energy Resources |
| DCGIS | District of Columbia Geographic Information System |
| DHCD | District of Columbia Department of Housing & Community Development |
| DOE | U.S. Department of Energy |
| DOEE | District of Columbia Department of Energy and Environment |
| DOES | DC Department of Employment Services |
| DSLBD | DC Office of Small and Local Business Development |
| EEFA | Energy Efficiency for All |
| EPA | U.S. Environmental Protection Agency |
| FPL | Federal Poverty Level |
| FY | Fiscal Year |
| GHG | Green House Gases |
| GIS | Geographical Information System |
| GEMS | Green Energy Market Securitization |
| Habitat | Habitat for Humanity |
| HUD | U.S. Department of Housing and Urban Development |
| HVAC | Heating Ventilation and Air Conditioning |

| | |
|---|---|
| ITC | Investment Tax Credits |
| KW | Kilowatt |
| kWh | Kilowatt Hour |
| LIHEAP | Low-Income Home Energy Assistance Program |
| LIHTC | Low-Income Housing Tax Credits |
| MW | Megawatts |
| MWh | Megawatt Hours |
| NPS | National Park Service |
| NYGB | New York Green Bank |
| OCTO | DC Office of the Chief Technology Officer |
| OPC | District of Columbia Office of the People's Counsel |
| PACE | Property Assessed Clean Energy Program |
| PHIUS | Passive House Institute US |
| PLUG | Power Line Undergrounding |
| PPA | Power Purchase Agreement |
| PSC | District of Columbia Public Service Commission |
| PV | Photovoltaic |
| QCEBs | Qualified Clean Energy Bonds |
| RIIB | Rhode Island Infrastructure Bank |
| RPS | Renewable Portfolio Standard |
| SETF | Sustainable Energy Trust Fund |
| SFRRP | DC Single Family Residential Rehabilitation Program |
| SREC | Solar Renewable Energy Certificate |
| STEM | Science, Technology, Engineering & Math |
| U.S. | United States |
| VOS | Value of Solar |
| VOST | Value of Solar Tariff |

# Key Takeaways

### Solar PV has the potential to meet a significant portion of the electricity needs of low-income households

- Solar PV panels mounted on rooftops in low-income areas can potentially generate electricity to meet a major portion of the electricity demand of low-income residents. This would offset, and possibly eliminate, their electricity bills.
- The maximum potential output of those rooftops is about 540 MW (Direct Current).

### Not all potential rooftops can be used for solar PV

- Lack of space
- Shading from other buildings
- Other structural and zoning issues

### Residents in buildings with unsuitable rooftops can still participate in solar

- Ground-mounted PV systems (in parking lots or other suitable spaces)
- Off-site community solar systems
    - This requires "virtual net-metering" (VNM).

### Models to facilitate solar PV in low-income neighborhoods are available

- Concept is utility-in-a-box
- Several examples of actual and planned models to deliver solar and distributed energy resources to low-income residents in the District

### "Energy Efficiency": Key element of Utility-in-a-Box

- Reduces consumption, energy burdens, and investment needed to install solar PV and other distributed energy resources
- Increases the amount of solar PV that can be sold to the grid
- Three variations of utility-in-a-box are:
    1. Housing Design + Solar PV
    2. Energy Efficiency + Solar PV + Storage
    3. Energy Efficiency + Neighborhood Scale Energy Systems + Solar PV

### There is a "value of solar" for low-income households

- Gives access to energy that reduces or eliminates monthly electricity costs (thereby reducing overall energy burden)
- Reduces need for ongoing ratepayer and taxpayer subsidies to pay electricity bills
- Increases access to solar's financial, environmental and social benefits; expands energy choices; provides energy security; and enhances energy independence

# Executive Summary

## Scope of Work & Purpose of Study

The Office of the People's Counsel (OPC) commissioned a study and report on residential customers and policies to equitably facilitate solar PV deployment, and an analysis of emerging distributed energy alternatives for low-income residential energy consumers in the District of Columbia. The U.S. Department of Housing and Urban Development's definition of low-income is used as the basis for this study's analysis.

## Focus of Study

This report indicates how low-income residents in the District can significantly participate in and benefit from solar PV installations. With this participation, low-income consumers stand to receive the same level of environmental and social benefits as higher-income groups.

## Theoretical Potential of Rooftop Solar in Low-Income Communities in the District

The report's basic unit of analysis is the "rooftop" on buildings in low-income neighborhoods. This report shows these rooftops could theoretically generate more than enough solar PV electricity to offset up to 100% of electricity usage of the District's low-income residents. "Theoretical potential" is sometimes referred to as "maximum" or "technical" potential.

For this study, the theoretical PV electricity generation capacity by PV power plants mounted on flat roof surfaces is estimated at 543 MW (Direct Current). Presently, the estimated electricity being generated by PV rooftop power plants installed on all residential and mixed-used buildings in the District is only 20 MW.

In addition to "rooftops," ground-mount solar PV installations provide another potential source for solar PV in low-income neighborhoods, and this source would be available to households living in buildings with rooftops unsuitable for solar PV installations. These installations provide households the opportunity to participate in solar PV, if sufficient space for the installations is available.

A third potential source is community solar, which is also an option for residents living in buildings with unsuitable roofs.

### Increasing the Amount of Solar Power Sold to the Grid

This report outlines ways to increase the amount of PV-generated solar power flowing into the grid, particularly from low-income neighborhoods. The primary instrument is to continue to improve "energy efficiency."

Energy efficiency is a powerful step for lowering energy consumption and costs for households, as well as for reducing greenhouse gas emissions. Consumption of any renewable energy resource without energy efficiency is wasteful—like trying to conserve water while not fixing dripping faucets. Energy efficiency optimizes energy usage in general. When paired with solar PV, energy efficiency can increase the amount by which production exceeds consumption, thereby increasing the amount of electricity available to the grid.

### Identifying and Removing Barriers to Solar Power in Low-Income Communities

As in other jurisdictions, in the District, practical barriers exist that limit the generation, accessibility, and utilization of solar PV and other distributive energy resources. This report identifies these barriers, and proposes ways to mitigate them. Further, the report suggests which District agencies should take actions to help low-income residents generate, access, and utilize solar PV systems.

The report groups the barriers in 10 categories as shown in Table E.1, and provides corresponding recommendations as shown in Table E.2.

#### Re-imagining Utility-in-a-Box

Additionally, this report discusses in some detail the concept of "Utility-in-a-Box." Utility-in-a-Box provides a range of options to improve the affordability and utilization of solar and reduce electricity bills. In this report, the concept of Utility-in-a-Box" is re-imagined. Three variations of Utility-in-a-Box are:

1. Housing Design + Solar PV
2. Energy Efficiency + Solar PV + Storage
3. Energy Efficiency + Neighborhood Scale Energy Systems + Solar PV

The application of the Utility-in-a Box concept will promote the bundling of solar PV with appropriate energy generation enhancements and energy and environmental conservation technologies; expand the number of generators (producers) who are simultaneously users (consumers); and enable customers to reduce their dependence significantly on the utility grid, or to "cut the cord" entirely, if they so choose.

**Table E.1: Barriers to Implementing and Expanding Solar PV in the District**

| | Category | Barriers |
|---|---|---|
| 1 | Building Rooftop | Unsound roof structure, electrical circuitry. |
| | | Unviable building or roof design or orientation to the sun; energy inefficient roofs (leaky building). |
| | | Inadequate space or exposure for generation viability/cost-effectiveness. |
| 2 | Regulatory | Zoning Restrictions (DCRA): historic preservation, flat roof setback installation requirements, parkland restrictions.<br>Zoning Restrictions (Federal and DCOZ): historic preservation, parkland restrictions. |
| | | Metering Restrictions (PSC): prohibition against residential sub-metering. |
| 3 | Education/Marketing (Outreach) | Lack of knowledge across stakeholder sectors about solar and its benefits (including community solar). |
| 4 | Sustainability Planning | Lack of coordination of the many trends, programs, and initiatives and ways to enhance and support those programs and initiatives. |
| 5 | Grid Interconnections/ Readiness | Potential limitations on grid's capacity to interconnect and manage large deployment of distributed generation. |
| | | Solar developer "split incentives," risk of expensive regulatory permitting or utility interconnection delays, "hassle" factor/complexity. |
| | | Amount of time to get interconnected once installation is completed |
| 6 | Workforce & Business Development | Dearth of Certified Business Enterprises (CBEs) and people working in the solar space—for example, solar installers, professional planners, designers, and scientists. |
| 7 | Community Solar | Lack of available land/space. |
| | | Lack of education and awareness of the ways community solar can be implemented. |
| 8 | Financing | Lack of access to financing. |
| | | Lack of understanding how to fund solar projects. |
| | | Lack of awareness of various financial options. |
| 9 | Administrative Coordination | "Siloing" of agencies involved in development of low-income solar; lack of inter-agency and intra-agency coordination. |
| 10 | Utility-in-a Box Reimagined | Lack of education and awareness of distributed energy resources and other complementary energy, water and environmental conservation programs; how to shop for them; and how to appropriately bundle them to gain the maximum economic and environmental benefits while also maximizing consumer choice. |

**Table E.2: Reducing or eliminating barriers to the implementation and expansion of Solar PV**

| | | |
|---|---|---|
| 1 | Building Rooftop | Institutionalize "solar readiness." |
| | | Promote Net Zero Energy and holistic green building design. |
| 2 | Regulatory | Remove regulatory barriers that limit availability of rooftops and land for rooftop and ground-mounted solar deployment. |
| | | Remove prohibitions against sub-metering for residential units in master-metered buildings or projects (multifamily or mixed-use). |
| 3 | Education/Marketing (Outreach) | Increase funding and development of education and marketing programs to address lack of public buy-In of solar and awareness of its "true" benefits. |
| 4 | Sustainability Planning | Optimize sustainability planning for lower-income households and affordable housing across the District. |
| 5 | Grid Interconnections/ Readiness | Require equitable modernization of the District's electricity of grid and power line undergrounding to enable high volumes of solar generation across all neighborhoods to be interconnected to the grid. |
| 6 | Workforce & Business Development | Build the local solar workforce by institutionalizing solar training programs. |
| 7 | Community Solar | Unlock space. |
| | | Expand education and awareness. |
| | | Promote different demonstration models for low-income community solar. |
| | | Explore options to encourage landlords of multifamily, master-metered buildings to give their tenants access to community solar. |
| 8 | Financing | Support the establishment of a Green Bank for District energy programs. |
| | | Establish a "Capital Aggregation" platform. |
| | | Explore possible use of low-income tax credits. |
| | | Lower costs of solar deployment through "Solar Co-op" or Neighborhood Deployment. |
| | | Expand solar financing for lower-income homeowners. |
| | | Expand subsidies for the very low-income homeowner group. |
| | | Expand low-cost loan programs for the "Middle" 60-80% AMI homeowner group. |
| 9 | Administrative Coordination | Enhance stakeholder coordination. |
| 10 | Utility-in-a-Box | Utilize existing "utility-in-a-box" models and expand on them. |

### Helping Customer-Generators Enter the Solar Power Market

Several policies that allow customer-generators to enter the market and receive payment for the power they supply to the grid are Net Metering; Value of Solar Tariffs (VOST); Renewable Portfolio Standards (RPS) and Solar Carve-Outs; and Tax Incentive and Rebates.

These policies are defined in Chapter 1. However, a detailed analysis of the impact of these policies was beyond the scope of the project.

## Topics for Further Study

Over the course of this study, some additional topics arose that also fell outside this report's original scope. This study's analysts and an independent reviewer of a draft of the study recommend the following areas of study:

1. Develop additional operational models. To assess additional for-profit and non-profit operational models to help promote the expansion of solar PV in low-income communities. This assessment would enable a variety of models to be considered and tested.
2. Develop Value of Solar Tariffs (VOST). To assess what it would take to get buy-in on VOST from all parties and stakeholders, particularly when stakeholder interests diverge.
3. Develop Value of Solar billing mechanisms. To assess what it would take to implement a value of solar billing mechanism and whether such a mechanism would promote investment in solar in low-income communities.
4. Assess the use of technologies such as CHP to increase the value of solar in multifamily buildings: To assess ways to promote the use various distributed energy resources technologies in multifamily buildings since many low-income residents in the District reside in these types of dwellings. It is important to find ways of increasing the value of solar in these facilities. One promising possibility is using solar with Combined Heat and Power (CHP).
5. Undertake pre-feasibility studies: To provide a good sense of how much of the technical potential can be realized currently and over time.
6. Fine-tune financial incentives: To guide policymakers on determining what incentives are most suitable for the limited-income target beneficiaries considered in this report.
7. Create a forum for groups and individuals mapping information about low-income communities: To create structured, ongoing opportunities or researchers to share and compile information and to leverage resources to ascertain a complete "set of maps."
8. Estimate values of "achievable potential": To explore what it would take to develop a model to estimate solar generation from rooftops that goes beyond the estimation of "technical potential."
9. Assessment of "capital aggregation models": To assess the feasibility of developing a "platform" that would pull together multiple sources and types of capital and to direct it in ways that would increase the funding of solar projects in low-income communities.

# Chapter 1: Introduction

## Scope & Purpose

The Office of the People's Counsel (OPC) commissioned a study and report on the value of solar, the potential for residential customers and policies to equitably facilitate solar deployment, and an analysis of emerging energy alternatives for low- and limited-income residential customers in the District of Columbia. This study uses the U.S. Department of Housing and Urban Development's (HUD's) definition of low-income as the basis for the analysis.

This study examines how low-income residents in the District can equally participate in, and benefit from, solar PV installations. Low-income populations stand to receive the same level of environmental and social benefits as higher-income populations because solar PV and other distributive energy resources create the possibility for those in all income groups to become simultaneously a "generator" (producer) and a "user" (consumer).

This study shows "rooftops of buildings" located in low-income communities could theoretically generate more than enough solar PV electricity to offset up to 100% of electricity usage and electricity costs of the District's low-income residents.[1] For those residents residing in buildings with rooftops not suitable to support solar PV rooftop installations, residents can still participate in the solar PV market through ground-mount installations (if sufficient property is available at their building) or in community solar programs.

This study also highlights the importance of "energy efficiency." Energy efficiency is a powerful step for lowering energy consumption and costs for households, as well as for reducing greenhouse gas emissions. Consumption of any renewable energy resource without energy efficiency is wasteful—like trying to conserve water while not fixing dripping faucets. Energy efficiency optimizes energy usage, and when paired with solar PV it can increase the amount by which production exceeds consumption, thereby increasing the amount of electricity available to the grid.

As in other jurisdictions, in the District, there are practical barriers to generation, accessibility, and utilization of solar PV and other distributive energy resources. This study identifies many of those barriers, proposes mitigation measures to overcome them, and identifies the District agencies responsible for implementing the measures to improve the ability of low-income residents to generate, access, and utilize solar PV systems in the District.

[1] The focus of this study in on the "maximum," not an expected average potential. See Chapter 3.

## Background

The DC Public Service Commission (PSC) initiated Formal Case 1130 in 2015.[2] OPC is a key stakeholder and a statutory participant in this case. This proceeding is a multi-stakeholder process to consider expanding the integration of distributed energy resources into the District's energy systems, to better meet the District's clean, affordable, reliable, and disaster resilient energy requirements and emissions goals while enhancing consumer choice.[3]

At the core of integrating high penetration of rooftop solar PV and other distributed generation into local and regional grids is the task of assigning value to distributed energy resources and decentralized systems, which in fact is no easy task!

Together, the PSC and OPC have rolled up their sleeves and taken on this challenge. Consequently, this report helps OPC to carry out its mandate effectively in the face of the big shifts in the energy and regulatory environment, to provide leaders of the District government and the city with the appropriate and necessary information to meet the challenging energy and climate needs of the 21st century, and to provide stewardship for the city's most vulnerable populations.

The report also enhances OPC's contribution to the national regulatory discussion overall, and development of best practices, by providing a resource for other jurisdictions, as they tackle these same challenges.

Additionally, this report builds on the long-standing District policy that states solar has value for its residents, particularly for its low-income ones. Over the past 10 years, the District has offered a variety of solar power initiatives to aggressively promote the utilization of solar power among its residents and businesses.

The intent of this policy was to assist residents and commercial operations in reducing the costs of their electricity bills as well as in accruing other economic, social and environmental benefits, such as gaining energy reliability and security.

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[2] Formal Case No. 1130, In The Matter Of The Investigation Into Modernizing The Energy Delivery System For Increased Sustainability

[3] In taking on this major regulatory challenge, the District has joined a vanguard of states with parallel proceedings, namely California, New York, Massachusetts, Minnesota, and Hawaii. Hawaii, for example, is aggressively planning for meeting its goal for 100% renewable energy by 2045, having already reached high rates of distributed solar photovoltaic (PV) penetration throughout its grid on an unplanned basis.

While some of these solar power initiatives are no longer operational, they helped increase the utilization of solar PV electricity in the District. However, even with those heavily incentivized programs, many low-income residents were not able to access solar PV.

Nationally, the District is on the frontline when it comes to adopting jurisdiction-wide policies and practices that promote and require the integration of distributed energy resources, particularly solar and smart-grid technologies.[4] The District also stands at the forefront of high-level stakeholder involvement and comprehensive energy systems planning. For example, as noted above, the PSC-initiated Formal Case No. 1130.

Also, the District's mayor and city council enacted D.C. ACT 21-466 on July 25, 2016. The law establishes a "Solar for All" program that will provide the District's seniors, small businesses, nonprofits, and low-income households greater access to the benefits of solar power. One of the goals of "Solar for All" is to reduce the electric bills of at least 100,000 of the District's low-income households (with high-energy burdens) by at least 50% by December 31, 2032.

Further, the DC Department of Energy and Environment (DOEE) has completed its climate and energy plan: "Clean Energy DC: The District of Columbia Climate and Energy Plan (Draft October 2016)." This plan (CEP) is the District's five-year roadmap for achieving its long-term target of reducing greenhouse gas (GHG) emissions by 50% by the year 2032, and by at least 80% by 2050. To achieve these ambitious targets, the District must pursue a range of innovative and aggressive actions. According to the CEP, District-wide energy use has already decreased over the past decade, thanks, in part, to Federal and District Government policies and private sector initiatives. GHG emissions have also declined, mainly due to a reduction in the number of coal-fired power plants that supply the District with electricity. However, significant challenges remain to achieve the District's 2032 and 2050 GHG targets.[5]

This report identifies some of those challenges to increase the penetration of solar in low-income communities in our city and to unlock the value of solar for them.

[4] N.C. Clean Energy Technology Center Releases Q4 Solar Policy Update to The 50 States of Solar. https://nccleantech.ncsu.edu/n-c-clean-energy-technology-center-releases-q4-solar-policy-update-to-the-50-states-of-solar/

[5] Clean Energy DC; The District of Columbia Climate and Energy Plan (Draft October 2016 https://doee.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/Clean_Energy_DC_2016_final_print_single_pages_102616_print.pdf. See Box 1, p. 23.

## Definitions & Concepts

This report uses an annual income of $68,500 or less for a four-person household to determine "low- income." Each year the U.S. Department of Housing and Urban Development (HUD) calculates area median incomes (AMI) using the American Community Surveys conducted by the U.S. Census Bureau. The AMI for fiscal year (FY) 2014 was estimated to be $107,000 for a family of four in the District of Columbia.[6]

The "Solar for All" legislation adopts the criteria of 80% of AMI, which is $85,000 (80% of $107,000). However, HUD introduces an adjustment to calculate the stated value of $68,500 for a four-person household.

Technically, the term "value of solar" (VOS) refers to a relatively new mechanism for the purchase of distributed solar generation. VOS is a technical term focusing on financial costs.[7] As noted in this report, the use of VOS has been broadened to include environmental, health and other benefits accruing from solar PV.

Several ways exist to define "distributed energy resources" (DER) technologies. For this study, DER technologies are those off-grid or grid-connected devices capable of producing and storing power to support the host load or the grid. DERs are typically located on the premises of the customer or end-user and their operation supply all, or a portion of, the customer's electric load. DER technologies can also help the transition toward a smarter grid.

