Long Island Solar Roadmap Economic Research Report

Prepared October 2019

Disclaimer
This interim report details the findings of research conducted for the Long Island Solar Roadmap, including literature review, analysis of publicly available data, and expert input. This document is a draft and is provided for information only. It takes into account information available at the time it was prepared, and it has not been updated to reflect more recent events, developments, or data. The content of the Long Island Solar Roadmap's final report takes precedence over this document.

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Introduction

The Long Island Solar Roadmap aims to advance the pace of solar installations on Long Island by reducing siting conflicts and lowering the barriers to installations in low-impact sites like parking lots, large rooftops, and areas previously impacted by human activities. Identifying and addressing economic barriers to solar energy development is a key component of this work. Economic factors such as project costs and availability of financing are important determinants of the economic feasibility of a project, and solar energy development has wide-ranging economic impacts at the local and regional scale. In fact, many of the environmental and human health impacts of transitioning to solar electricity generation from fossil-fueled generation can be expressed in economic terms. Therefore, addressing the economics of solar energy development on Long Island is critical for advancing low-cost, low-impact projects that maximize local and regional economic benefits.

Here, we share findings from research into the economic opportunities and barriers to mid- to large-scale solar photovoltaic (PV) installations (250 kW in capacity and larger) on Long Island. We focus on solar PV systems, as this is the dominant solar technology for electricity generation in this region, and simply use the term 'solar' throughout. Specifically, this report characterizes and compares the direct economic costs of development for different types of solar installations, discusses the economic considerations or barriers for solar development in different settings, such as commercial or municipal properties, and describes the indirect economic benefits and costs of solar systems, including to whom these impacts are allocated. Finally, we provide recommendations for addressing economic barriers, improving economic benefits, and reducing economic costs for solar development on low-impact sites.

The intended audience for these results is members of the Long Island Solar Roadmap's stakeholder consortium. This report aims to build knowledge of commonly used business models for mid- to large-scale solar development, available financing and incentives on Long Island, comparative costs and benefits of each type of solar installation and site, the economic considerations and barriers affecting the economic feasibility of developing each type of solar installation and setting. This information will be integrated into the broader project by informing whether sites identified through the spatial analysis are economically feasible and informing possible economic policies, incentives, or disincentives to lower costs and drive solar to low-impact sites.

Overview of New York State and Long Island Energy

In July 2019, New York State adopted the Climate Leadership and Community Protection Act (CLCPA), which sets aggressive mandates for renewable energy generation and greenhouse gas reductions. The CLCPA mandates that 70% of the state's electricity is generated from renewable resources by 2030,[1] 100% of electricity from carbon-free sources by 2040, and a 100% carbon-neutral economy by 2050 (State of New York 2019). According to the New York Independent System Operator (NYISO), electricity generation was responsible for 17% of all greenhouse gas emissions in New York State in 2018. Only 26% of electricity was produced from renewable sources and 56% from carbon-free sources, which includes nuclear energy as well as renewable sources (Figure 1) (NYISO 2019). In the

[1] Under the law, the following sources of energy qualify as renewable energy sources: solar thermal, photovoltaics, on land and offshore wind, hydroelectric, geothermal electric, geothermal ground source heat, tidal energy, wave energy, ocean thermal, and fuel cells which do not utilize a fossil fuel resource.

down-state region, which includes the Hudson Valley, New York City, and Long Island, 5% of electricity was from renewable resources and 28% from carbon-free sources. Therefore, New York State will need to bring a significant amount of new renewable energy generation online within the next decade to meet the mandated targets, and much of this generation will need to be sited down-state close to load centers. While some energy flows from upstate to downstate, transmission constraints on the grid limit the ability to supply more clean energy from upstate to downstate consumers (NYISO 2018).

With the expansion of intermittent renewable energy generation, adding energy storage capacity will also be crucial to securing a reliable electric grid. In 2018, the New York State Public service Commission (NYSPSC) announced a target to install 3,000 MW of energy storage in New York State by 2030, and the New York Department of Public Service (NYSDPS) and NYSERDA published the New York State Energy Storage Roadmap, which details the approach and a series of recommendations to achieve the energy storage goal (NYSDPS and NYSERDA 2018). The NYSPSC issued an order in December 2018 to implement the Roadmap, which among other things, directs the states' utilities to procure a minimum of 350 MW of energy storage, authorizes $350 million in incentives to accelerate energy storage market, and adopts energy storage deployment policies to help eliminate barriers inhibiting the deployment of storage projects. In April 2019, the Governor made available $280 million to support energy storage projects in addition to NYSERDA's $70 million and another $55 million will be provided to support storage projects specifically on Long Island (New York State Office of the Governor 2019).

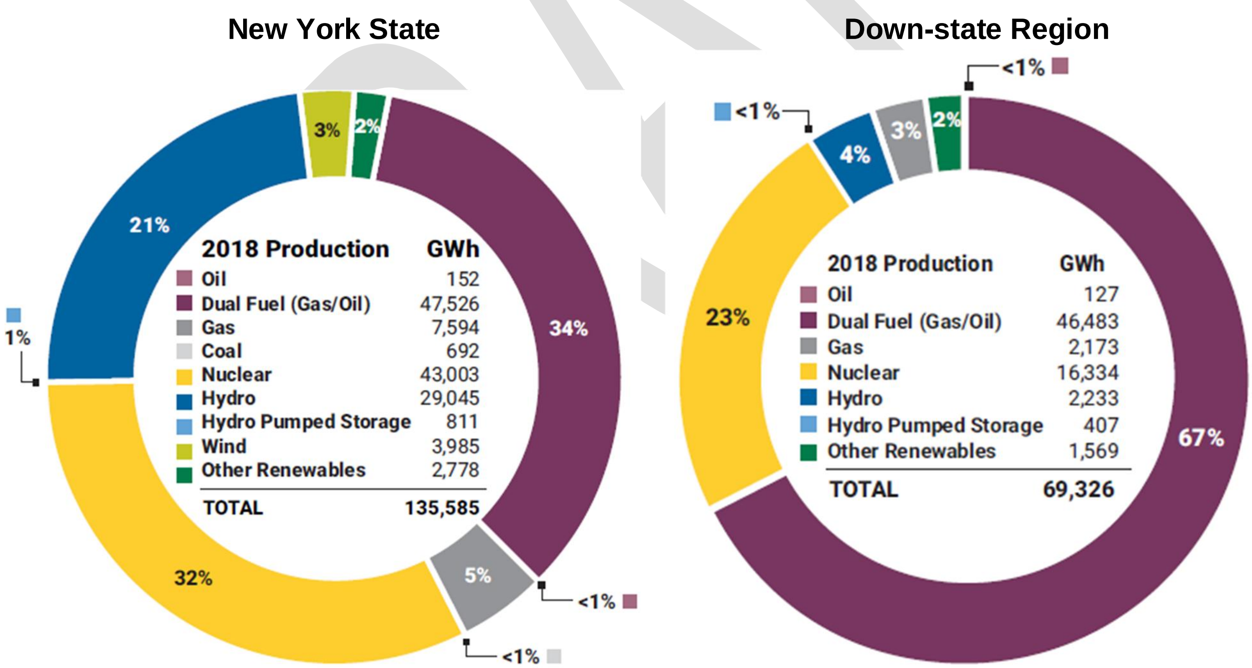

Figure 1. Electric energy production by fuel source in New York State (left) and the down-state region, including the Hudson Valley, New York City, and Long Island, in 2018 (NYISO 2019).

While utilities across the state are strategizing to meet these new mandates, many of them already committed to acquiring renewable energy. For example, under the 2016 Clean Energy Standard, the Long Island Power Authority (LIPA) committed to adding 800 MW of clean energy by 2030, enough to power 300,000 homes. By doing so, LIPA would contribute 12.3% of all renewable energy in the state.

In their 2017 Integrated Resource Plan, LIPA indicated it would meet the 800 MW Clean Energy Standard target by acquiring 400 MW of renewable resources by 2022 and another 400 MW by 2030 either through new generation or through purchase of renewable energy credits (RECs) from outside the state. LIPA anticipates that offshore wind will make up the majority of new generation, while distributed solar is expected to reduce electricity demand from end users. LIPA expects electricity demand to be reduced by approximately 950 MW through energy efficiency, rooftop solar, and other ‘behind-the-meter’ initiatives.

In pursuit of these targets, LIPA signed power purchase agreements (PPAs) for 130 MW offshore wind and 79 MW of utility-scale solar, launched feed-in tariffs (FITs) for 20 MW of smaller-scale solar and 40 MW of fuel cell resources in 2017. In addition, they signed a power purchase agreement for another 880 MW of offshore wind in 2019 (Falcone 2018). Together, these resources will add up to 1,110 MW of clean energy to New York’s energy system. Furthermore, LIPA procured New York’s largest utility-scale battery project and implemented a new system for compensating distributed energy resources that incentivizes smart and efficient development.