DERs may also be capable of injecting power into the transmission and the distribution system, or into a non-utility local network in parallel with the utility grid. These DERs include such technologies as solar photovoltaic (PV), combined heat and power (CHP) or cogeneration systems, micro-grids, wind turbines, micro-turbines, back-up generators and energy storage. Some, including the New York Public Service Commission, have defined DERs more broadly to include energy efficiency and demand response.[8]

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[6] DC Office of Planning. http://planning.dc.gov/node/1128597 2010-2014 ACS 5-Year Districtwide (Spreadsheet)

[7] "The value of solar (VOS) is a relatively new mechanism for the purchase of distributed solar generation that is being considered in some locations. A VOS tariff is intended to be compensation for the real value provided by the solar installations to the electric system." (1) In this document, VOS rate and VOS tariff are used interchangeably to refer to the amount (number) that is being paid by the utility for solar generation by self-generating or on-site generating customers. The term VOS mechanism is used to refer to the policy or program in the broader sense." See Taylor, Mike, McLaren, Joyce, and Cory, Karlynn, and Davidovich, Ted, Sterline, John, and Makhyoun, Miriam, Value of Solar: Program Design and Implementation Considerations. Technical Report, NREL/TP-6a20-62361, March 2015, Contract No. DE-AC36-08GO283O8. www.nrel,gov/docs/fy15osti/62361.pdf.

Currently, there is no uniform approach to establishing a VOS for the electricity produced by distributed energy systems, since agreements between customers and their utilities vary from state-to-state and utility territory to utility territory because of state law, utility commission rules, and the dispositions of utility companies.

As utilities look to address dramatic increases in customer adoption of distributed energy resources like solar PV and their interests in deploying renewable generation facilities, the implementation of a valuation methodology can help define costs and benefits.

### Benefits of Solar Power for Low-Income Residents

This report validates the findings of other reports from around the United States and the world. For example, in a 2015 report published by the NC Clean Energy Technology Center, the following findings are highlighted. Among them, investing in solar PV presents a real opportunity for anyone looking to take greater control over their monthly electricity bills and make them a long-term and (relatively) low-risk investment.[9] This investment opportunity is available directly to low-income residents in single-family buildings in the District, and to multifamily and mixed-use buildings housing low-income families in the city.

The NC Clean Energy Technology Center report goes on to note the following: For customers in 46 of America's 50 largest cities, 100% financed is a better investment than the stock market! This rate of return applies to low-income, single-family owned buildings and buildings occupied by low-income families.

Additionally, the center's report ranked jurisdictions based on a 30-point ranking system for a five-kilowatt (KW) PV power plant. According to that report, the District ranked sixth out of the 50 largest cities in the United States, being evaluated for affordability of solar PV rooftop installations. Finally, the report highlights that for a variety of reasons, the cost of solar PV systems has decreased tremendously. Because of these decreases, investments in solar have increased. Supportive federal, state, and local incentives, and public policies are the main reasons for the decrease in cost.

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[8] NY Public Service Commission. "Report Recommends New Approaches to Determine the Full Value of Renewable Power & Money-Saving Technologies." http://www3.dps.ny.gov/pscweb/WebFileRoom.nsf/ArticlesByCategory/9E768D349F2CE14B8525805A005C8623/$File/pr16073.pdf?OpenElement

[9] N.C. Clean Energy Technology Center Releases Q4 Solar Policy Update to The 50 States of Solar. https://nccleantech.ncsu.edu/n-c-clean-energy-technology-center-releases-q4-solar-policy-update-to-the-50-states-of-solar/

## Helping Consumer-Generators Enter the Solar Power Market

The basic policies that allow consumer-generators to enter the market and receive a payment for the power they supply to the grid are net metering, Value of Solar Tariffs (VOST), Renewable Portfolio Standards (RPS) and Solar Carve-Outs, and tax incentives and rebates.

- Net Metering: Net metering has significantly contributed to the growth of the solar industry. However, where states have eliminated it or made significantly less favorable changes to the policy, the rate of PV installations was reduced significantly. Utility companies have argued changes to net metering are necessary because solar PV installation homeowners do not pay for transmission and distribution costs. Consequently, in their view, "net metering" shifts the costs onto electricity customers who do not have solar panels. To the contrary, PV owners assert the environmental and health benefits of solar, and the financial benefits of the distributed nature of solar power, generate a net benefit for ratepayers and for the environment. For example, the Brookings Institution found "net metering, more often than not, is a net benefit to the grid and all ratepayers."[10]

- Value of Solar Tariff (VOST): VOST allows solar PV owners to enter the market and receive a payment for the power they produce. Also, it allows PV owners to sell all the power generated by their system to their utility at a rate reflecting the value of solar energy to the grid, and then buy all the power they consume from the utility.

- Renewable Portfolio Standards (RPSs) and Solar Carve-Outs: These more directly aid the solar market by mandating retail electricity suppliers obtain a certain percentage of their power from renewable sources.

- Tax Incentives & Rebates: There is a federal investment tax credit. Some states also offer tax credits of varying amounts for solar PV installations. Additionally, some states and utilities also offer rebates. These incentives and rebates help lower the costs of installation, thereby promoting solar adoption.

## Utility-in-a-Box

This report discusses the "Utility-in-a-Box" concept" and promotes it as a way for low-income residents to capture the value of solar for them and their communities. A "Utility-in-a-Box" bundles the appropriate energy generation enhancement and energy conservation technologies with solar PV; provides options to enable ratepayers to greatly reduce their dependence on the utility grid to improve solar affordability and utilization; reduces electricity bills and enhances energy security, independence and democracy; and better yet, allows ratepayers "to cut the cord" entirely," if they choose to do so.

[10] Marc Muro and Devashree Saha. May 23, 2016 "Rooftop solar: Net Metering is a net benefit." Brookings. https://www.brookings.edu/research/rooftop-solar-net-metering-is-a-net-benefit/

# Chapter 2: Defining "Low-Income" for Purposes of Study

## Area Median Income Defined

The U.S. Census Bureau (Census) annually updates and publishes poverty guidelines. Unlike the guidelines for area median income (AMI), the federal poverty level (FPL) is set nationwide, with no separate figures for metropolitan areas or cities. Therefore, it represents a federal poverty guideline that varies by family size to determine who is poor and who is eligible to participate in subsidized programs. (See Table 2.1 below.)

Additionally, each year the Department of Housing and Urban Development (HUD) calculates area median incomes (AMI) using the American Community Surveys conducted by the U.S. Census Bureau. The AMI for fiscal year (FY) 2014 was estimated to be $107,000 for a family of four in the District.[11]

HUD considers households whose earnings are less than 80% AMI to be low income, less than 50% AMI to be "very" low income, and less than 30% AMI to be "extremely" low income. Because household incomes differ by the number of people in the household, HUD adjusted AMI for the District by household size. (See Table 2.1 below).

AMI and FPL are alternative guidelines to determine the eligibility of an individual or household to participate in a program providing public assistance. Using the 2014 guideline of 200% of FPL, to participate in a program, the annual income of a two-person household could not exceed $31,460.[12] Similarly, using 80% of AMI (based on HUD guidelines), the annual income of a four-person household could not exceed $68,500. [13] Using AMI expands the number of households who can benefit from a program. The median household income in the District was $69,235 in 2014.[14]

[11] DC Office of Planning. http://planning.dc.gov/node/1128597 2010-2014 ACS 5-Year Districtwide (Spreadsheet)

[12] The 2014 FPL value for a 4-person household is $23,850, and for a 2-person household, it is $15,730.

[13] See https://www.huduser.gov/portal/datasets/il/il2014/2014summary.odn for the calculations with the adjustment.

[14] DC Office of Planning. http://planning.dc.gov/node/1128597 2010-2014 ACS 5-Year Districtwide (Spreadsheet)

Table 2.1: Income limits for target group[15]

| Income Criteria | Persons in Household | Income Limit |
|---|---|---|
| 200% Federal Poverty Level (FPL) | 2 | $ 31,460 |
| 200% Federal Poverty Level (FPL | 4 | $ 47,700 |
| 80% Area Median Income (AMI) | 2 | $ 54,800 (HUD) |
| 80% Area Median Income (AMI) | 4 | $ 68,500 (HUD) |

### Importance of Using "Household Unit"

This report uses "household" as the unit of analysis, not "family," so a one-person household gets included in the analysis. If "family" had been used, the smallest unit would have been a two-person one.

The average household income size in the District is 2.3,[16] but this report uses a four-person household unit as the basis of its analysis. The reason is HUD starts with a four-person household unit to define income limits, and then applies a formula to define the income limits for household sizes below or above a four-person one.

### AMI Level Used in this Study

This study uses an annual income level of $68,500. This level of income covers all households at or below that level.

[15] Source: For AMI https://www.huduser.gov/portal/datasets/il/il2014/2014summary.odn. Source: For FPL https://static.ark.org/eeuploads/hbe/2014-Federal-Poverty-Levels.pdf

[16] Source: https://censusreporter.org/profiles/16000US1150000-washington-dc/.

# Chapter 3: Theoretical Solar PV Potential of Residential Building Rooftops in Low-Income Communities

## District of Columbia's Commitment to Promoting Access to Solar Power

The results of the District's effort to increase the number solar PV power plants on rooftops of houses in low-income communities have been limited. While some earlier solar PV incentives are no longer operational, tax credits, renewable energy credits, and rebates are still available in some markets. Overall, the District has increased the utilization of solar PV in the city.

In part to increase the penetration of solar PV in the District and in low-income communities within the city, in 2011, the District Government established the District of Columbia Sustainable Energy Utility (DCSEU), with the overall objectives of reducing per-capita energy consumption; increasing renewable energy generating capacity; reducing the growth of peak electricity demand; improving the energy efficiency of low-income housing; reducing the growth of energy demand from the District's largest energy users; and increasing the number of green-collar jobs.[17]

The Sustainable Energy Trust Fund (SETF), funded by gas and electricity ratepayers in the District, provides money to finance the DCSEU programs, and a requirement of the DCSEU is one-third of the funds provided to the organization must be spent annually on energy efficiency, conservation, and sustainability programs in low-income communities.[18]

Thus, the gap in low-income, single-family building participation in the installation of solar PV is beginning to close due to the aggressive rooftop solar PV installations promoted by and paid for – either fully or partially – by the DCSEU. In the past four years, the DCSEU has provided financial support for the installation of approximately 500 solar home systems on the rooftops of low-income, single-family buildings.[19]

[17] DC Clean and Affordable Energy Act of 2008.
https://doee.dc.gov/publication/clean-and-affordable-energy-act-2008

[18] DC Clean and Affordable Energy Act of 2008.
https://doee.dc.gov/publication/clean-and-affordable-energy-act-2008

[19] Interview with Ted Trabue, Managing Director, DCSEU

## Despite Efforts, Installed Solar Power Capacity is Low

Even with the SETF and the DCSEU, only approximately 20 MW of installed solar PV capacity exists in the District. The annual solar PV generation of 31,225 MWh represents a small proportion of the total electricity sales of 2,496,559 MWh to the District's residential sector in 2015; and an even a smaller proportion of total electricity sales of 11,308,230 MWh in 2015.[20]

Table 3.1: Actual Solar PV Generation and Electricity Sales

| | MWh |
|---|---|
| Current Solar PV Generation (2015) | 31,225 |
| Total Residential Electricity Sales (2015) | 2,496,559 |
| Total Electricity Sales (2015) | 11,308,230 |

Source: JSPA analysis of data from the DC Public Service Commission[21]

## Current Goal is to Increase Solar Generation in the District

One objective of this study is to determine–on a theoretical basis–the amount of solar PV available to low-income communities based on the rooftops in these neighborhoods. Alternatively, there will be a determination of the theoretical maximum amount of solar PV power the rooftops in low-income communities can produce.

This study did not consider net generation, reduction in electricity bills, or costs of the consumer-generators. It also did not consider the barriers to solar PV generation from those rooftops, other than to assume the approximate roof surface area available for mounting the panels, with no consideration of the structural condition of the roof to support the solar PV system.

Only estimates of the theoretical maximum from rooftop power plants are considered.[22] Estimates from ground-mount or community solar systems are not included. For the most part, the solar PV technical potential from ground-mount systems located on the properties of single-family buildings and buildings housing low-income residents would not be significant because the District is an urban area with little open land space available in residential communities.

[20] http://www.eia.gov/state/search/#?1=102&2=188&6=134&r=false. Also, see the information on installed capacity in the Appendices of this report.

[21] http://www.dcpsc.org/PSCDC/media/PDFFiles/Electric/electric_sumstats_cust_energyuse.pdf

[22] The focus of this study in on the "maximum," not an expected average potential.

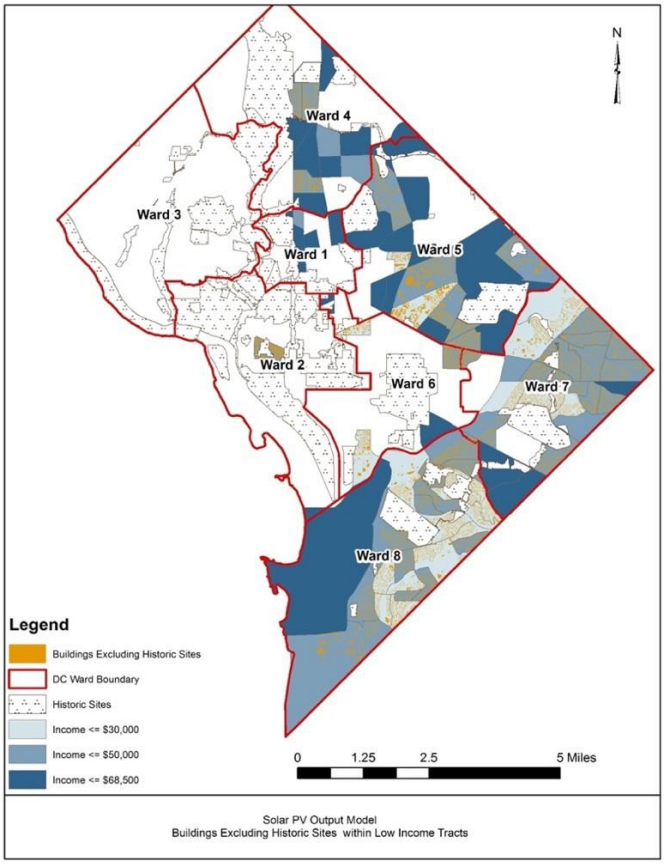
## Methodology Used to Estimate Theoretical Potential

There are many ways to determine theoretical solar PV potential from rooftops. The methodology used in this study is outlined below:[23]

### 1. Identify Relevant U.S. Census Tracts

The analysis starts with selected U.S. Census tracts[24] with median incomes less than or equal to the threshold as "low-income neighborhoods" for GIS (Geographical Information System) maps. Figure 3.1 shows the identified Census tracts based on 80% AMI (HUD)—$68,500 and below.

**Figure 3.1. Identified Buildings Within the U.S. Census Tracts**



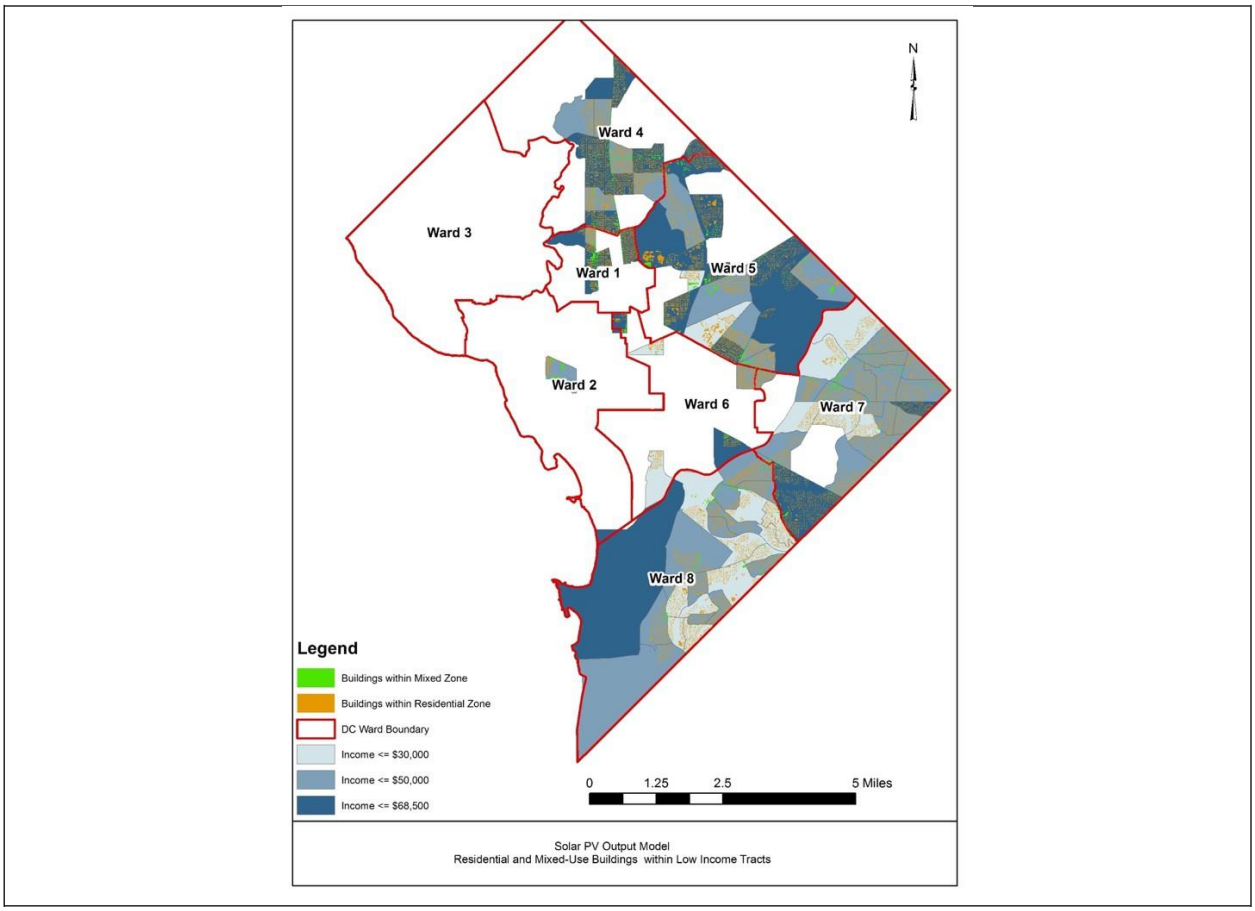

[23] A discussion of data sources in provided in the Appendices to this report.

[24] Missing income data were observed in the attributes of three census tracts in the US Census tract data set. These three census tracts were excluded from the analysis.

### 2. Select Low-Income Residential Areas and Buildings

This step adds two overlays on the "low-income study areas": building footprints and historic areas. The effects of these overlays are shown in Figure 3.2. Historic areas were identified, and low-income buildings within areas were removed. Figure 3.2 shows the resultant buildings in low-income study areas, but not in historic areas.[25]

**Figure 3.2: Identified Buildings within the U.S. Census Tracts Excluding Historic Areas**




### 3. Sort Buildings into Residential and Mixed-Use

The identified low-income buildings were sorted into residential and mixed-use categories, using the District's 2016 zoning regulations. This data set was extracted from the District of Columbia Geographic Information System (DCGIS) open data.

The DC Office of Zoning (DCOZ) defines "residential zoning" as a single dwelling unit, flat, or a multiple- dwelling unit development. DCOZ provides additional residential zoning categories: low-

[25] As noted: All historic districts were excluded. Without special exemptions, historic districts are precluded from having PV panels installed. Chapter 5 notes "historic preservation as one of the barriers to solar PV penetration.

density, medium-density, or high-density neighborhoods. Mixed-use development includes office/retail, housing, and mixed uses. Per the DC Municipal Regulations (DCMR), a development must satisfy the following three criteria to be categorized as "mixed-use":[26]

1. Established, pedestrian-oriented commercial areas, which also include substantial amounts of housing, typically on the upper stories of buildings with ground floor retail or office uses;

2. Commercial corridors or districts, which may not contain substantial amounts of housing today but where more housing is desired in the future. The pattern envisioned for such areas is typically one of the pedestrian-oriented streets, with ground floor retail or office use and upper story housing; and

3. Large sites (generally greater than 10 acres in size), where opportunities for multiple uses exist. (A plan has yet to be prepared to indicate the precise location of these sites.)

This analysis included buildings in low-income area located inside the residential zoning boundary. Mixed-use buildings intersect the mixed-use zoning boundary. The analysis identified 61,843 buildings within the Residential Zone and 2,708 buildings within the mixed-use zone.

### 4. Theoretical Electricity Generation Potential in Kilowatts Using PV Panels

In estimating the theoretical power yield on the rooftop of buildings within the low-income residential and mixed-use communities, this study utilized the constant value assumption method coupled with GIS mapping. This method assumed that 49% of the flat surface areas of the building rooftops is available for the mounting or installation of solar PV power plants.[27] The remaining 51% of the roof area is utilized by other equipment associated with PV installations, such as conduit for wiring and inverters; walkway space for firefighting and maintenance; and other building equipment—such as HVAC (Heating Ventilation and Cooling) equipment, vents or drains—that also occupies some portions of the available spaces.

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[26] Title 11-Zoning DC Municipal Regulations and DC Register, http://www.dcregs.dc.gov/. Also available from https://dcoz.dc.gov/zrr/zr16

[27] Forty-nine percent is an accepted maximum for estimating PV Rooftop Area on flat surfaces with no obstructions. Observations made by PEER based on its fieldwork examining land-based solar farms in the U.S. ranging from 1 MW to 579 MW revealed that in all cases: 1) the sites were flat with no, or almost no, obstructions on the properties except for PV infrastructure; and 2) in no instance did the area of PV solar cells exceed 49% of the land area for the site.

The 49% value is a calculated value, based on past project experiences of PEER, where observations were made at several flat, land-based solar farms in the United States. The comparison with land-based installations was used to show that even with "flat" ground surfaces, only 49% of those areas are used for actual installation of the racking and panels, while the other 51% is used for other purposes associated with the site.

This assumption of 49% of the building roof surface area gives an approximate maximum theoretical electricity generation output.

### 5. Calculate Theoretical Solar PV Output (MW)

"Output" is the resultant electricity generated from putting panels on the roof, and it is expressed in MWh. The "Theoretical PV Output" is calculated as a product of the useable rooftop area, in square feet, and commercially available PV panel peak power output, which is 13 Watts per square foot.[28] The PV Output is expressed in Watts or Kilowatts.[29]

For example, a roof with a useable surface area of 1,000 square feet would have a maximum theoretical PV output of 1,000 x 13 = 13,000 Watts or 13 Kilowatts (KW). The total number of buildings, useable rooftop area and theoretical electricity generation using PV panels is shown in Table 3.2. (Note: Here, the measure of MWs is "direct current" (DC) and not the conventional "alternating current" (AC) measure of MW).

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[28] The Lightway online spec sheet shows 13.6 W/sq. ft. http://www.solardesigntool.com/components/module-panel-solar/Lightway/2397/LW285-35-P1970-990/specification-data-sheet.html. According to the Lightway Solar Module Report, PV rooftop output of 13 watts per square foot is the measure for commercially available PV panel. The calculated output is intended for buildings and not households.

Calculation
Module Type: LW285(35)
P1970 x 990

The "Lightway Panel" produces 285 watts. The panel's dimensions are 1970mm x 990mm, which equate to 197cm x 99cm or 6.46ft x 3.25 ft. The square footage of the panel, including its frame, is 21.0 square feet. That means for each panel, 285 watts is produced from 21.0 square feet which results in 13.6 watts per square foot of panel. PEER's "teaming partners" on actual PV projects have used this panel in the past for commercial projects.

[29] In a perfect world, theoretical potential is the maximum output from an array of solar panels, or the maximum amount of power that can be generated from them. Alternative terms used are "technical potential" and "maximum potential." "Theoretical potential" is a useful concept because it provides a starting point to determine whether a project is worthwhile to pursue, and given the estimate of technical potential in this report, solar PV projects are worthwhile to pursue in low-income communities.

**Table 3.12 Theoretical PV Capacity – MW**

| Scenario/Building Type | Total Number of Buildings | Total Useable Rooftop Area (Sq. ft.) | Total Theoretical PV Output (MW Direct Current) | Average Output per Rooftop (KW Direct Current) |
|---|---|---|---|---|
| TOTAL | 64,551 | 41,824,212 | 543 | 8.4 |
| Residential | 61,843 | 37,144,177 | 483 | 7.8 |
| Mixed Use | 2,708 | 4,680,035 | 60 | 22.5 |

Source: PEER analysis[30]

## Conclusion

The theoretical maximum solar PV electricity that could be generated from rooftops in low-income communities is approximately 543 MW (DC). The average theoretical PV output for low-income residential and mixed-use buildings is about 13,680 kWh (DC).[31]

[30] An analysis done specifically for this study.

[31] See additional information on the calculations in the Appendices to this report.

# Chapter 4: Increasing Amount of Solar Power Sold to Grid

## Introduction

Typically, multifamily buildings and communities (low-income or otherwise) can gain access to solar through rooftop PV installations. However, some rooftops may not be feasible for solar PV for several reasons—lack of space, shading from other buildings, and other structural and zoning issues. However, residents and building owners can still participate in solar through ground-mounted PV systems (in parking lots or other suitable spaces) and off-site community solar systems. Also, when rooftop solar or other distributed energy options exist, residents and building owners can use energy efficiency to lower consumption and increase the number of solar PV-generated "electrons" flowing into the grid. The following simple formula guides the analysis to understand how to increase the amount of solar power sold to the grid:

| $\Sigma$(PV Generation – Electricity Consumption) = Amount of Solar Power Sold to the Grid [32] |
|---|

As this formula suggests, the amount of solar power sold to the grid can be increased by:

1. Reducing the consumption of buildings and households through energy efficiency, conservation, smart design, and

2. Increasing the amount of solar power sold to the grid by optimizing energy generation— "Utilities-in-a-Box" re-imagined, and

3. Increasing the amount of solar power sold to grid by reducing the consumption of buildings and households through energy efficiency, conservation, smart design.

### Dramatic reduction of residential energy consumption through net zero energy homes and deep energy efficiency retrofits

The District is currently planning to drastically reduce consumption in the building sector by reducing New Building Energy Consumption to "Net Zero"[33] by 2032, and Older Existing Building

[32] This is a "notional formula" to illustrate the focus of this report, which is "putting electrons or electricity on the grid." This formula is a simple way to express the amount available to be sold to the grid. It does not represent site-specific single family homes or households who may subscribe to the "Community Renewable Energy Facility" (CREF). For information on CREF see: http://www.pepco.com/DCCREF/

[33]." Net zero energy" buildings produce as much (or more) clean energy than they use annually. Consequently, energy consumption is at a minimum. Utility bills to the extent they exist would cover primarily distribution charges. See "Net

Energy Consumption by 15-30%, by 2032 through stricter standards for energy retrofits, increased funding and education. [34] Also, the District, like other jurisdictions, is systematically raising the requirements for energy efficiency in its building codes and standards on a three-year cycle. These goals are part of the District's "Sustainable DC" plan with the desired outcome being the reduction in District-wide energy use by 50% by 2032, compared with 2012 levels.[35]

Specifically, by 2032:

- For new construction, the District aims to achieve near "net-zero energy building standards"[36] for building performance.[37] Consequently, new housing will produce the clean energy it consumes annually, if not more. The phased approach to adopting net zero energy building codes for new construction will most likely start with smaller residential buildings, under 10,000 square feet. Larger residential and commercial buildings most likely will follow.

- New buildings will have tightly insulated and sealed building envelopes to net-zero standards. They will also have high-efficiency energy systems. These systems will reduce energy needs to modest levels, and on-site, remaining consumption will be offset by generation from renewables, participation in neighborhood scale or "district energy systems," or off-site community renewable generation from within the District. Thus, over time, solar generation–both solar thermal and solar photovoltaic–will become a familiar feature of the District's new building stock, and solar generation will play a larger role in offsetting the energy demand in the city.

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Zero and Living Building Challenge Financial Study: A Cost Comparison Report for Buildings in the District of Columbia" 2013.
https://living-future.org/wp-content/uploads/2016/11/NZEB_LBC_-DC_Financial_Study.pdf

[34] Clean Energy DC; The District of Columbia Climate and Energy Plan (Draft October 2016)
https://doee.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/Clean_Energy_DC_2016_final_print_single_pages_102616_print.pdf

[35] The District of Columbia, 2012, Sustainable DC Plan. http://www.sustainabledc.org/about/

[36]. The U.S. Department of Energy (DOE)'s definition of a Zero Energy Building: "A zero energy building (ZEB) produces enough renewable energy to meet its own annual energy consumption requirements, thereby reducing the use of non-renewable energy in the building sector." This definition also applies to campuses, portfolios, and communities."http://energy.gov/eere/buildings/downloads/common-definition-zero-energy-buildings

[37] California is further ahead: its net-zero building standards will take effect for all new residential construction in 2020. http://www.californiaznehomes.com/

Existing buildings constitute most of the District's building stock, and they are likely to be around for years to come. District policies will expand energy retrofits of these building, resulting in an expected 15-30% reduction in energy usage depending on the extent or depth of the retrofit.[38]

The District's CEP has identified measures needed to achieve these energy goals. They include new regulations; data tracking systems; incentives for adoption of necessary behaviors and actions; and engagement and education programs to increase market awareness, consumer demand, and skills development, as well as funding mechanisms. However, the realization of the full impact of the measures will take time. In the next 15 years, assuming the phasing in of new standards, the District's CEP[39] projects "achievable site energy use reductions" for all commercial and residential buildings are: 5.0% from new construction actions and 5.5% from existing building retrofits, by 2032, as compared with the baseline energy use in 2012.

In the meantime, "affordable housing," overall, is moving at a faster pace than the city in achieving high levels of energy efficiency. Affordable housing is showing the positive results of energy efficiency and how to achieve those results, and it is the trailblazer in creating an ultra-efficiency and net-zero residential sector in the city. Indeed, most of the District's near-net zero energy buildings are affordable housing projects.

**Dramatic reduction of energy consumption through net-zero energy districts**

While this report focuses on housing, another model focuses on geographical areas. Reporting on its integrative business model for net zero energy districts (NZEs), the Rocky Mountain Institute (RMI) notes: "Net zero energy (NZE) buildings—those that are responsible for the production of as much (or more) clean energy as they use annually—have been gaining momentum around the world." Also now, "there are even net zero energy districts being contemplated, like Fort Collins's Fort ZED, Arizona State University, and UC Davis's West Village."

According to RMI, their model "develops net zero energy districts in a way that is attractive to the district developer, parcel developer, and tenants; creates a profitable business or an integrated energy services provider; and benefits the local electric grid and neighboring community. It was developed specifically for a 180-acre development in a midsize U.S. city."[40]

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[38] Clean Energy DC; The District of Columbia Climate and Energy Plan (Draft October 2016), p. 38.

[39] Clean Energy DC; The District of Columbia Climate and Energy Plan (Draft October 2016), p. 45.

[40] Rocky Mountain Institute Business Model for "Net Zero Energy Districts." http://blog.rmi.org/blog_2016_08_01_Report_Release_An_Integrative_Business_Model_For_Net_Zero_Energy_Districts. Here is a link to a full exposition of their model: http://www.rmi.org/Content/Files/Insight%20brief_Net-zero%20energy8_2.pdf

**Impact on affordable housing of increased energy efficiency standards**

How will housing affordability change over the next 5 to 15 years due to increased energy efficiency? Answering this question would add depth to our report, but it was not possible to conduct such an analysis under the current scope of work. For now, the report describes in general terms the effects of energy efficiency on affordable housing.

The low-income housing stock falls into three categories: detached homes; row houses; and high-rise, medium-rise and low-rise condos, and multifamily buildings. Most low-income households are renters. Many low-income residents live in multifamily buildings that qualify as "low-income housing" under affordability guidelines. Also, some live in newer buildings developed at market rates. A portion of these market-rate buildings that are subject to inclusionary zoning laws could include up to 10% affordable rentals. These affordable units would be available to households making up to 80% of AMI.[41]

Over recent years, while the requirements of the District's building codes for energy efficiency have become more stringent for new construction and major retrofits of larger buildings, they have left out smaller residential buildings. Also, existing District "Green Construction" codes do not apply to single-family and small multifamily buildings of less than four stories or 10,000 square feet.[42]

As noted, current green building standards for "assisted housing" have outpaced those in the District's building codes. For example, the "Enterprise Green Community Standards" from the DC Department of Housing and Community Development (DHCD) apply to assisted housing receiving "Gap Funding" assistance for construction and major or moderate retrofits in single-family and multifamily housing, regardless of size.[43] Enterprise Green Community "new construction and major retrofit" standards easily exceed the District's current building codes for energy efficiency.

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[41] Moring, Daniel, 2014. George Washington University Capstone Project (unpublished), M.A. degree program, Sustainable Urban Planning.

[42] An analysis of affordable housing by building type and location is outside the scope of this study.

[43] See Enterprise Green Community Standards for affordable housing:
http://www.enterprisecommunity.com/solutions-and-innovation/enterprise-green-communities

Also, DHCD, which administers Gap Funding, provides special incentives for projects designed with programs requiring advanced, near net-zero levels of building performance, such as Passive House Institute US (PHIUS), Living Building Challenge, and the Zero Energy Ready Home standards of the Department of Energy (DOE).[44] These standards can reduce building and household energy consumption up to 80-90%. Especially given the current push for new affordable housing projects, these green energy standards potentially mean a faster reduction of on-site energy consumption for the affordable housing sector than the projected 5.0% reduction for overall buildings in 2032.[45]

Along with this reduction in energy demand comes a heightened incentive for investing in solar PV. One large group of affordable projects will see this impact almost *immediately:* new projects in the pipeline. Additionally, DHCD is awarding new "Gap Grants" for affordable housing every six months and continues to include near net-zero projects in their grant portfolio.

In the coming years, the DC Housing Authority (DCHA) will be making major retrofits to 80% of its building stock, as funding becomes available. DCHA's properties constitute almost 20% of the District's affordable housing. So, DCHA's efforts will significantly reduce the energy consumption in the city's affordable housing units.

Under the "Enterprise Green Community Standards" and the District's evolving building energy codes, retrofits taking place in the low-income housing stock will be subject to radically higher energy efficiency standards, thereby substantially lowering site energy demand, and making investments in solar PV or distributed solar power more attractive to lower-income tenants.

However, one lower-income housing group not included for systematic improvement of building performance design and retrofit is "private single family homes." This group is neither subject to the District's green building codes, nor to those criteria in the Enterprise Community Standards. The retrofit programs of the DCSEU will reach some of the homes. However, the implementation of the District's new "Solar for All" legislation will need to focus on this housing group.

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[44] 2016 DHCD-HUD 5-Year Plan https://dhcd.dc.gov/service/consolidated-plan-housing-and-community-development and conversations with Molly Simpson, Greening Affordable Housing Program Analyst Urban Sustainability Administration, Department of Energy and Environment.

[45] Clean Energy DC; The District of Columbia Climate and Energy Plan (Draft October 2016)

**Case Studies: Impact of increased energy efficiency on affordable housing**

To date, there are about 10 affordable housing projects in the District built to near net-zero energy building performance standards, and there are more in the pipeline. Consequently, the District has become a "proving ground" for models of affordable net-zero energy and holistic approaches to making housing affordable and sustainable. Provided below are profiles of affordable housing in the District built to near net-zero energy standards, including Passive House standards.

According to PHIUS,[46] buildings that meet Passive House specifications have been shown to use 85% less energy than conventional homes and 75% less than Energy Star homes. They even use 65% less energy than DOE Zero Energy Ready Homes, which is DOE's label for high-performance homes. For these homes, their renewable energy systems can offset their annual energy consumption.

What sets the passive design methodology apart from all others is its proven ability to reduce heating and cooling energy use by up to 90%, compared with conventional construction. With such a "low-energy load" and cost savings, these buildings can then cost- effectively incorporate other "green" features and renewable energy technologies for their electricity needs and achieve near-zero energy use and carbon emissions. Passive principles apply everywhere and to all building types—residential, multifamily, and commercial.

*CASE STUDY #1: DC HABITAT'S EIGHT PASSIVE HOUSE TOWNHOMES*[47]

Habitat for Humanity of Washington, DC (DC Habitat) has been a leader in developing affordable and sustainable housing. Habitat DC's projects showcase affordable, energy-efficient, solar-powered homes in low- and mixed-income neighborhoods. These projects are also pioneering the introduction of near net-zero Passive House townhomes into the District's housing stock.

DC Habitat's eight Passive House townhomes use the "Empower House" model that won DOE's Solar Decathlon's award for affordability in 2011 and have proven to reduce energy loads by 80-90%.[48] The Empower House model was designed using "Passive House" standards by students at the New School and Stevens Institute of Technology, as part of the Solar Decathlon design competition held on the National Mall in 2011, and was developed in partnership with DC Habitat and DHCD.

[46] Passive House Institute US (PHIUS) http://www.phius.org/home-page

[47] Information for this case study was compiled from online sources, interviews and a site visit.

[48] See brief Youtube of DC Habitat for Humanity Dedication in Ivy City of Passive House Home including home tour and tenants: https://www.youtube.com/watch?v=MXV2jisUx5Y

Each of the first two Empower Houses in Deanwood (Ward 7) cost residents $250,000 to purchase, making them affordable. Average energy costs for a typical house in Deanwood is $2,300 per year. A Passive House would bring those costs down to $480 (a savings of $1,910), and a Passive House with renewable energy would bring them down to near $0.

Based on the success of this model, DC Habitat built six more Empower Houses as part of their mixed-income development project in Ivy City, a low-income neighborhood in Ward 5. DC Habitat completed the Passive House townhomes in Ivy City in 2015-2016. DC Habitat made Earth Craft their default building standard because it is cheaper to build using these standards than using Passive House ones.

By using the Earth Craft Standards, DC Habitat's funding could support the development of more houses than if it had used the Passive House model. All DC Habitat homes meet at least LEED Gold standards by using the Earth Craft House Certification. Thus, their homes are at least 15% more efficient than new homes built only to current code. Furthermore, the Earth Craft Standards include a holistic approach and integrated planning criteria for sustainable home and neighborhood development. As a result, those living in DC Habitat Communities enjoy a host of financial, health, and social benefits from being part of a Passive House community.

### *How Habitat DC's Passive House "Near Net-Zero Energy" Home Serves Low-Income Customers*

At the time of this study, the median sales price of a house in the District is $499,900. According to DC Habitat and DHCD, half of the District's households spend greater than or equal to 30% of their income on rent, and 20% of District residents spend up to 50% or more of their income on rent. Given these income-to-rent ratios, near net-zero energy homes help improve the affordability of housing.

This DC Habitat model focuses on home purchases, not rentals. It uses a tiered-based financing mechanism to help fund homes and make them affordable for low-income households. Buyers sign a 15-year covenant. This covenant prevents them from selling their home at market rates and "flipping."

Orlando Velez, former Director of Housing Programs and Community Advocacy at DC Habitat, provided an example of a District family that had previously qualified for federal housing benefits. The family saved so much on energy bills in its new Passive House, it no longer needed public assistance.

### *CASE STUDY #2: ULTRA ENERGY EFFICIENT MULTI-FAMILY RETROFIT MODEL: WEINBERG COMMONS (HOUSES SPECIAL NEEDS RESIDENTS, WARD 7)*[49]

Through a low-income energy efficiency retrofit and upgrade model to achieve net-zero energy, residents of Weinberg Commons, a three-building, 37-unit apartment complex (Ward 7) can realize 70-90% in energy savings for a typical two-bedroom apartment compared with apartments in the wider DC area. Weinberg Commons is the nation's first certified, multifamily Passive House retrofit development.