Long Island is currently a leader in installed solar in New York State, in part because it has the greatest solar energy generation potential in the state (Figure 2). As of March 2019, there are over 45,700 residential photovoltaic (PV) solar installations on Long Island in addition to over 1,250 commercial solar PV installations, representing over 355 MW and 66 MW of nameplate solar capacity (direct current, DC), respectively. Many of these projects benefited from various incentive programs, including solar rebate programs administered by LIPA and PSEG Long Island, the NY-Sun program, and federal tax incentives. To date, LIPA has also issued three FITs to support distributed solar PV. While up-front solar PV incentives are no longer available to new installations on Long Island and the most recent FIT is fully subscribed, ongoing installation of over 500 solar PV projects monthly since their expiration is indicative of a thriving solar industry in the region.

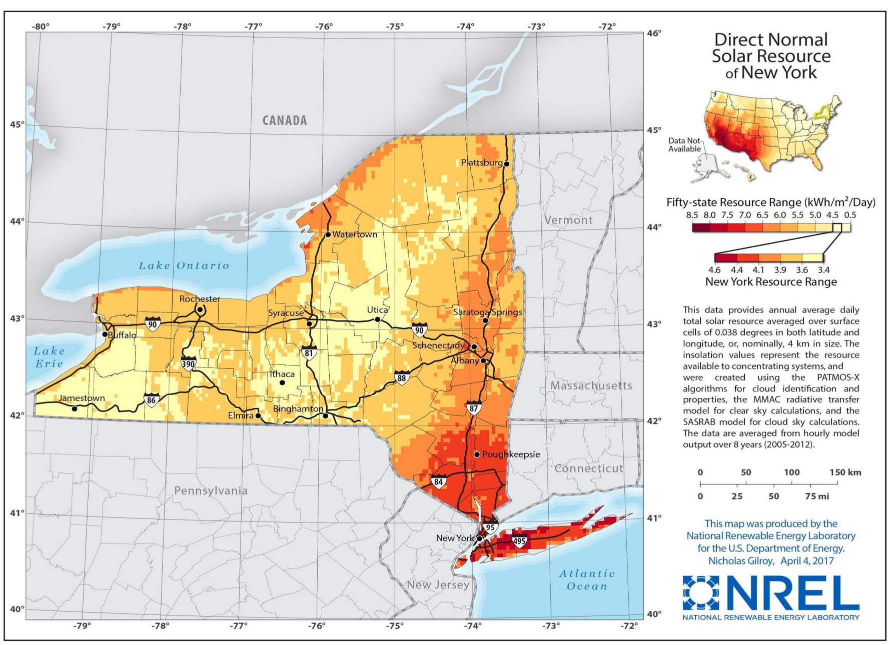

Figure 2. A map of average daily solar insolation in New York in 2017 (National Renewable Energy Laborator (NREL) 2008).

Mid- to Large-scale Solar Business Models

Generally, there are four solar business models available for mid- to large-scale solar installations, each differentiated by ownership of the solar system and the property on which it is located:1) the ownership model, 2) the host model, 3) the third-party owner model, and 4) community shared solar. Each business model may be more or less suitable in different settings and circumstances, and each has different implications for the flow of direct and indirect costs and benefits. In the next section, we describe the advantages and considerations for each model. Table 1 at the end of this section summarizes the information provided in this section. Battery storage can be integrated into any of these business models.

We also describe if the business model is suitable for behind-the-meter or front-of-the-meter solar systems. A behind-the-meter solar system (also called distributed energy generation, distributed energy resource, or DER) is connected to the grid *through* a customer's utility meter, meaning that energy produced is used on-site and only excess energy generated by the system is delivered to the grid. Front-of-the-meter solar systems (also called utility-scale systems) deliver energy directly to the electrical grid, and none of the energy generated is used on site. A third option is remote net metering, where energy from the system is delivered on-site and/or to the grid and credited to multiple accounts owned by the system owner.

Ownership Model

In the ownership model, also called the owner-funded model, the solar system is purchased, owned, maintained, and operated by the owner of the property on which it is situated. In this scenario, the energy produced by the solar system can be used on-site and/or to supply electricity to the grid. While this model generally has higher up-front costs to the property owner, all the energy produced by the system can be used on-site at no additional cost, reducing the owner’s electricity bills. The owner could also use remote net metering to credit any excess energy generated by the system to multiple accounts. An ownership model is well-suited in situations when the property owner will use at least part of the energy produced on-site, when the owner has access to capital and financing, and for projects that are relatively small with lower up-front cost.

Host Model

In the host model, a property owner leases space (rooftop or ground area) to a solar developer to serve as a host site for a front-of-the-meter solar system. The solar developer finances, builds, owns, and operates the solar system, and the energy produced by the solar system is delivered to the grid for off-site use. In this case, there is little to no up-front cost to the property owner, and they receive a steady revenue stream from the solar developer in the form of lease payments. Since no energy is used on-site by the property owner, this does not change their electricity bills. The developer monetizes any applicable incentives and tax credits. This model is advantageous for property owners that have little to no tax liability, such as nonprofit organizations and government entities, and are thus unable to take advantage of tax credits. Independent power producers, the developers that build and operate solar systems under this business model, usually focus on developing large solar installations that deliver energy directly to the grid.