The renovation project transformed run-down apartments into housing units with state-of-the-art energy features, affordable rents, and services for low-income families. Weinberg Commons used Passive House standards. Adhering to those standards cost approximately 8% more than using traditional techniques and materials. Some of the energy efficient features include:

- Well above code-compliant wall and airtightness
- High-performance insulation and air sealing
- Solar gain design features that optimize shade and sun for year-round comfort and energy efficiency
- Energy Recovery Ventilator
- Ground loop heat exchanger
- High-efficiency heating and cooling
- Drain water heat recovery
- Solar thermal collector for domestic hot water
- On-site PV array, a cost-effective addition to a very energy efficient building.

Because the benefits exceeded the costs, Weinberg Commons charges below-market rents, including all utilities. Reduction of energy consumption by 50%, with a target to achieve a 90% reduction, is among the benefits.

### *CASE STUDY #3: ULTRA ENERGY EFFICIENT LOW-INCOME SUSTAINABLE DESIGN PILOT MODEL: eCASA*[50]

Inscape Publico is a 501(c)(3) nonprofit architecture firm whose mission is twofold: (1) to provide professional architectural services for other nonprofits and for the people those nonprofits serve; and (2) to foster excellence in design and create architecture that represents the vision, goals, and sensibilities of each nonprofit it serves.

[49] Information for this case study was compiled from discussions, interviews and a review of documents.

[50] Information for this case study was compiled from discussions, interviews and a review of documents.

Mi Casa (a nonprofit provider of affordable housing, sustaining diverse and healthy communities in the District and Baltimore metropolitan areas) and Inscape Publico are collaborating on a net-zero housing prototype. This project will provide affordable high-performance housing to low-income families in the District. The house is net zero, through photovoltaics producing as much energy as it uses annually.

The project aims toward sustainable energy and environment, energy and space efficiency, lower energy costs, and improved comfort, and quality of life. The project will combine energy efficiency and storm water management through the implementation of green roofs. Green roofs will mitigate "the urban heat island" effect associated with conventional construction. This mitigation, in turn, cools the surrounding air, reduces storm water runoff by 50-90%, improves the thermal resistance of the roof assembly, increases the life expectancy of the membrane roof, and provides an opportunity to produce and cultivate urban rooftop farms.

Efficient artificial lighting, in combination with ample daylight, transforms a space and improves one's experience of space while reducing energy consumption and improving the functionality of the space.

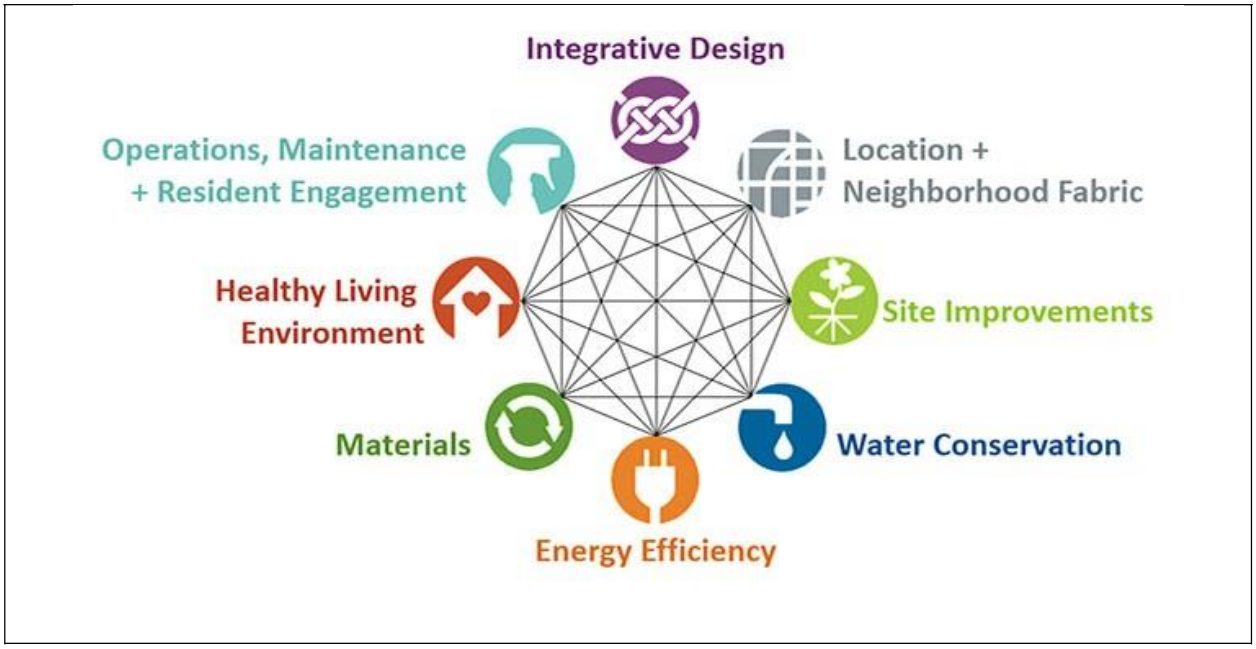
### *CASE STUDY#4: AFFORDABLE SUSTAINABLE COMMUNITY APPROACH: DHCD ENTERPRISE GREEN COMMUNITY MODEL*[51]

As discussed previously, DHCD requires Enterprise Green Community Standards for all affordable housing projects receiving Gap Funding in the District. Also, as mentioned, overall, these green community standards are more stringent than the District's energy efficiency building codes. While these standards do not mandate "ultra-efficiency" levels for building performance, they structure a holistic approach to sustainable communities whether low- or mixed-income. Figure 4.1 below illustrates this approach.

DHCD deserves credit and recognition for having adopted these standards. Its approach means District residents and neighborhoods will receive economic (financial), environmental (water conservation), social (health and community), and energy security (resiliency) benefits. This holistic, integrative approach reflects a growing trend in low- and mixed-income urban planning.

[51] Information for this case study was compiled from DHCD documents describing the program and from discussions.

**Figure 4.1 Enterprise Green Approach**




Source: Enterprise Green Communities 2015 criteria

## The impact of implementing smart roof technologies in conjunction with solar PV

Smart roof technologies such as "cool paints," polymer coatings, and green or vegetated roofs reduce the energy required for space conditioning and storm water runoff into local water bodies. Polymer roof "paint," which is an advanced nanotechnology coating, can cool the roof and absorb the water. These types of roofs exceed the District's new storm water regulations.

The polymers can be cross-linked to absorb a desired amount of water. When a precipitation ends, the absorbed water sublimates, which is much better than evaporation and provides a cooling effect as well as a heat selection effect.

The U.S. Environmental Protection Agency (EPA) and the District government have accepted the District's storm water runoff has severely impaired the Anacostia Watershed system. Several benefits gained from incorporating smart roof technologies (applicable to residents of all income levels) include:

- Reductions in direct energy use, peak demand, greenhouse gas emissions; UHI effect (indirect energy use); urban pollutants related to "heat mortality"; ozone concentration; fine particles <2.5 micrometers, aka PM2.5; landfill usage by extending roof life; and storm water fees, which provide additional financial incentives to install these technologies.

- Increases in global cooling; protection of roof from elements, resilience to reduce risks due to energy market fluctuations, PV efficiency, employment through an increase in rooftop agriculture opportunities, and aesthetically-pleasing homes.

These benefits exceed the costs, including installation, maintenance, replacement, and disposal. As distributed generation is becoming much cheaper, distributed electricity storage is too, largely due to mass production of batteries for electric vehicles. Solar power is already starting to erode utility sales and revenues in some parts of the world and in the United States. The bringing together of solar PV plus related rooftop, battery storage, and smart technologies will drive energy prices lower than those offered by utilities, and will make the electric grid optional for many customers, without compromising the reliability of their energy.

### Increasing the amount of solar power sold to grid by optimizing energy generation—"Utilities-in- a-Box" re-imagined

A "Utility-in-a-Box" concept ("re-imagined") expands on these "+ solar" combinations. It combines appropriate energy generation enhancement and energy conservation technologies with solar PV, which enables customers to reduce their dependence on the utility grid or better yet, allows them to "cut the cord" entirely. Per RMI's 2014 report the "point at which solar-plus-battery systems reach grid parity—already here in some areas and imminent in many others for millions of U.S. customers—is well within the 30-year planned economic life of central power plants and transmission infrastructure."[52] In places like Hawaii—for commercial "solar-plus- battery systems" with a standby generator—grid parity is already here under all modeling scenarios. In other regions with high commercial retail electricity prices, such as the Northeast (for example, Westchester County, N.Y.), these systems will potentially become competitive with retail prices within the next 10 years.

Since residential grid parity typically lags commercial parity by five years, technology advancements, smart bundling of appropriate measures, demand-side improvements, and deployment of robust financing, public policy and partnership mechanisms can accelerate grid parity for the residential sector.

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[52] Rocky Mountain Institute. "The Economics Of Grid Defection; When And Where Distributed Solar Generation Plus Storage Competes With Traditional Utility Service."
http://www.rmi.org/PDF_economics_of_grid_defection_full_report

The District's CEP contemplates a systematic, planned approach for integration and optimization of distributed energy resources (DERs) District-wide, and examines new policy, education, financial incentives and regulatory frameworks required to integrate and optimize DERs. In the meantime, "integrated energy planning initiatives" are being included in projects underway by DHCD and DCHA.

Estimating the added value of future wide-scale adoption of integrated energy systems for the lower-income sector in the District is beyond the scope of this project. However, below there is a description of (1) how solar PV + storage, + combined heat, + micro-grids, + structural design, etc. can be—or is being—integrated with affordable housing in the City, and (2) what the potential of this combination could be.

### *Design + Solar*

Design features can optimize the amount of solar power generated from rooftop panels in significant ways.

- *Siting of buildings and design of new or replacement roofs* for "solar readiness" or solar integration.
- *Directionality of panels.* though "southern facing panels" are the default for installation, in certain jurisdictions, California is providing financial incentives for westward facing panels to capture more sunlight for power generation in the afternoon, when the grid needs it most.
- *Roofing materials and "cool" or "vegetative" roofs* (as noted above) can reduce overheating of solar panels and losses of efficiency, as well as mitigate the "urban heat island" effect overall, and in the case of "vegetative" roofs, reduce storm water run-off.

### *Design features can be promoted by policy*

- The District is considering adding "solar readiness" to its green building codes, similar to what the City of Baltimore has done. "Solar readiness" is among the recommendations of the District's CEP Plan.[53]
- The Enterprise Green Community building standards (as noted above) apply to all District affordable housing receiving Gap Funding through DHCD, and those provisions cover "solar-ready" rooftops.
- The District (also, as noted above) provides financial incentives for installing vegetative roofs, and the city's building codes already stipulate several "cool roof" or solar reflectance and thermal emittance criteria.[54]

[53] Clean Energy DC; The District of Columbia Climate and Energy Plan (Draft October 2016), p. 83

### *Energy Efficiency + Solar PV + Storage*

Broadly speaking, solar power generation faces two challenges. First, it does not produce energy when the sunlight does not hit the panels.[55] Also, some grids (particularly aging ones and those lacking in distribution automation infrastructure) are not able to accept solar power once total solar and other distributed energy resource generation exceeds certain levels

"Storage" enhances the benefits of solar power generation because it makes energy available even when the sun is not shining. Storage is also helpful for both single-family and multifamily dwellings since it can reduce costs, increase resiliency, and balance supply and generate financial benefit on the grid.[56]

Storage systems include batteries as well as other forms.[57] "Battery storage" is quickly being adopted throughout the United States, and is dropping in price. Solar + storage can be integrated into a standalone project or incorporated into a micro-grid that provides other critical functions. (See discussion below of "solar + micro-grids.")

**Financing models to promote the adoption of "storage"**

States are recognizing the potential benefit of solar + storage for both single-family and multifamily lower-income dwellings, and several pilots have recently been deployed, or are in the process of being developed, using different financing models.[58]

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[54] DC Municipal Regulations and D.C. Register. Cool Roof Requirements
http://dcregs.dc.gov/Search/FullTextSearch.aspx?SearchType=DCMR&KeyValue=cool+roofs

[55] Even if the District did not have a "sunshine problem," 'not enough sunlight hitting the panels" would still be an issue because of shading from neighboring structures and other orientation.

[56] The focus here is on "solar + storage" having greater financial and resiliency benefits compared to "solar only."

[57] For an update on compact ice storage units being used in Southern California, tied to solar, see:
http://www.utilitydive.com/news/ice-energy-will-provide-1-mw-of-residential-storage-to-southern-california/435676/

[58] For current examples of solar + storage deployment for low-income housing, see:

States are also adopting time-of-use electricity rates because storage becomes more affordable when these rates are available for residential customers. California, Illinois, Hawaii, Arizona, and Ontario, are using them. When electricity rates are tied more directly to the market price and actual demand, and where the ratio of off-peak price is high, the benefits of solar, and solar + storage can increase considerably.[59] This linking of rates and demand is the one reason for the rising adoption rate of storage in California.

The value propositions for a "utility-in-a-box" have different characteristics depending upon regulatory frameworks and rate design. For example, currently, regulatory obstacles for time-of-use pricing exist in the District. To overcome them would require policy and rule changes.

Solar + Storage can:

- Reduce potential financial risks that may arise from "solar only." Tenants overall and particularly those on a fixed income may experience an increase in economic insecurity because they may be subject to value-of-solar tariffs (VOST) and net metering. With VOSTs and net-metering, tenants might face fluctuating and spiking rates. Solar + storage mitigates these risks.
- Make solar energy more valuable and open the opportunity for many new sources of revenue for affordable housing developers, which they can then pass on to their tenants.
- Provide clean, reliable power during an emergency.[60]

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Brooklyn, NY, Marcus Garvey Complex:
http://www.globalsmartgridfederation.org/2017/02/01/nyceec-brings-the-battery-to-brooklyn-financing-energy-storage-for-a-low-income-housing-microgrid

Vermont, McKnight Lane Rural Redevelopment Project:
https://www.solarreviews.com/news/low-income-net-zero-energy-housing-project-vermont-solar-storage-102016

California's Imperial Irrigation District Program
http://www.utilitydive.com/news/enphase-grid-alternatives-launch-low-income-residential-solar-plus-storage/435498/

[59] For a recent description of a value proposition of solar + storage with "time of use rates," See Seth Mullendore (January 20, 2017). "Time-of-Use Means It's Time for Storage" http://www.cleanegroup.org/hawaii-tou-solar-storage/

In its October 2015 report "Resilience for Free,"[61] the Clean Energy Group[62] (CEG) describes how the use of solar with storage systems can "reduce costs and increase power resiliency in multifamily affordable housing." CEG suggests "battery storage is the emerging third generation of clean energy technologies for affordable housing in the country–following investments made in energy efficiency and renewable energy." CEG argues that "with the right market structures and incentives, solar + storage systems can provide an economic return while making affordable housing energy resilient by powering critical loads like common area lighting, water, and communications–protecting vulnerable residents at little to no net cost.[63]

CEG's economic analysis model for the District concludes:

> *While the payback period is similar for solar-only [approximately three- to five-year payback period], the solar + storage system achieves a higher cumulative project value over 20 years and provides crucial resiliency benefits solar-only systems cannot.* [64]

CEG based its model on $40/MWh for frequency regulation sold to the transmission grid. Since its report was issued, the price has been falling—to $12-$20/MWh in 2016[65]—which means a significantly longer payback period. However, the length of this payback period will be reduced to some extent by decreases in the price of storage systems.

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[60] Waite, Wayne and Milford, Lewis. (March 23, 2016) "Efficiency, Solar and Storage Offer a Unique Opportunity to Bring Clean Energy to Affordable Housing" https://www.greentechmedia.com/articles/read/affordable-housings-progress-toward-integrated-energy-solutions

[61] Resilience for Free: How Solar + Storage Could Protect Multifamily Affordable Housing from Power Outages at Little or No Net Cost, 2016, http://www.cleanegroup.org/ceg-resources/resource/resilience-for-free-how-solar-storage-could-protect-multifamily-affordable-housing-from-power-outages-at-little-or-no-net-cost/

[62] Clean Energy Group; Innovation in Finance, Technology & Power http://www.cleanegroup.org/ceg- projects/resilient-power-project/

[63] *Resilience for Free* p.2.

[64] *Resilience for Free, p. 15.*

[65] James McAnany. (March 6, 2017: 2016 Demand Response Operations Markets Activity Report; March 2017. See Figure 39 of http://www.pjm.com/~/media/markets-ops/dsr/2016-demand-response-activity-report.ashx.

CEG's report goes on to note:

> *However, with the pressing need for more resilient buildings to protect people in need, pure market forces should not be the only way to protect people against the next major disaster. Our analysis further suggests that policy makers in states like New York that want more resilient power must do more. These states should consider implementing targeted incentive programs that support solar + storage development in low-income and affordable housing sectors. Such programs are needed to improve the economics of those projects, protect those in need, and accelerate market development for resilient power technologies in low-income communities. Three years after Superstorm Sandy, it is time to act without delay.* [66]

The importance of "resiliency" is being highlighted. Solar + storage (battery storage or thermal storage) enhances emergency back-up power. Solar + storage can make solar power available during prolonged outages due to emergencies–whether nature or manmade.[67] These characteristics make facilities serving the District's most vulnerable populations priority candidates for solar + storage (for example, seniors and disabled residents have unique emergency power back-up requirements.)

The "Resilience for Free" report highlights the value of providing "ancillary services" to the grid. In addition to the resiliency benefit, energy storage can provide valuable frequency regulation to balance power supply with power demand throughout the day. The PJM Wholesale Interconnection Market can compensate energy generations that provide this grid stabilization service,[68] and thus benefit both owners of solar + storage systems by helping to finance these systems, and potentially ratepayers District-wide through more efficient management of the grid.[69]

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[66] *Resilience for Free*, p.25.

[67] *Resilience for Free*, p.8.

[68] PJM Interconnection is a regional transmission organization (RTO) that coordinates the movement of wholesale electricity in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia.

[69] *Resilience for Free*, pp. 14-17

### *Neighborhood Scale Energy Systems: Combined Heat & Power, District Energy, Micro-Grids + Solar PV*[70]

Solar + storage when combined with highly efficient generation devices, such as CHP units often enhances other sources of power that increase resiliency.

> *Highly efficient generation systems, such as combined-heat-and power (CHP) units, often make sense when combined with solar + storage to enhance resiliency. These devices can increase the resiliency benefits of a system and may improve the overall economics of the system as well. In general, adding solar + storage to an existing or planned CHP system should not negatively impact the economics or functionality of the system*.[71]

Large, multi-family affordable housing projects or campus-style housing complexes owned by a single owner, such as DCHA (another of this report's case studies), lend themselves potentially to the installation of highly efficient on-site, centralized neighborhood-scale power generation and distribution systems that provide both electricity and thermal energy for heating and cooling.

Such systems include "combined heat and power" (CHP), "district energy systems," or ultimately, micro-grids. These systems can run either in parallel to or in isolation from the grid. As a result, they offer functionality to critical facilities–for example, affordable housing for seniors and the disabled during grid emergencies. Such systems at present are primarily run on natural gas, but increasingly, they are being designed for or converted to clean, renewable energy, using hybrid systems.

Energy efficiency, solar PV, and energy storage play a valuable role in the proliferation of such energy generation systems nationwide. These systems offer a host of benefits: financial, environmental, back-up in case of grid emergencies (including long-term blackouts), as well as direct benefits to the grid. When further integrated with infrastructure planning of municipal energy distribution systems, even higher levels of benefits may be achieved. Examples of planning include electrical grid circuitry and substation upgrades, the use of thermal systems such as sewage pump stations or waterways, or other locational resources.[72]

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[70] The Appendices provide detailed descriptions of combined heat and power and district energy.

[71] *Resilience for Free*, p.26, footnote 9.

[72] Ken Kellison. (January 2016). Unlocking the Locational Value of DER 2016: Technology Strategies, Opportunities, and Markets www.greentechmedia.com/research/report/unlocking-the-locational-value-of-der-2016

In fact, the D.C. Council has allocated funding to DCHA to install a CHP plant at Langston Terrace project, a 20-building complex. DCHA chose a sophisticated turbine-driven combined heat and power plant after the agency explored several options. Solar generation will complement the CHP system, and consideration is being given to eventually phasing in full micro-grid capability. (See profile of the Langston Terrace initiative below.)

In the wake of Superstorm Sandy (Hurricane Sandy) micro-grids have gained tremendous attention across the United States to provide community-scale electric back-up during long-term grid failures, whether due to natural or potentially, man-made disasters. The District is no exception as noted in the report "District Energy; Deploying Clean Energy Microgrids in the Nation's Capital."[73]

**A case study that validates the reimagined "utility-in-a-box" approach**

*Case Study #5: Langston Terrace DCHA Community Scale Energy Resources*[74]

DCHA properties consume an aggregate of approximately 65,000,000 kWh (65,000 MWh) of electricity per year. These figures include DCHA's roughly 60 affordable residential projects comprising 8,000 units (2016 figures) along with its other, non-residential buildings.

A combined cooling, heat and power system (CCHP) is the basis for the redesign of an old power plant DCHA's Langston property in Ward 7. This redesigned power plant will generate electrical output to meet a significant portion of DCHA's overall electricity demand, and thermal energy (waste heat from the electric power plant) will provide community-wide (district) heating and cooling.

Currently, there is no quantification of the new plant's "community thermal off takes." Most likely one or two gas turbine generators will run the new "tri-generation" plant (producing heat, cooling, and power). Based on feasibility studies, the plant will produce 100 percent of the electricity at Langston Terrace, and as much as 15 percent of the electricity at DCHA's remaining properties.

[73] See the definitions for CHP, District Energy, and Microgrids, along with brief Youtube illustrations and links report in Appendix Also see: DISTRICT ENERGY: Deploying Clean Energy Microgrids In the Nation's Capital. Prepared for the Department of Energy and Environment September 2015
https://doee.dc.gov/sites/default/files/dc/sites/ddoe/service_content/attachments/DOEE%20District%20Energy%20Presentation%20(Sept%202015).pdf

[74] Information for this case study was compiled mainly from DCHA's documents describing the plans of the Agency.

Langston Terrace is the showcase project of DCHA's "Energy Capital Improvement Plan," which is funding sustainable improvements in 44 of its properties. DCHA plans to increase its solar capacity tenfold and to conserve water by installing low-flow plumbing fixtures and utilizing more efficient pumps throughout its properties. A computerized monitoring system will:

- Link several properties
- Provide real-time heating and cooling
- Increase the awareness of users and employees of their energy use;and
- Allow employees to respond quickly to any problems or issues to maximize savings.

Langston Terrace Dwellings are historic structures located in the Kingman Park neighborhood in the District's Ward 7. The apartments, built between 1935 and 1938, are listed on the National Register of Historic Places. Langston Terrace was the first federally funded housing project in the District and only the second one in the United States. The cost was $1.8 million. The rent for rooms was $6 per month, or $4.50 per month, without utilities. Primarily African American laborers constructed this 274-unit complex. These garden apartment buildings were built around common areas. Daniel Olney's "The Progress of the Negro Race" is a terra-cotta frieze in the central courtyard. It depicts African American history from slavery to World War I migration.

In 2012, the District provided DCHA with $245,000 from the Sustainable DC Innovation Challenge grant to test the feasibility of redeveloping an idle power plant at Langston Terrace into a clean energy-generating asset. The study, completed in January 2014, found the energy usage of the residential units was higher than comparable buildings, due primarily to an antiquated HVAC system that was not optimized and could compromise indoor air quality. (This situation is typical for low-income multifamily buildings and is disproportionately affecting low-income, minority residents.)

The study explored seven scenarios for clean energy generation and recommended three of them for further investigation during the pre-development phase:

1. District-scale bio-gas powered fuel cell with rooftop photovoltaic panels
2. A geothermal exchange variable refrigerant flow heating and cooling with rooftop solar photovoltaic panels; and
3. Heating upgrades and the introduction of cooling along with rooftop solar photovoltaic panels.

The study also explored multiple technologies for potential use such as: solar PV, solar thermal, split system DX cooling, Variable Refrigerant Flow (VRF) heat pumps, geothermal exchange, fan coil unit retrofit (heating/cooling), micro-turbine generators, turbine generators, fuel cells, electric chillers, and absorption chillers.

The results of the Langston Terrace study showed the project has the potential to be an engine of revitalization for the community by demonstrating how to leverage the Langston Power Plant beyond just energy production and energy savings renewable energy power production. The study's results highlighted the expected significant improvement in the quality of life of the residents that will take place.

DCHA and its partners held several sessions to teach residents about renewable energy, to listen to their ideas, and to create a program that would benefit their families. There were field trips and a scholarship competition for young residents of Langston Terrace to explore further sustainable programs in the District and worldwide.

The project incorporated outreach and engagement to ascertain the resident priorities. Some of their priorities included:

- Creating jobs for residents
- Addressing space and comfort conditions and maintenance issues
- Developing a center of education for the community, with an emphasis on preparing youth for STEM (Science, Technology, Engineering, and Math) jobs; and
- Reducing pollution by generating clean electricity.

## Lessons Learned from Case Studies

### *Affordable Housing*

**DCHD is:**

- Providing the results of the reduction in energy consumption, primarily based on the implementation of the Enterprise Green Community Standards.

- Generating data from its existing projects to suggest "useful practices" that other groups can follow to reduce the energy burden in low- and moderate-income households since the agency is moving faster toward reducing energy consumption than the overall rate of reduction for the District.

**Nonprofit Housing Providers**

Nonprofit housing providers such as DC Habitat are:

- Pioneering Net Zero Passive House projects. The aim of these housing providers is to reduce the energy burden of low- and moderate-income households.
- Sharing data on the effects these types of homes have had on reducing the energy burden, and noting the support they receive from agencies to mitigate barriers to solar PV.

*Public Housing*

DCHA is:

- Exploring useful practices for reducing the operating costs of public housing, reducing the energy burden of the residents, and enhancing the overall quality of life for residents.

*Private Single-Family Homes*

Private single-family homes will most likely experience an increase in solar PV because of:

- The energy codes for new construction or major renovation;and
- Financial incentives for solar + energy efficiency lower the costs of new construction and major renovations.
- Increasing the amount of solar power sold to the grid by expanding low-income participation in distributed solar

**For-profit models: Individual households**

Several firms are currently installing solar panels in the District. SolarCity, the most prominent one, is a national enterprise. At present, the focus of these companies is not on low-income households, which may change after government agencies take the actions proposed in Chapter 5.

Nevertheless, it is useful to understand the SolarCity model, to understand how for-profit models can serve low-income residents and what nonprofits can glean from their experiences.

SolarCity is America's leading full-service solar provider and the largest installer of residential solar systems in the United States. It offers four pathways to solar in the residential sector:[75]

1. Cash Purchase: SolarCity brokers this deal and handles the installation. Homeowners receive the panels free and clear and can own the panels permanently. This pathway may be suitable for their target group. Very likely, it will not be appropriate for those below 200% FPL (Federal Poverty Level) because households at this income level do not have funds to finance the panels.

2. Loan: $0 down payment, 10 or 20-year repayment term, as low as 2.99% APR, and residents gain federal tax credits. This pathway is unlikely to be suitable for limited-income households because it involves fixed monthly payments for many years.

3. Power Purchase Agreement: SolarCity owns the panels, installs them, and then sells the power they generate to the consumer. Per SolarCity, the rate charged per kWh is typically lower than what a utility charges. This method is likely to be suitable for their target group. Hence, the question is: "Is this pathway advantageous to SolarCity for limited-income households?" This question needs to be investigated. However, it is likely that consumers with limited power usage per month will be attractive, as the revenue streams they generate may be quite low.

4. Lease: SolarCity takes no money down and leases panels over a 20-year period, covering installation costs. The consumer never owns the panels. Instead, they rent them and acquire the energy they capture. This lease option allows some homeowners to pay less each month than they previously paid for electricity from the utility company. This pathway is unlikely to be suitable for the limited-income households because it involves fixed monthly payments for many years.

SolarCity offers roof and system warranty and installation free-of-charge on all residential installations, which is the largest overall upfront cost. SolarCity specifically designed this option to lower the upfront costs to their customers. Prospective residents get a free, customized quote for residential rooftop solar using energy bills and satellite imaging to obtain the necessary information. Customers also get free 24/7 support and unlimited access to the MySolarCity app (which has state-of-the-art data analytics capabilities on the backend and can capture data across SolarCity's installation footprint). "It is a marriage between big data and energy services" says Jonathan Bass, spokesperson for SolarCity.

[75] The information in this section on SolarCity is drawn from several sources: http://www.solarcity.com/
http://www.businessinsider.com/how-solarcitys-business-works-2016-8
https://www.bloomberg.com/news/articles/2016-05-09/solarcity-loss-widens-as-biggest-rooftop-installer-slows-growth
http://marketrealist.com/2016/04/solarcity-make-money/

**For-profit models: community subscription**

SolarCity and Sunrise Energy Ventures have partnered[76] to create a new community solar program in Minnesota that allows renters, schools, municipalities and other customers to purchase renewable energy without installing solar panels on their properties. SolarCity will invite renters, low-income housing residents, schools, and others in the Minneapolis-St. Paul area to enter subscriber agreements to purchase the solar power that the gardens produce at a rate of 13 cents per kWh.

There is no compelling reason why the model SolarCity and Sunrise Energy Ventures developed and used in Minnesota cannot be a model well-suited to nonprofit organizations as well. The applicability of this model for nonprofit groups should be explored in the District.

For up to 25 years, Xcel Energy—a utility company providing the energy that powers millions of homes and businesses across eight Western and Midwestern states—will credit subscribers at a rate of 14.7 cents per kWh purchased from SolarCity through a "solar garden subscriber agreement." The anticipated saving of 1.7 cents per kWh (11.5 percent) will be immediate for subscribers, who will remain Xcel Energy customers.

As of January 2017, Arcadia Power a for-profit company based in the District began offering a new community solar subscription model that crosses both state and utility borders.[77] It allows both District residents and people outside the District to purchase subscriptions that fund new solar installations in the District and lower their bills through a monthly direct on-bill credit provided on their utility bill by Arcadia Power's software.

Arcadia Power sets up community solar projects on a local host property, using a power purchase model financed through "community subscribers." Proprietary software intakes all PPA payments along with SREC revenues for a given host site, and distributes it to participants through billing software compatible with the local distribution utility (Pepco). The minimum cost of participating in the community subscription program is $300, making it affordable to households with modest incomes, though not those at lower-income levels. To date, 12 such projects have taken off in the District.

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[76] SolarCity Introduces its First Community Solar Option for Renters (Press Release June 15, 2015). http://www.solarcity.com/newsroom/press/solarcity-introduces-its-first-community-solar-option-renters

[77] Arcadia Power: Save with Arcadia Community Solar (Website) https://www.arcadiapower.com/solar; and interview with Arcadia Power Community Solar Program Director Joel Gamoran, 3/24/17.

These models offer significant potential for the District and should be considered further by the PSC, DOEE, OPC, and Pepco with firms interested in developing models suitable for low-income residents—whether financed by for-profit entities or nonprofit institutions.

**Community solar**

Community solar offers an equitable solution for District ratepayers—including low-income ones, who cannot install solar directly at their residences—to receive the financial and environmental benefits of locally generated solar energy. The process of "virtual net-metering" (VNM) enhances access to community solar. VNM permits ratepayers to "subscribe" to a solar installation off-site (within the District). "Once they have done so, the electricity produced by their portion of the solar installation will be credited to their monthly electric bill."[78]

As part of the growing trend in community solar in the United States and spurred by strong civic advocacy, the District passed a legislative mandate for community solar (2013) for which the District's Public Service Commission developed a regulatory framework (2015),[79] and Pepco, a set of procedures. Of the various models from around the United States for financing community solar (or "virtual net metering") two models have emerged in the District for low-income ratepayers—the Corporate Community Benefit Model and the Nonprofit Model.

### *Corporate Community Benefit Model*

The Corporate Community Benefits Model is the first community solar project in the District to be up and running. The Nixon Peabody law firm's solar demonstration project (DC Rooftops for Low-Inncome Residents Community Solar Project) was interconnected to the grid by Pepco in March 2017.[80]

[78] From the DC SUN website which describes the substance and mechanics of the District's community solar succinctly: https://sites.google.com/site/dcsolarunitedneighborhoods/key-issues-and-committees/community-renewable-energy-act-of-2012

[79] See "Community Renewable Energy Act of 2013": http://dcclims1.dccouncil.us/lims/legislation.aspx?LegNo=B20-0057 and District Public Service Commission rules at http://dcpsc.org/Utility-Information/Electric/Renewables/Community-Renewables-Energy-Amendment.aspx

[80] Project summary produced for this report by the Nixon Peabody Law Firm, LLC, community solar project team, Nixon Peabody Partners, Herb Stevens and Jeff Lesk, March 2017.

The Nixon Peabody Law Firm's project operates on a pro bono basis. The project is a corporate community benefit model for low-income homeowners in the District. (See Nixon Peabody's detailed description in the Appendix.).

In the Nixon Peabody project, rooftops of three mixed-use buildings in Downtown D.C., owned by a single commercial entitty are being used to host solar panels. These send 181 KW of power to Pepco's grid, resulting in $26,000 worth of electricity a year (using a base of 12.5 cents/KWh). So far, 88 low-income ratepayers are signed up as "subscribers" to this community solar project, a number expected to reach 100-105 shortly. Subscribers get $250/year for the 20-year life of the project, through a credit on their Pepco bills.

All residents are renters in two affordable housing apartment complexes, in Southeast and Southwest D.C., which are individually metered to tenants. Tenants thus each have an account with Pepco against which their bill is credited for the amount of electricity generated by their community solar subscription. The Nixon Peabody law firm receives no material benefits from this project, and neither does the property owner hosting the solar panels, who also is participating on a corporate community benefit basis.

**Nonprofit Model**

Two D.C.-based nonprofit institutions—Groundswell, which provides equitable clean energy, and The Temple of Praise Church located in Southeast, D.C.—are in the initial stages of collaborating on a low-income "equitable community solar project" announced in December 2016. The location of the solar panels will be on the property of Temple of Praise Church. The aim of the project is benefit 150 or more low-income households in District Wards 7 and 8. In this nonprofit financed, mission-driven community solar model, "anyone who pays their power bill, including renters and owners, can buy subscriptions for a portion of the energy produced by the system, which is credited against their power bill."[81]

[81] https://groundswell.org/temple-of-praise-groundswell-cs-pressrelease/

**Other Community Solar Financing Models**

The Nixon Peabody corporate community benefit model can be utilized and works well with non-profit entities such as Grid Alternatives. Incentives can be shared with building owners so long as the amount of financial benefits to low-income residents is at least equal to the value of all the electric energy produced for at least 15 years and the low-income residents have the potential to share in other benefits of the system.[82]

For examples of other models for financing community solar emerging around the country, see document linked below. It includes the model the City of Baltimore adopted to reduce the risks of financing community solar installations, an approach that will help Baltimore to meet "its goal of providing solar energy to 1,000 low-income households."[83]

[82] Interview and correspondence with Nixon Peabody Partner & Chief Innovation Officer, Herb Stevens and DC Office Managing Partner Jeff Lesk, March 2017.

[83] https://energy.gov/eere/articles/3-cool-ways-finance-community-solar-projects

# Chapter 5: Identifying and Removing Barriers

## Introduction

As noted in Chapters 3 and 4, long-standing District policy expresses interest in insuring low-income families have access to solar PV and all distributed energy resources. This chapter presents ways to increase the participation of low-income communities in solar PV through wide-scale deployment of both "on-site" and "community solar" for low-income multifamily buildings. Robust financing mechanisms, public policies, and partnerships to unlock barriers impeding the participation of low-income households in solar in the District are discussed in this chapter. The following table summarizes the categories and barriers:

**Table 5.1: Barriers to Implementing and Expanding Solar PV in the District**

| | Categories | Barriers |
|---|---|---|
| 1 | Building Rooftop | Unsound roof structure, electrical circuitry. |
| | | Unviable building or roof design or orientation to the sun; energy inefficient roofs (leaky building). |
| | | Inadequate space or exposure for generation viability/cost-effectiveness. |
| 2 | Regulatory | Zoning Restrictions (DCRA): historic preservation, flat roof setback installation requirements, parkland restrictions<br>Zoning Restrictions (Federal): historic preservation, parkland restrictions. |
| | | Metering Restrictions (PSC): prohibition against residential sub-metering |
| 3 | Education/ Marketing (Outreach) | Lack of knowledge across stakeholder sectors about solar and its benefits (including community solar). |
| 4 | Sustainability Planning | Coordinating the many trends, programs and initiatives and ways to enhance and support those programs and initiatives. |
| 5 | Grid Interconnections/ Readiness | Potential limitations on grid's capacity to interconnect and manage large deployment of distributed generation. |
| | | Solar Developer "split incentives, risk of expensive regulatory permitting or utility interconnection delays, "hassle" factor/complexity. |
| | | Amount of time to get interconnected once installation is completed. |
| 6 | Workforce & Business Development | Dearth of Certified Business Enterprises (CBEs) and people working in the solar space—for example, solar installers and professional planners and designers and scientists. |
| 7 | Community Solar | Lack of available land/space. |
| | | Lack of education and awareness of the ways in which community solar can be implemented. |
| 8 | Financing | Lack of access to financing. |
| | | Lack of understanding how to fund solar projects.. |
| | | Lack of awareness about various financial options. |
| 9 | Administrative Coordination | "Siloing" of agencies involved in development of low-income solar; lack of inter-agency and intra-agency coordination. |
| 10 | Utility-in-a Box Reimagined | Lack of education and awareness of distributed energy resources and other complementary energy, water and environmental conservation programs; how to shop for them, and how to appropriately bundle them to gain the maximum economic and environmental benefits while also maximizing consumer choice. |

## Barriers and Technical Potential for Rooftop Solar PV on Low-Income Buildings

Key immediate barriers to deployment of solar PV for low-income buildings in the District are:

- Structural inadequacy (like outdated electrical systems or roofs)
- Solar unfriendly roof design and orientation, or shading from buildings
- Limited availability space on-site
- Regulatory obstacles
- Lack of coordination among stakeholders and agencies in program development
- Lack of consumer knowledge about the benefits of solar, lack of marketing, and
- Lack of financial resources/support (most important).

Electric grid design, operation, and management considerations will come into play as solar deployment gains momentum. With careful, coordinated planning and strong, committed leadership across sectors, many of these barriers can be significantly mitigated.

Indeed, ways to mitigate these barriers are already being deployed in the District— "Energy Choice DC"[84] and the DCSEU's low-income multifamily program are examples. In its CEP,[85] DOEE lays out a full set of recommendations that address many of these barriers. Furthermore, charged with overseeing the implementation of the 2016-mandated District "Solar for All" program, DOEE developed grant guidelines to seek solutions for overcoming the principal barriers for solar deployment to low- to modest-income households.[86]

In the meantime, stakeholders widely agree—to achieve the District's ambitious goals for generating solar power within District boundaries—"community solar" will play a critical role in achieving wide-scale low-income solar adoption, as mandated by the Renewable Portfolio Standards and by the "Solar for All" legislation. Indeed, moving the "Solar for All" program vigorously ahead–while barriers are being addressed–will require a strong focus on community solar installations on rooftops or land. Community solar can benefit many off-site households investing in a project, and shelf-ready, on-site rooftop deployment that benefit single or multiple households.

[84] Energy Choice DC is an outreach initiative organized by DOEE that educates residents and businesses about their ability to bundle their collective electricity demand for the opportunity to secure a more affordable, reliable, and sustainable electricity option. https://doee.dc.gov/service/energychoice

[85] Clean Energy DC; The District of Columbia Climate and Energy Plan

[86] Notice of Funding Availability and Request for Applications (RFA), Government of the District of Columbia, Department of Energy & Environment, 2-10-2017

Community solar will make the benefits of solar accessible to households that do not have the option to have solar on their buildings, because they either rent in a building that cannot or will not install solar; they own homes not suitable for solar; or do not have sufficient exposure to sun. Because of rental status and building design, a significant proportion of the District's low-income households most likely will only can gain access to solar through community, off-site or shared solar. However, while community solar has great potential for low-income ratepayers, obstacles to community solar in the District exist. This chapter addresses some these obstacles.

With the newly legislated "Solar for All" program and the release of the District's CEP, a host of recommendations are now being discussed to move distributed solar ahead for lower-income households as well as in the city overall. The following recommendations both coincide with and draw upon those being made elsewhere.

This chapter also makes the case for reimagining the concept of a "utility-in-a-box" to promote the bundling of appropriate energy generation enhancement and energy conservation measures with solar PV to enhance customer choice and empowerment, and reduce their dependence on the grid.

## 1. Building Rooftop[87]

**Institutionalize "solar readiness"**

It is considerably cheaper to design solar into a building at the outset than to retrofit it for solar later. Therefore, incentives should be provided to incorporate "solar readiness" into new building requirements and design.

Building orientation, structural and spatial design of a roof and choice of roofing materials, as well as relevant electricity infrastructure, can optimize solar generation along with accommodating other rooftop real estate functions.

Supporting the District's CEP recommendation that "solar readiness" be included in the next iteration of District building codes is a critical step toward increasing access to solar PV for low-come residents. In addition, by supporting "solar readiness," the District will be following the lead of jurisdictions such as Baltimore City.

[87] This barrier was identified through interview and review of reports. DOEE has identified four Core Barriers to expanding solar capacity on multifamily, commercial and institutional building, and non-residential surface spaces in the District. Barriers 1 and 2 address building roof top limitations.
RFP link: Core Barriers (Page 24 of 32 RFA: Solar for All Multi-Family Buildings)
https://doee.dc.gov/sites/default/files/dc/sites/ddoe/release_content/attachments/Request%20for%20Applications_14_1.pdf

Building codes are the most expeditious way to affect design changes, provided they are adequately enforced. Such regulations would remove the need to "market" or persuade developers to design buildings to optimize solar generation. It is key to ensure permitting and other regulatory bureaucracies for such solar-ready codes are made more efficient and cost-friendly.

Buildings of all ownership and development types in all neighborhoods will start to participate in the District's clean energy generation program, as the city moves to becoming a "virtual clean power plant" with solar power generation distributed across the city.[88] With most District households living in multi-family buildings and with inclusionary zoning including buildings in high-end neighborhoods, the participation of eligible buildings in community solar would be the only way to serve tenants for whom on-site or rooftop solar is not an option.

The current lack of incentives or requirements to make new and existing building stock "solar ready" for developers is cited as a major barrier to readying buildings for solar in the District. Developers and their financiers are reluctant to incorporate solar for several reasons, including:

- The split financial incentive *(It might benefit tenants in the form of reduced energy bills, but what's in it for those who must front the capital costs?); and*
- More traditional real estate preferences for use of rooftop space (patios and pools, for example), and the "hassle factor." *(Why should developers take on unknown challenges?)*

Other actions that can help make the District building stock more solar-ready include:

- Assigning more incentive points for "solar readiness" in affordable housing design criteria for new construction and roof rehabilitation or replacement. Solar readiness is already an option in Enterprise Green Communities standards that apply to all low-income housing receiving Gap Funding. The HUD 5-Year Plan administered by DHCD is a potential vehicle for advancing solar incentives/requirements.[89]
- Adding solar readiness to DCHD's Single Family Residential Rehabilitation Programs (SFRRP). This program helps qualified homeowners to finance home repairs by providing funding of loans and grants up to $75,000. Currently, its roof repair program consists of grants up to $15,000 to replace a roof, paying for exterior and gutter work only. Such grants, possibly aggregated with other financing, could enable a roof replacement to be "solar ready." A topic that requires further exploration is whether a solar readiness design requirement should be mandated for certain categories of buildings receiving such roof assistance to rehabilitate.

[88] The concept of a "virtual power plant" is being promoted by the Grid 2.0 Working Group and the DC Consumer Utility Board.

[89] 2016 DHCD-HUD 5-Year Plan https://dhcd.dc.gov/service/consolidated-plan-housing-and-community-development

**Promote Net-Zero Energy and holistic green building design**

Net Zero Energy and holistic design should be promoted along with renewable energy. As discussed in Chapter 4, building energy efficiency is paramount in reducing energy costs and promoting clean energy. "Deep energy efficiency" reduces demand and increases the amount of solar power available for storage or sale to the grid, and can help residential buildings meet net-zero energy standards. Consequently, it is necessary to promote a strategic approach for balancing the use of public subsidies for green energy, incentivizing where possible, energy efficient retrofits along with solar or other distributed generation, and to support the recommendations of the District's CEP for a pathway to net-zero building performance.

**Suggested responsible agencies and suggested actions**

DOEE (DC Department of Energy and Environment)

- Undertake this work jointly with all the stakeholders—building owners and operators, nonprofit organizations, DHCD, and DCHA—to promote "solar readiness" to insure coordinated and aggressive actions.

- When appropriate, provide input to the Office of Zoning regarding regulations that inhibit or promote the expansion of solar PV.

DCRA (DC Department of Consumer and Regulatory Affairs)

- Continue adopting regulations favorable to building designs that promote solar PV.

DHCD (DC Department of Housing and Community Development)

- Continue sharing information on outcomes of the agency's initiatives.

DCHA (DC Housing Authority)

- Continue sharing information on outcomes of the agency's initiatives.

## 2. Regulatory

**Remove regulatory barriers that limit availability of rooftops and land for rooftop and ground-mounted solar deployment**

District and federal zoning laws either prohibit or severely restrict the installation of solar on properties and neighborhoods designated for "historic preservation." Further, they prohibit solar on properties and land subject to National Park Service (NPS) guidelines. Because of the District's many historic preservation properties, these zoning laws eliminate a significant percentage of District space for solar development potential.

Further, District zoning requirements for setbacks of solar arrays on flat roofs can make installation of solar arrays less attractive. Anecdotally, at least one large national solar installer considers the setback requirement as cutting severely into to their value proposition for developing solar in the District. Actions that can be taken to address the issue include:

- Reconsidering regulatory barriers that limit availability of rooftops and land for rooftop and ground-mounted solar deployment;

- Modifying flat roof setback requirements. Explore setback requirements in other jurisdictions in the country where solar is being intensively deployed, that have similar storm (wind) exposure, building heights, etc., and propose alternative regulations to DCRA, as applicable; and

- Updating the District's historic preservation restrictions. The conditions imposed on solar installation make it onerous for developers to deal with historic buildings and neighborhoods.

**Suggested Responsible Agencies and Suggested Actions**

DCOZ (DC Office of Zoning)

- Explore what provisions will be necessary to promote community solar on restricted sites for low-income households.

DCRA

- Explore what provisions will be necessary to promote community solar on restricted sites for low-income households.

**Remove prohibitions against sub-metering for residential units in master-metered buildings or projects (multifamily or mixed-use)**

A large percentage of the District's low-income households live in multifamily buildings or projects that are master-metered. Each of these multifamily buildings or projects has one meter and one account with Pepco, which is held by the landlord. The landlord divides utility bills among tenants regardless of their consumption, and tenants pay for their utilities as part of the rent.

Some of the owners of these master-metered buildings/projects will be able and willing to install solar arrays, passing on the reduction in energy costs to their tenants through the their rent payment. When such buildings cannot or will not adopt solar, tenants ideally should have the option to participate in community, off-site, or shared solar projects that would reduce their bills. However, this option is not currently available because tenants in master-metered buildings do not have their meter or Pepco account against which they can "net meter" for solar or community solar directly with Pepco. Without sub-metering, tenants in master-metered buildings or projects cannot participate in community solar.

District law prohibits master-metered buildings from sub-metering residential units for electricity or gas. This age-old prohibition exists largely for tenant protection. However, almost a decade ago, the District lifted the restrictions on sub-metering of commercial tenants in master-metered buildings. Jurisdictions around the country have increasingly allowed residential sub-metering. Now residential sub-metering for electricity is becoming less expensive due to the development of advanced metering and energy management technology.

There are important reasons to revisit this regulation, especially given the availability of more accurate and reliable sub-metering technology, at least for electricity and the increasing opportunity cost of not doing so. Not only would sub-metering make it possible for a large portion of the District's tenants to participate in community solar, it would also make them accountable for their household electricity use, since their electric bills would be pro-rated accordingly. Sub-metering might also provide a financial incentive for them to reduce their consumption.

While sub-metering would make it technically possible for tenants in master-metered buildings or projects to participate in community solar, they would be dependent upon their landlord to administer their billing. (Complications could arise if different tenants wish to participate in different community solar projects.) With sub-metering, each unit includes a meter provided by the landlord, that enables the landlord to track each household's consumption and to charge them for their portion of the overall building's electric bill. The tenants do not have their account with Pepco under this system, and it is the landlord who handles the pro-rated billing. Again, key to implementing this is changing legislation to allow sub-metering for residential units in master-metered buildings or projects (multifamily or mixed-use).

**Suggested Responsible Agencies and Suggested Actions**

OPC (Office of the People's Counsel)

- Develop a set of guidelines for tenants (future ratepayers) to follow when the risks and rewards from solar PV get redistributed.

PSC (DC Public Service Commission)

- Work with the Rental Accommodations Commission to develop ways in which tenants can access the benefits of solar PV.

### 3. Education/Marketing (Outreach)

**Increase funding and development of education and marketing programs to address lack of public buy-In of solar and awareness of its "true" benefits**

The lack of social or public buy-in to solar is a major obstacle. Home and building owners generally know little about it, and do not realize how financially accessible solar is. Most importantly, people are unaware of the "true" benefits of solar, beyond just bill reduction.

*Questions typically include: Why should I bother? What's in it for me? Why should I know about solar? What happens when the sun goes down or it rains?*

Educating stakeholders about solar and marketing to them is a major, expensive proposition. Education and marketing cannot be treated as a "soft" consideration. These initiatives will be key to the successful implementation of the "Solar for All" legislation. The District's CEP devotes a section on the role of education and training, and demonstration projects in catalyzing "energy change." The section below goes well beyond solar and provides a comprehensive series of recommendations.[90]

Other actions can be to:

- Include substantial funding for education and training of stakeholders across sectors as part of the "Solar for All" program;
- Increase DCSEU's funding for education and outreach;
- Increase programs for inter- and intra-agency exchange and coordination;
- Increase the interaction of OPC and other cross-cutting agencies/groups; and
- Use of online, social ideation and other customer engagement tools.

[90] Clean Energy DC; The District of Columbia Climate and Energy Plan (Draft October 2016), Chapter 3, Section "Education and Training," pp. 91-103.

**Suggested Responsible Agencies and Suggested Actions**

OPC

- Promote education and expand awareness jointly with DOEE;
- Implement education and training and demonstration projects;
- Implement education and marketing programs and coordinate inter and inter-agency education and marketing programs; and
- Create "public conversations" to expand awareness of options for access to solar.

DOEE

- Develop a "help-desk" type function that would guide households and installers; and
- Expand the coordination of financial incentive programs. (DOEE already convenes stakeholder groups meetings and acts as a conduit for information between stakeholders and the agency.)

DHCD

- Continue providing the results of the reduction of energy consumption based on the implementation of the Enterprise Green Community Standards;
- Provide data from its projects to suggest "useful practices" other agencies mayfollow to reduce the energy burden of low-and moderate-income households; and
- Consider implementing in its programs the potential of installing storage systems for solar power generated on its housing facilities.

DCHA

- Continue sharing data on the effects of energy efficiency improvements and distributed generation on reducing operating costs and improving the overall quality of life of residents in these communities.

### 4. Sustainability Planning

**Optimize sustainability planning for lower income households and affordable housing across the District**

Ways to optimize sustainability planning include:

- Integrating "Solar for All" into affordable housing planning, across District agencies and coordinate with other sustainable housing initiatives;
- Optimizing community energy planning opportunities that involve the District's low-income housing sustainable development program, such as:
    - "Solar for All";
    - HUD/DHCD: 5-year plan covering all assisted housing;
    - DCHA: 80% of housing stock in need of deep rehab;
    - DCSEU: Solar Advantage Plus program (up to 50% AMI);
    - Private nonprofit, mission-driven green affordable housing developers (Mi Casa, DC Habitat, etc.).

- Coordinating the development and use of metrics, and geospatial mapping among relevant agencies;
- Exploring opportunities for affordable housing planning around locational energy resources;
- Addressing inter-agency and intra-agency "siloing" of initiatives;
- Building expertise within government agencies and private institutions dealing affordable housing. (Engaging all employees and promoting education forums internally within, as well as between agencies.);
- Including energy analysis in literature on the District's affordable housing by local agencies, institutes, think tanks, because an "energy" prism needs to be more vigorously applied to analyses of the low-income sector in the District; and
- Developing energy data for affordable housing.

**Suggested Responsible Agencies and Suggested Actions**

DOEE

- Promote the integration of "Solar for All" into affordable housing planning, across District agencies and coordinate with other sustainable housing initiatives;
- Optimize planning to link affordable housing and solar;
- Build on the expertise within government agencies and private institutions dealing with affordable housing;
- Engage all employees by promoting education forums within and across agencies;
- Promote the planning of affordable housing around locational energy resources; and
- Coordinate the development and use of metrics and maps among relevant agencies and organizations.

### 5. Grid Interconnections/Readiness

**Require equitable modernization of the District's electricity grid and power line undergrounding to enable high volumes of solar generation across all neighborhoods to be interconnected to the grid**

Currently, the District's electric grid infrastructure can accommodate the amount of solar and other distributed power generation coming on line now. Thus "interconnecting" local solar installations to the grid is not an immediate issue. However, the grid's capacity to integrate power from local "distributed" solar generation will become an issue with the deployment of solar at a much larger scale through the new "Solar for All" program and other initiatives on the horizon.

The deployment of "smart grid" technologies along the Pepco grid will both support the capacity of feeders to integrate intensive solar generation and prevent disruption along the grid from two-way power flow. It will also help to fully leverage potential benefits of distributed solar generation on the grid, including ancillary services enabled by solar + storage, which can bring down costs for all customers over time and provide added resiliency of the grid in the face of storms and other emergencies.

Pepco is in the process of deploying "smart grid" elements. Advanced Metering Infrastructure (AMI) is already installed, serving the entire District.[91] Distribution automation is being installed selectively. The primary power lines targeted for undergrounding through the DC PLUG program (over the next 10 years) will integrate communication and distribution automation features.[92]

It is important that deployment of grid automation upgrades take place equitably throughout the District to support the growth of solar generation in all areas, including low-income neighborhoods. PSC's open proceeding on "Modernizing the Energy Distribution System for Increased Sustainability" is a logical forum for raising this issue. Other regulatory avenues should also be explored.

With large-scale deployment of solar, the use of advanced, "smart" inverters at the customer end will become necessary to preserve grid stability.[93] As demonstrated in the U.S. Department of Energy-sponsored demonstration projects over recent years, advanced ("smart") utility-interactive inverters can solve grid-stability challenges of two-way power flow caused by large amounts of distributed generation on the grid.[94]

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[91] AMI includes "smart" meters and a two-way communication system across the grid that enables information about energy consumption to be relayed instantaneously between the meter and the central system.

[92] http://www.pepco.com/DCPLUG/

[93] For details about uses and standards regarding advanced "smart" inverters see:
NREL, "Advanced Inverter Functions to Support High Levels of Distributed Solar: Policy and Regulatory Considerations (Brochure), Nov. 2014, http://www.nrel.gov/docs/fy15osti/62612.pdf
Technical Report, NREL/TP-7A40-65063 September 2015, available for free:
www.nrel.gov/docs/fy15osti/65063.pdf

[94] For examples and further detail, see U.S. Department of Energy link:
U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. "EERE Success Story—SunShot-funded Advanced Inverter Testing Enables 2,500 Solar Energy Systems to Connect to Hawaii's Electric Grid" https://energy.gov/eere/success-stories/articles/eere-success-story-sunshot-funded-advanced-inverter-testing-enables. 2/1/2017.

Also see:
Jeff St. John. September 10, 2015. "California Launches Its First Real-World Smart Inverter Test." https://www.greentechmedia.com/articles/read/california-launches-its-first-real-world-smart-inverter-test

This smart inverter technology, though proven, has been held back by the delayed adoption of accredited safety standards by the Underwriters Laboratory (UL- certifying standards).[95] However, UL announced its new "Advanced Inverter Testing and Certification Program" in September 2016.[96] With the removal of this barrier, it remains to be seen how quickly the new specification standards will affect the actual adoption of the technology, nationwide and in the District.

**Suggested Responsible Agencies and Suggested Actions**

OPC

- Continue to increase the awareness of all stakeholders regarding the latest technologies that have the potential to increase the rate at which solar PV and other distributed energy resources can be adopted in the city, in general, and in low-income communities, in particular.

PSC

- As part of the process of grid planning and modernization, ensure ratepayers are being provided access to those technologies that enhance their ability to deploy solar PV and other distributed energy resources.

**Reduce amount of time to interconnect to the grid**

One immediate concern is the amount of time it takes for a building to be connected to the grid. Any delay in connecting reduces the cost-benefit ratio of a project.

**Suggested Responsible Agencies and Suggested Actions**

OPC

- Promote the empowerment of consumer-producers under a soon-to-be new generation regime.

PSC

- Monitor all concerns regarding the need to reduce the time it takes Pepco to complete interconnections of solar PV generation with the distribution system;
- Work with Pepco to insure there are no unnecessary delays in getting systems connected; and

[95] Industry Perspectives on Advanced Inverters for U.S. Solar Photovoltaic Systems: Grid Benefits, Deployment Challenges, and Emerging Solutions, National Renewable Energy Laboratory, (NREL), September 2015, page v. http://www.nrel.gov/docs/fy15osti/65063.pdf

[96] Joseph Bebon (September 8, 2016) "UL Publishes Long-Awaited Advance Inverter Standard." http://solarindustrymag.com/ul-publishes-long-awaited-advanced-inverter-standard http://solarbuildermag.com/news/uls-advanced-inverter-testing-and-certification-program-finally-ready/

- Include the following issues in Formal Case 1130, related to grid modernization:
  - Are grid automation upgrades being deployed equitably throughout the District to enable "Solar for All" legislation goals?;
  - Is modernization taking place in a way that can accommodate the RPS goals?; and
  - Is the role of the new energy consumer-producer, such as a household with solar panels, being fully considered in meeting the District's energy needs?

DCRA

- Monitor all concerns regarding the need to reduce the time it takes to get permits and inspections to complete interconnections of solar PV generation with the distribution system.

## 6. Workforce & Business Development

**Build the local solar workforce by institutionalizing solar training programs**

A solar installation jobs training program, or any green jobs training program, can be offered at vocational high schools, the University of the District of Columbia (UDC) Community College, and UDC's School of Engineering and Applied Sciences. Job training requires incentivized collaboration among the government, industry and academic institutions. The large-scale deployment of solar PV mandated by the new "Solar for All" program will strain existing "solar" workforce resources, and potentially, those of allied professionals involved in roof repair, electrical upgrades, engineering, etc.

Where installation programs require local installers, the pinch may come sooner rather than later. Expanding the District's local "solar workforce," therefore, must be addressed now. Several subsidized solar programs require on-the-job workforce training, and the upswing of the solar market is likely to spur new local business development with attendant job training. However, a planned, coordinated approach across local stakeholder agencies and institutions will be necessary to meet the needs.

**Increase the number of Certified Business Enterprises (CBEs)**

In addition to there being pressures on the workforce, the demand for Certified Business Enterprises (CBEs) in the District is expanding as well. District agencies most likely to be involved in developing a solar workforce are:

- DC Public Schools (DCPS)
- University of the District of Columbia (UDC)
- Department of Employment Services (DOES)

District agencies most likely to be involved in developing CBEs are:

- Department of Small and Local Business Development (DSLBD)
- DC Sustainable Energy Utility (DCSEU)

**Suggested Responsible Agencies and Suggested Actions**

DC Public Schools (DCPS)

- Continue developing and implementing workforce readiness programs and coordinating efforts with other agencies listed in this section.

University of the District of Columbia (UDC)

- Continue developing and implementing workforce readiness programs and coordinating efforts with other agencies listed in this section.

Department of Employment Services (DOES)

- Continue developing and implementing workforce readiness programs, funding solar workforce development initiatives, and coordinating with other agencies listed in this section.

Department of Small and Local Business Development (DSLBD)

- Continue developing and implementing business readiness programs to expand the number of CBEs eligible to provide services.

DC Sustainable Energy Utility (DCSEU) (a private company under contract with DOEE)

- Continue efforts promoting the use and development of CBEs.

### 7. Community Solar

**Unlock Space/Expand Education & Awareness**

Locked "space" is cited as the No. 1 barrier for large-scale community solar development, whether roof top space or land for ground mounted solar installations. Hence, unlocking "space" is critical.

*For large-scale community solar projects*

- Explore feasibility of using of District parkland, brownfields or other uninhabited public property for public, nonprofit community solar projects without compromising the integrity or mission of the park.
- Explore use of the properties on public land that is managed by the Washington Convention & Sports Authority. These sports/entertainment arenas and convention centers comprise among the largest (non-federal) rooftop real estate in the District. Furthermore, such projects are being added to and expanded on a regular basis since large amounts of taxpayer dollars go into their development.

By developing these properties with community solar along with near net-zero energy efficiency standards and battery storage, the projects could provide an exponentially higher rate of return on the local District public's investment. The benefits would include: lower energy costs for individual households and District ratepayers as a whole,[97] lower emissions, and resilience for neighborhoods during emergencies and prolonged blackouts. Thus, these civic properties could take on an added public role by becoming energy hubs for the District, possibly organized as neighborhood micro-grids.

*For medium-scale community solar projects*

- Expand the creative aggregation of multiple building rooftops under a single ownership. Nixon Peabody, for example, pioneered using a Corporate Social Responsibility model for low-income households in the District;
- Apply this model to nonprofit owners as well; and
- Explore models that emerge in other jurisdictions such as Baltimore or through the grant making process under the DOEE's "Solar for All" demonstration grant program.

**Promote different demonstration models for low-income community solar**

District government-assisted demonstration projects will help promote the use of community solar by accelerating understanding of both its mechanics and benefits. These efforts are reflected in DOEE's February 2017 Request for Applications for the District "Solar for All" Grant Program. Recognizing solar power benefits are not available to the many low-income residents who do not receive electric bills, and therefore "cannot receive net-metering energy credits," DOEE's RFA seeks proposals that "would creatively provide the associated energy and financial benefits (SREC value and bill reductions) generated from the installation of new solar systems to low-income residents."[98] This might generate non-regulatory solutions to the problem. (Applications were due on March 31, 2017.)

**Explore options to encourage landlords of multifamily master-metered buildings to give their tenants access to community solar**

As noted previously, most multifamily buildings in the District are master-metered and house a significant percentage of lower-income District households. The simplest way for owners to make solar available to their tenants is by installing solar directly on their rooftop and passing the reduction in energy bills onto their tenants

[97] Such energy projects could be planned to optimize the efficiency of the District's electricity grid, in such a way as to off-set demand from the grid and minimize the need to make costly capital investments in building out infrastructure. This would help keep overall ratepayer costs down.

[98] Notice of Funding Availability and Request for Applications (RFA), Government of the District of Columbia, Department of Energy & Environment, 2-10-2017.

In this scenario, the master-meter would be net-metered; thus, the prohibition on residential sub-metering discussed above, would not be a barrier. Where a landlord might not be able, or want, to install solar directly onto their multifamily building, they should be encouraged and incentivized to make community solar available to their tenants. This can only happen if the prohibition against residential sub-metering is lifted via future legislation.

DOEE addresses this barrier in its February 2017 Request for Applications (RFA) for the District Solar for All program. Recognizing solar power benefits are not available to the many low-income residents who do not receive electric bills, thus who "cannot receive net-metering energy credits," DOEE's RFA seeks proposals that "would creatively provide the associated energy and financial benefits (SREC value and bill reductions) generated from the installation of new solar systems to low-income residents."[99] This might generate non-regulatory solutions to the problem.

Other actions can include:

- Promoting education programs and possibly public incentives—for example "green leases"—to encourage landlords of master-metered multifamily buildings to participate in community solar projects, thus passing the break on electric bills to their tenants;
- Using Alternative Compliance Funds (ACP) for "solar readiness" under the Solar for All program to provide financial incentives to landlords who sign on to community solar programs, for example, matching funds[100]; and
- Including education programs about the advantages of community solar tailored to building owners, managers, and tenants in the Solar for All program.

**Suggested Responsible Agencies and Suggested Actions**

OPC

- Advance the understanding of the importance of "community solar" in expanding access to solar in for low-income residents;

  Promote the availability of sub-metering for residential units in master-metered buildings or projects (multifamily or mixed-use); and
- Work with the Rental Housing Commission to insure tenant rights are protected if there is a shift from multi-metered to single meters.

[99] Notice of Funding Availability and Request for Applications (RFA), Government of the District of Columbia, Department of Energy & Environment, 2-10-2017.

[100] Note: If residential sub-metering were to be permitted, Alternative Compliance Funds for "solar readiness" under the Solar for All program might be used to finance sub-metering of multi-family buildings.

DOEE

- Continue to support innovative demonstration projects that will increase the rate of adoption of solar PV and all distributed energy resources in the District.

PSC

- Expand the availability of sub-metering for residential units in master-metered buildings or projects (multifamily or mixed-use); and
- Work with the Rental Accommodations Commission on this issue.

DCOZ

- Explore what provisions will be necessary to promote community solar on restricted sites for limited income households; and
- Promote the development of solar installations that are complementary to historic sites, parks, and restricted open spaces.

### 8. Financing Solar for Low-income Households

What makes solar readiness—solar installation along with the energy efficiency upgrades and other green practices and energy resources—financially attractive to low-income residents and owners of buildings who house low-income residents in the District? A key factor is "financing." The upfront installation costs must be reduced.

The new Solar for All legislation provides a financing framework using ACP accrued every year to fund solar installation as well as "solar readiness." This financing will be the backbone to meet Solar for All goals for deploying solar for lower income households across the District. However, the ACP funds will by no means cover all needs.

Below is a list of strategies, ranging from overarching large-scale financing of green energy to measures addressing specific dimensions of deploying solar, and the needs of lower-income homeowners, very low-income households, middle-income households, and finally, developers.

#### *Support the establishment of a Green Bank for District energy programs*

On March 15, 2017, Mayor Muriel Bowser announced she will be introducing legislation to establish a "green bank." As part of her announcement, she noted the District will be the first city in the United States, and the second city in the world, to create a green bank. She sees green banks as "innovative policy tools that seek to expand renewable energy, lower energy costs, reduce greenhouse gas emissions, and create green jobs."[101]

[101] Mayor Bowser Announces Plan to Establish DC Green Bank. http://doee.dc.gov/release/mayor-bowser-announces-plan-establish-dc-green-bank

A green bank will allow homeowners of different income levels to own their solar installations more readily, rather than lease them, and thus be better able to reap their bill saving benefits as well as help build equity in their homes. The District's CEP outlines several recommended features of a green bank:[102]

- Establishing a separate board of directors appointed by the mayor and Council of the District of Columbia;
- Capitalizing the green bank with $100 million of public money over time and from several sources to build approximately $500 million in private investment;
- Providing an ongoing stream of dedicated public funding to a green bank on an annual basis;
- Giving the green bank the ability to issue bonds under various structures;
- Borrowing administrative staff from DOEE to initiate the Green Bank, then hire a team of dedicated staff to operate it;
- Using the Green Bank to provide a portfolio of financing and market-based solutions that target renewable energy, energy efficiency, and low- to zero-emission transportation; and
- Targeting specific funds to low- to moderate-income individuals and combine these funds with other instruments (for example, on-bill financing).

### *Establish a "Capital Aggregation" platform*

This platform will pull together multiple sources and types of capital to optimize solar deployment funding for projects in low-income communities. For example, through the green bank, financing may become available for deep energy efficiency and renewable generation including solar.
On such a "platform" funds can be leveraged using PACE (Property Assessed Clean Energy Program) and other existing funds, including DCSEU, and possibly a portion of LIHEAP (Low-Income Home Energy Assistance Program) funding. Some combination of these funds can be used to provide "seed capital" for the green bank, and scale up Solar for All and complementary Deep Energy Efficiency Retrofit programs.

[102] Clean Energy DC; The District of Columbia Climate and Energy Plan (Draft October 2016), p. 82.

An analysis of an "aggregation model" to leverage funds is beyond the scope of this project. However, an integrated approach to management of energy financing for the District's low- and medium income residents (and small businesses) merits study. Models in two states worth examining are California and Oregon. For example, MPower, Oregon's capital aggregation platform, aims to "deliver much-needed capital to existing, occupied, affordable housing properties through a mechanism that does not rely on hard-asset collateral and does not require a restructuring of the existing affordable housing financing including tax-credit, equity-based capital partnerships."[103]

In the District, the Nixon Peabody model described in Chapter 4 and the Appendix provides an example of how "a deal gets structured":

> *Nixon Peabody is assisting New Partners Community Solar Corp., in the financing, as part of its philanthropic enterprise and commitment to sustainability. The system will be paid for through (1) a loan (which is repaid through sale of SRECs), (2) tax credit equity, (3) a grant from the District of Columbia Department of Energy and the Environment, and (4) a cash grant and pro bono legal services from Nixon Peabody. The system will be maintained by New Partners over its lifetime.*

### *Explore possible use of low-income tax credits*

These credits can be used to promote the integration of solar into affordable housing, both new construction and major rehabilitation. Of note:

> *The financial opportunity from solar PV is especially evident when owners of affordable rental housing are able to integrate solar PV into new construction or substantial rehabilitation using federal Low-Income Housing Tax Credits (LIHTC) in conjunction with Business Energy Investment Tax Credits (ITC). As shown below, since solar PV installations generate operational cost savings and can also reduce tenant utility costs, solar installations financed by LIHTCs as part of a larger construction or renovation project can increase capital funding sources over uses and make it possible to provide greater benefits to low-income households.*[104]

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[103] See ACEEE 2012 Summer Study on Energy Efficiency in Buildings, p. 4-359. http://aceee.org/files/proceedings/2012/start.htm Two models of note are: NOAH (Network of Oregon Affordable Housing) (https://noah-housing.org/) and MPower Oregon (http://mpoweroregon.com/ capital aggregation model for funding major upgrades in affordable multifamily buildings might be relevant.

[104] Waite, Wayne and Milford, Lewis. (March 23, 2016) "Efficiency, Solar and Storage Offer a Unique Opportunity to Bring Clean Energy to Affordable Housing" https://www.greentechmedia.com/articles/read/affordable-housings-progress-toward-integrated-energy-solutions

For existing properties seeking to add solar PV to an efficiency-only retrofit, the economic feasibility of solar is a bit more challenging, but can still be favorable. The growing market for third-party ownership structures and improved access to solar investment funds has enabled turnkey financial options that leverage ITCs and real estate depreciation tax benefits to provide financing without the need for upfront capital investments by the property owner."[105]

*Lower costs of solar deployment through "Solar Co-op" or Neighborhood Deployment*

Enabling bulk materials purchasing and light roof and electrical upgrades, as well, can lower marketing costs of low-income solar programs. A collective approach to "going solar" can lower installation costs through bulk purchase of materials and reduce the costs of labor as well. Under the umbrella of the nonprofit DC SUN, District neighborhood solar coops spread across wards have used this community approach successfully over many years.[106]

The DCSEU's "Solar Advantage Plus" program achieves good results with low-income neighborhood solar development. These include another manifestation of neighborhood solar where over a multi-year period word spread among neighbors in single-family homes in a low-income area about the benefits of solar, resulting in strong increase in SEU's program along a single street. With lack of knowledge about solar being one of the strong barriers to its adoption, such an impact is invaluable and reduces the steep marketing cost involved in the broad deployment of solar. One result of the word spreading and the DCSEU responding was an increase in the number of people seeking training in solar installations.

*Expand solar financing for lower-income homeowners*

For the low-income households in the District that own their homes or co-op units, they have control over their rooftop space for installation of solar systems, subject to zoning restrictions. Co-op housing complexes may permit unit owners to install solar on individual roofs.

However, low- and middle-income homeowners often do not have access to low-cost financing or affordable leases for solar systems. Furthermore, they may not benefit from solar tax credits or other incentive programs because of insufficient income or inability to claim benefits.

Expanded financing options could include:

- Increasing subsidies and low-cost funding option because funding for structural and electrical upgrades are needed to support solar PV installation;

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[105] Waite, Wayne and Milford, Lewis. (March 23, 2016) "Efficiency, Solar and Storage Offer a Unique Opportunity to Bring Clean Energy to Affordable Housing."https://www.greentechmedia.com/articles/read/affordable-housings-progress-toward-integrated-energy-solutions

[106] See the website for DC SUN: http://www.dcsun.org/

- Increasing the amount of money devoted to funding programs for solar providers (for example, the DCSEU Solar Advantage Program), because there is a need to increase the awareness of residents in low-income neighborhoods about the benefits of solar and to navigate the process of accessing solar and getting solar projects financed; and
- Financing leases under the green bank because homeowners could benefit from the option of owing their solar installations and accruing more fully the benefits of the energy asset.

*Expand subsidies for the very low-income homeowner group*

Because of their income levels, the groups of homeowners with very low incomes will need financial assistance.

- Capitalization and maintenance (structural and electrical preparation, solar install, and maintenance) are cost prohibitive for this group. Their capitalization and maintenance costs must be virtually zero. A partial solution for this group is third-party system ownership and power purchase mechanisms that cover the cost of the solar system and maintenance. DCSEU provides funds to facilitate solar power purchases for households who do not earn more than 50% AMI. Ratepayer electricity fees are the source of this funding. Other sources of funding include: Alternative RPS compliance funds, federal government grants, and private grants through nonprofit organizations.

- Funding will expand exponentially once the District government "unlocks" the RPS funds (approximately, $20 million in accumulated funds) as required to implement the new Solar for All legislation. Additionally, this legislation allows financing for structural and electric upgrades to make buildings "solar ready." This will greatly expand the pool of solar-eligible homes in this group (one DCSEU installer estimated recently that only about two out of 10 roofs in this income pool have the integrity needed to move forward with solar without renovation).

- A complementary policy would be to allow homeowners to use a portion (for example, 25%) of federal LIHEAP energy assistance funding to deploy renewable energy. Additional financing mechanisms would be necessary to address full rooftop replacements and major electrical needs. However, given the high cost of such renovation, consideration would have to be given to comparative benefits of alternative uses of such energy investments for these homes. For example, would households benefit more by having the funding go to energy efficiency measures? And would such funding be more readily available for such energy efficiency retrofits?

  Third-party ownership of these low-income solar installations means the lowest income groups, though their electric bills are lowered, do not share in the equity benefit of solar installations. For renters, this is not an issue. For low-income homeowners, there may be solutions for making such "energy" equity available, especially via mission-driven nonprofit low-income housing developers such as DC Habitat. The green bank initiative could help could help address this issue as other green banks around the country have.

*Expand low-cost loan programs for the "Middle" (60-80% AMI) homeowner group.*

This group can participate modestly in capital costs (structural/electric upgrades) associated with readying their homes for solar systems with the help of low-cost financing such as the Solar for All program and the residential Property Assessed Clean Energy (PACE) program DOEE is currently developing. These households have the option of third-party ownership of the solar system with no money down, and, by the same token, less return than they would get by owning the installation. Through the green bank, there is the possibility of financing affordable solar leases that could lead to outright ownership. The green bank could also support a "leveraged loan fund." The establishment of such a fund was the consensus recommendation coming out of the 2014 symposium at the GW Solar Institute. Such a fund would guarantee investments by private developers in either building-based or community-sited renewable systems.[107]

**Suggested Responsible Agencies and Suggested Actions**

DOEE

- Expand the coordination of financial incentive programs. (DOEE already convenes stakeholder group meetings and acts as a conduit for information between stakeholders and the agency.)

### 9. Administrative Coordination

**Enhance stakeholder coordination**

Coordination of efforts across agencies and among stakeholders is necessary to bring solar + efficiency (and eventually storage) to lower-income households, namely the coordination of efforts across agencies and stakeholders. This coordination can be enhanced by creating a "one-stop shop" for information on services/incentives/financing for energy efficiency and solar, coordinated among relevant agencies. The District's CEP contains examples of programs and activities to include in an effort that enhances coordination:[108]

- DOEE Weatherization
- DOEE Low-Income Home Energy Assistance Program
- DOEE/DCSEU Solar for All Program
- DOEE Healthy Homes Program
- DOEE RiverSmart Homes/Communities

[107] Ronen, Amit and Schoolman, Anya. (2014) Consensus Recommendations on How to Catalyze Low-Income Solar in DC. http://solar.gwu.edu/research/consensus-recommendations-how-catalyze-low-income-solar-dc

[108] Clean Energy DC; The District of Columbia Climate and Energy Plan (Draft October 2016), p. 90.

- DCSEU: Energy efficiency programs
- DCSEU: Affordable Solar Program
- DHCD: Single Family Residential Rehabilitation Program (SFRRP)
- DOEE and DHCD: Lead Safe Program
- PACE for residences, other financing
- Office of the Tenant Advocate

One program to build on is DHCD's Housing Resource Center (located in Southeast D.C.),[109] a "one-stop shop" for information about solar and energy efficiency programs.

**Suggested Responsible Agencies and Suggested Actions**

DOEE

- Promote the integration of Solar for All into affordable housing planning, across District agencies, and coordinate with other sustainable housing initiatives;
- Optimize planning to link affordable housing and solar;
- Build on the expertise within government agencies and private institutions dealing with affordable housing;
- Engage all employees by promoting education forums within and across agencies;
- Promote the planning of affordable housing around locational energy resources; and
- Coordinate the development and use of metrics and maps among relevant agencies and organizations.

### 10. Models for bringing Solar + Energy Efficiency + Storage to affordable housing.

**Utilize existing "Utility-in-a-Box" models and expand on them**

As discussed in Chapter 4,

- "Energy Efficiency + solar + storage" is already in reach for the District, including for multifamily affordable housing, and needs to be factored into medium- and long-term energy planning, given its powerful benefits.

- CEG makes the case for energy storage for multifamily affordable housing in the District.[110]

[109] DHCD Single Family Residential Rehabilitation Program (SFRRPP)
http://dhcd.dc.gov/service/single-family-residential-rehabilitation-program-sfrrp

[110] Resilience for Free: How Solar + Storage Could Protect Multifamily Affordable Housing from Power Outages at Little or No Net Cost, 2016, http://www.cleanegroup.org/ceg-resources/resource/resilience-for-free-how-solar-storage-could-protect-multifamily-affordable-housing-from-power-outages-at-little-or-no-net-cost/

- California is leading the way in bringing energy efficiency + solar + storage to affordable housing. It may offer helpful models although its energy utility regulation and rate structures are different from the District's. A recent article by the director of the California Housing Partnership, entitled, *Efficiency, Solar and Storage Offer a Unique Opportunity to Bring Clean Energy to Affordable Housing*, argues that California "needs to get its new policies right," including its set of incentives for owners to install solar PV, storage and energy efficiency all in one package or "box" (for example, "utility-in-a-box" in multifamily affordable housing.)[111]

The concept of "utility-in-a-box" can be reimagined to promote the bundling of appropriate energy generation enhancements and energy conservation measures with solar PV to amplify customer choice and empowerment, and reduce their dependence on the grid. These bundling further increases the adoption of energy and environmental conservation measures while also increasing the amount of financial incentives that can be delivered directly to the customer, in addition to reduction in energy bills.

The reimagined utility-in-a-box approach presents an opportunity to various District government agencies to reduce programmatic redundancies and inefficiencies among the many existing energy, water and environmental programs and optimize incentives offered to the ratepayers. Utility-in-a- box has the potential to greatly help both the city and its residents get the most "bang for their buck." The following actions can be taken to promote the reimagined utility-in-a-box approach:

**Suggested Responsible Agencies and Suggested Actions**

All appropriate agencies as noted in this chapter can assist with a wide-scale adoption of the reimagined utility-in-a-box approach. Several actions to expand the use of the concept of "utility-in-a-box" include:

- Creating and constantly updating a public database that lists all the programs and incentives that are available to District customers who are interested in measure/incentive bundling;

- Promoting awareness and marketing programs that educate building owners and residents on all available energy, water, and environmental conservation measure that have an impact on either reducing energy consumption or increasing solar PV generation;

[111] Efficiency, Solar and Storage Offer a Unique Opportunity to Bring Clean Energy to Affordable Housing https://www.greentechmedia.com/articles/read/affordable-housings-progress-toward-integrated-energy-solutions

- Promoting legislation to help low-income customers finance their residential energy and storage projects; and

- Promoting inter- and intra-agency cooperation, sharing of information, knowledge and program insights, joint public education initiatives, and consultation between appropriate agencies before new programs or incentives are rolled out.

Utility-in-a-box is by far the most versatile strategy to combine several distributed energy technologies, policies and programs in conjunction with solar PV throughout the District; to integrate technologies into PEPCO's electric distribution network; to accelerate grid-parity; to increase energy and environmental resilience, reduce grid dependence, and to eventually "cut the cord" entirely from the grid, if that is what is desired.

## Summary of Recommendations

**Table 5.2: Reducing or eliminating barriers to the implementation and expansion of Solar PV**

| | | |
|---|---|---|
| 1 | Building Rooftop | Institutionalize "solar readiness" |
| | | Promote Net Zero Energy and holistic green building design |
| 2 | Regulatory | Remove regulatory barriers that limit availability of rooftops and land for rooftop and ground-mounted solar deployment |
| | | Remove prohibitions against sub-metering for residential units in master-metered buildings or projects (multifamily or mixed-use) |
| 3 | Education/Marketing (Outreach) | Increase funding and development of education and marketing programs to address lack of public buy-In of solar and awareness of its "true" benefits |
| 4 | Sustainability Planning | Optimize sustainability planning for lower income households and affordable housing across the District |
| 5 | Grid Interconnections/ Readiness | Require equitable modernization of the District's electricity grid and power line undergrounding to enable high volumes of solar generation across all neighborhoods to be interconnected to the grid |
| 6 | Workforce & Business Development | Build the local solar workforce by institutionalizing solar training programs |
| 7 | Community Solar | Unlock space |
| | | Expand education and awareness |
| | | Promote different demonstration models for low-income community solar |
| | | Explore options to encourage landlords of multifamily master-metered buildings to give their tenants access to community solar |
| 8 | Financing | Support the establishment of a green bank for District energy Programs |
| | | Establish a "Capital Aggregation" platform |
| | | Explore possible use of low-income tax credits |
| | | Lower costs of solar deployment through "Solar Co-op" or Neighborhood Deployment |
| | | Expand solar financing for lower-income homeowners |
| | | Expand subsidies for the very low-income homeowner group |
| | | Expand low-cost loan programs for the "Middle" (60-80% AMI) homeowner group |
| 9 | Administrative Coordination | Enhance stakeholder coordination |
| 10 | Utility-in-a-Box | Utilize existing "utility-in-a-box" models and expand on them |

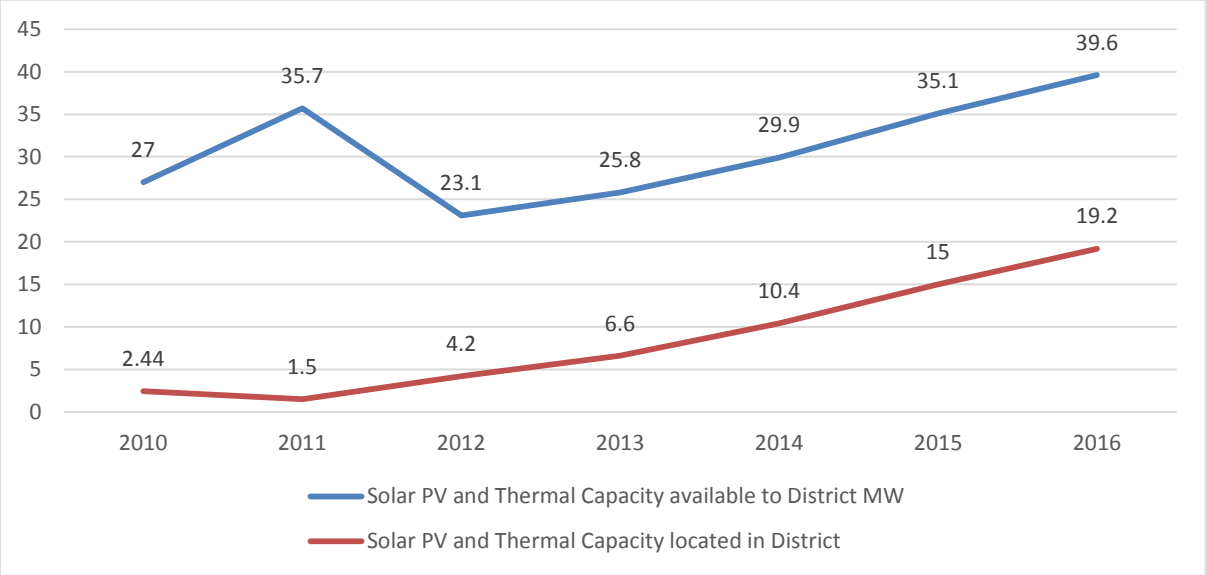
# Appendices

## Chapter 3: Installed Solar Power in the District

Installed PV Capacity in DC

For 2015, the total reported installed capacity is about 39.6 megawatts (MW). This capacity comes from 4,395 approved in the District and external solar energy systems to meet the District's Renewal Portfolio Standard (RPS) requirements. Only 19.2 MW of this installed capacity is in the District. This 19.2 MW is a 457% increase over the 4.2 MW installed capacity in 2012. (See Figure A-1.)

Figure A-1: RPS Eligible Solar PV Capacity




Source: DC Public Service Commission Report on the Renewable Energy Portfolio Standard for Compliance Year 2015, May 2, 2016

The District of Columbia Sustainable Energy Utility (DCSEU), a program management contractor that manages energy efficiency and conservation programs in the District, has installed approximately 670 kW of solar PV generation capacity between 2012-2016. The following are statistics on the installations:

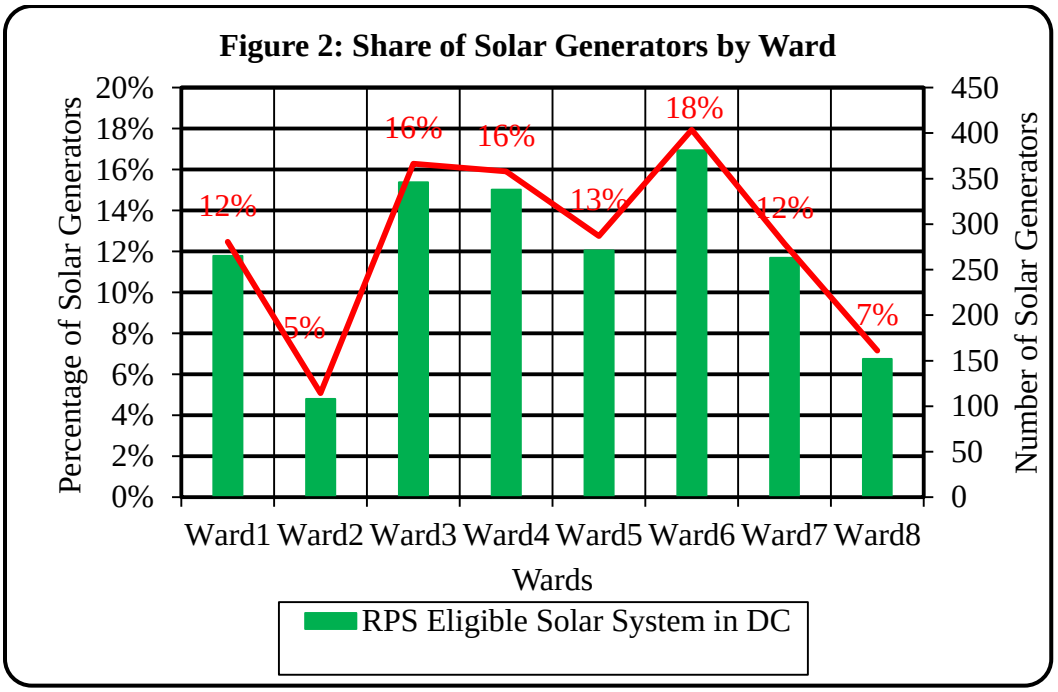
- Installed 372 solar PV power plants on rooftops of low-income, single-family homes.
- Installed 2 solar PV power plants on rooftops of non-low-income, single-family homes.
- Installed 29 solar thermal hot water systems (22 were installed on rooftops of low-income single-family homes).[112]

[112] Ted Trabue, Managing Director DCSEU

Share Of Low-Income Households with Solar

Specific data are not available to on the number of limited and low-income, single-family homes or buildings in the District that have solar PV power plants on their rooftops. However, there are approximately 2,124 installed solar PV power plants and solar thermal energy systems for heating hot water. These energy systems are in all eight wards, with Ward 6 having the largest number of these energy systems installed on residential and mixed-use building rooftops. Ward 6 has the largest percentage of public housing units in the District, and Wards 7 and 8 have the largest percent of District population that meet the household, annual low-income value. (See Figure A-2).

**Figure A-2: Share of Solar Generation by Ward**




*Source: PSC Report on the Renewable Energy Portfolio Standard for Compliance Year 2015, May 2, 2016*

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- Installed 29 solar thermal hot water systems--22 were installed on rooftops of low-income single-family homes.[113]

**Converting MW into Direct Current (DC) Megawatts**

Step 1: Convert MW into Direct Current (DC) Megawatt Hours

Solar panels produce electricity in the direct current (DC) format, not the conventional alternating current ("AC") format.

- The amount of electricity produced by a solar panel depends on the hours and intensity of sunshine. (In practice, the actual output is somewhat lower than the indicated capacity because of practical factors such as improper installation, shading, etc.)
- The variable 'sun hours' captures two factors. It measures how many 'full'-equivalent sunshine hours a given location receives on an average day throughout the year. (This number is needed because the capacity of the solar panels is measured in MW based on 'full' sunshine.)
- The maximum value for the District is 4.69. (The low is 3.37 and the average is 4.23.)[114]

Hence, the calculation for solar generation from 19.2 MW on an average day is:

Daily DC generation = 19.2 MW * 4.69 sun hours = 90.05 DC MWh (megawatt-hours)

To estimate the annual generation, we multiply the above generation by 365 days: Annual DC generation = 90.05 MWh * 365 = 32,868 DC MWh

Step 2: Convert DC Mega-Watt Hours into Conventional AC Megawatt-Hours

An "inverter" converts DC output from solar panels into AC. There is some loss of electricity in the process. At present, the loss is about 5.115%. In other words, the AC MWh are only 95% of the DC MWh.[116]

Applying this factor, we obtain:

Annual AC generation = 0.95*32,868 MWh = 31,225 AC MWh

The annual solar PV generation of 31,225 MWh represents a small proportion of the total electricity sales of 2,496,559 MWh to the District's residential sector in 2015 and an even smaller proportion of total electricity sales of 11,308,230 MWh in 2015.

[113] Interview with Ted Trabue, Managing Director DCSEU

[114] http://www.bigfrogmountain.com/SunHoursPerDay.html.

[115] See http://www.sma-america.com/uploads/media/SUNNYBOY5678-DCA111929W.pdf

[116] The only losses accounted for are losses due to the "inverter."

**Table A-1: Actual Solar PV Generation and Electricity Sales**

| | MWh |
|---|---|
| Current Solar PV Generation (2015) | 31,225 |
| Total Residential Electricity Sales (2015) | 2,496,559 |
| Total Electricity Sales (2015) | 11,308,230 |

Source: JSPA analysis of data from the DC Public Service Commission[117]

## Chapter 3: Theoretical Potential of Solar PV

### Data Sources for Calculating Theoretical Electricity Generation using PV Panels

*GIS Data Collection: Source and Definition*

The following sources of data were reviewed as a part of estimating the theoretical PV solar power generation within the District:

**Census Tract data 2010** – The U.S. Census Tract dataset contains an extract of selected geographic and cartographic information from the U.S. Census Bureau's Master Address File / Topologically Integrated Geographic Encoding and Referencing (MAF/TIGER) Database (MTDB). Each polygon in the shapefile includes the key geographic area codes for almost all geographic areas for which the Census Bureau tabulates data for both the 2010 Census and Census 2000. This dataset was used as a reference map to represent all the census tracts within the District.

**Building Footprints** - The Building footprint dataset contains polygons representing planimetric buildings, created as part of the D.C. Geographic Information System (DCGIS) for the D.C. Office of the Chief Technology Officer (OCTO). These footprints are a completely new capture from aerial photography, completed on April 24, 2015.

**Historic Site** - The Historic Site dataset contains Historic Districts officially designated by the District of Columbia, as part of the DC Geographic Information System (DCGIS) for the D.C. Office of the Chief Technology Officer (OCTO). Published May 9, 2014.

**Landuse Data** - The Land Use dataset contains existing Land Use delineations for Washington District of Columbia, as part of the DC Geographic Information System (DCGIS) for the D.C. Office of the Chief Technology Officer (OCTO). This data set is from 2004. Published May 2005.

**Zoning Data** - The Zoning dataset contains existing residential and mixed-use Zoning delineations for Washington District of Columbia, as part of District of Columbia zoning regulations of 2016. This data set is extracted from the District data catalog. Published March 2016. The dataset represents the revised zone designations of the Zoning Regulations of 1958, relating to District properties.

[117] http://www.dcpsc.org/PSCDC/media/PDFFiles/Electric/electric_sumstats_cust_energyuse.pdf

**DC Wards** - The Ward dataset contains polygons representing boundaries of District of Columbia 2012 election wards, created as part of the DC Geographic Information System (DCGIS) for the D.C. Office of the Chief Technology Officer (OCTO). Published January 30, 2012

**Water bodies and NPS property** - The Water Bodies and National Park Service (NPS) datasets contain polygons representing water bodies and NPS lands, respectively, created as part of the DC Geographic Information System (DCGIS) for the D.C. Office of the Chief Technology Officer (OCTO).

### *Income Data: Source and Definition*

Tract Level income data for the District of Columbia was acquired from the U.S. Census Bureau's American Community Survey (ACS). The data used were 2014, 5-year survey data. The ACS data were joined to the Census Tract GIS data for spatial analysis. Based on the metadata information, the field HC01_EST_VC13 (Households; Estimate of Median income) was selected for analysis.[118]

## Calculation of the Theoretical PV Potential for Residential and Mixed Use

*Derive the total MWh in Direct Current, using the sun-hours variable:*

The amount of electricity produced by a solar panel depends on the hours and intensity of sunshine.[119] These two factors are captured in a variable called 'sun hours', which is a variable for measuring how many 'full'-equivalent sunshine hours a given location receives on an average day throughout the year.[120] The value for the District is 4.69. (The low is 3.37 and the average is 4.23.)[121]

*Daily DC generation* = 543 MW * 4.69 sun hours = 2546.67DC MWh (megawatt-hours)
*Annual DC generation* = 2,546.67 MWh * 365 = 929,534.6 DC MWh

*Next, convert DC MWh into conventional AC MWh, using the result that the AC MWh are only 95% of the DC MWh.* On applying this factor, the result is:

*Annual AC generation = 0.95 *929,534.55 DC MWh = 883,058 MWh*

The average theoretical PV output for low-income residential and mixed-use buildings is about 13,680 kWh, derived as: *883,058 MWh/64,551 buildings = 13,680*

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[118] See https://www.census.gov/data/developers/data-sets/acs-survey-5-year-data.html for a complete description of 5-year ACS data.

[119] In practice, the actual output is somewhat lower than the indicated capacity because of practical factors such as improper installation, shading, etc.

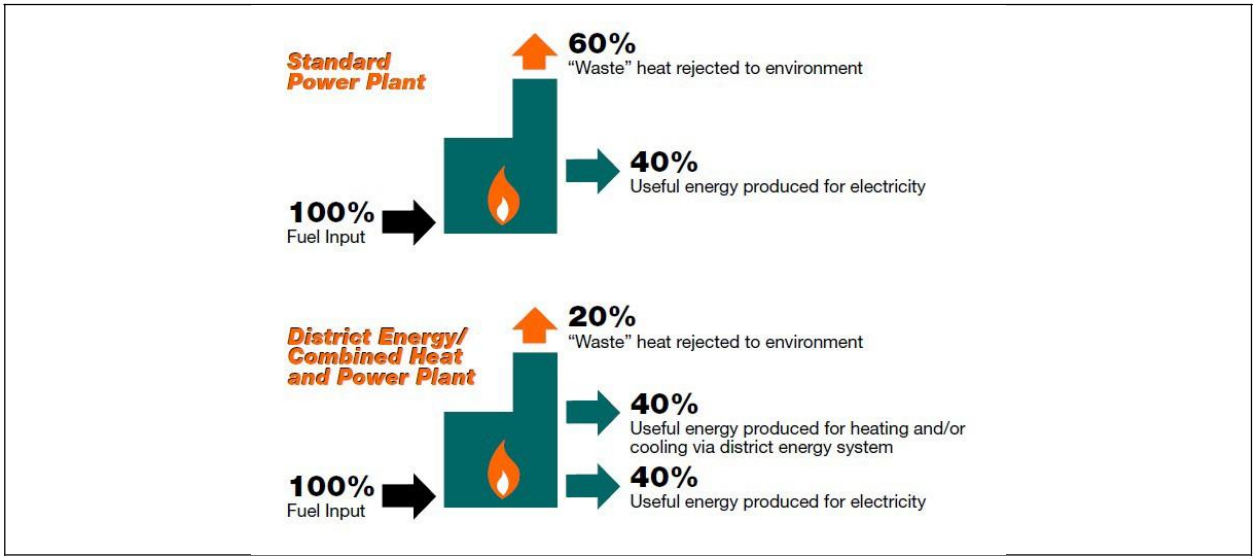
[120] This number is needed because the capacity of the solar panels is measured in MW based on 'full' sunshine.

[121] http://www.bigfrogmountain.com/SunHoursPerDay.html.

## Chapter 4: Combined heat and Power (CHP)

**Combined heat and power (CHP)** – also known as cogeneration – is a way to increase the efficiency of power plants. Standard power plants use 40 percent of the fuel they burn to produce electricity. Sixty (60) percent of the fuel used in the electric production process ends up being rejected or "wasted" up the smokestack, as shown below in the Figure below:[122]

**Figure A.3: District Energy versus Standard Power Plant Illustrated**




*Source: International District Energy Association* (http://www.districtenergy.org/what-is-chp)

This waste heat from a CHP plant can be used to heat or cool buildings in a surrounding area through a district energy system. CHP may be possible when there is an area near the plant that has a need for the heat – a downtown, a college campus or an industrial development.[123]

[122] Here is a link to a short video that explains how CHP works: https://www.youtube.com/watch?v=uXLUoqzlT2k&feature=youtu.be

[123] http://www.districtenergy.org/what-is-chp