Third-party Owner Model

With this model, the property owner provides the site for the solar system through a lease or easement and agrees to either lease the solar system or purchase the energy generated through a PPA. The developer, investor, or specially created limited liability corporation (LLC) designs, builds, owns, and operates the solar system and monetizes the tax credits and other incentives, usually passing this savings on to the property owner through lower lease payments or reduced cost of electricity ($/kWh). A third-party ownership model may be best suited for larger projects with higher up-front cost, and when property owners do not wish to take on the responsibility for initial development and ongoing operation and maintenance.

If the property owner leases the solar system from the developer, they receive all the energy generated by the system, reducing their electricity bills. Their lease payment for use of the system is usually less than the monthly loan repayment if the property owner had financed the system themselves under the ownership model. This would be the case if the third-party owner has access to lower cost financing (lower interest rates) than the property owner. Leasing is typically a good option when a property owner has good solar access and demand for energy on-site but little to no tax liability, or if the owner lacks the capital or access to financing needed for the ownership model.

Alternatively, through a PPA, the property owner agrees to purchase the energy generated by the solar system on a long-term basis, generally around 20 years. In some cases, the price of electricity ($/kWh) under the PPA might be lower than the cost of electricity from the utility. The developer receives the income from these sales of electricity as well as any tax credits and other incentives generated from the system. There is little to no up-front project development cost to the property owner. PPA’s are most suitable when the host’s energy usage and available space for solar are compatible. When the solar energy generation potential of a setting is much greater than on-site energy use, the host business model may provide greater income for the host (Yazdi et al. 2019).

Community Shared Solar

Community shared solar, also called community solar or community distributed generation, enables multiple customers (off-takers) to receive the benefits of energy produced by a single solar system. There are two main models of community solar in New York, the purchase model and the subscription model. In the purchase model, individual customers decide how many panels in a community solar system they would like to own and pay the up-front cost for those panels when the system is built. The panels provide power to the grid, and each customer receives credits on their electricity bill for the electricity their panels produce. Eventually, the savings they receive from those credits add up to more than their initial payment – allowing for a return on their investment.

An alternative is the subscription model. In this model, the main actors are the sponsor and subscribers. The sponsor designs, builds, owns, and operates the solar system, and interfaces with subscribers and the utility to ensure energy is properly allocated and billed. The sponsor may be a property owner who also owns the solar system or a developer who leases the site for the solar system from the property owner. Energy from the system is delivered directly to the grid, and that energy can be credited to multiple subscribers. Similar to a PPA, each subscriber agrees to purchase a certain percentage of the energy generated by the system.

In New York, community shared solar systems can be up to 5 MW in capacity and must have a minimum of 10 subscribers. The group may include a single subscriber with demand greater than 25 kW, and they can receive no more than 40% of the energy generated by the system. All other subscribers must have an individual demand below 25 kW, and their total energy use from the array must aggregate to at least 60% of the system's output. Each subscriber must be allocated at least 1 MWh of energy generation annually (NYSERDA 2019a).

Many different settings can support community solar systems. If a property owner does not subscribe to receive any of the energy generated, the benefits to the property owner are similar to those of the host business model. If a property owner does become a subscriber to the system, the benefits they receive are similar to those under a PPA. Typically, the cost of electricity to subscribers of community solar systems are lower than the cost of purchasing electricity from the utility. For example, in March 2019, the average rate of electricity in New York was 16.86 cents per kWh. If community shared solar provided a 10% discount to subscribers, the cost would be reduced to 15.17 cents per kWh (EnergySage 2019a). For an average home, that amounts to approximately $16 of savings in their monthly electricity bill.

Table 1. Summary of four solar business models available for mid- to large-scale solar installations

Model Name	Ownership Model	Host Model	Third-party Ownership Model	Community Shared Solar
Description	Property owner owns site and owns their solar system. Energy produced goes directly to offset their own electricity bill.	Property owner leases site to a solar installer. Energy produced goes directly to the grid.	Property owner owns site and leases their solar system. Energy produced goes directly to offset their own electricity bill.	Community shared solar from a solar system that sends energy directly and only to the grid, virtually crediting individual homes and businesses, typically at a discounted rate.
Behind-the-meter or Front-of-the-meter	Behind	Front	Behind	Front
System owner and tax credit recipient	Property owner	Developer / Financier / Tax equity partner (can also be host)	Developer / Financier / Tax equity partner	Developer / Financier / Tax equity partner (can also be host)
Other beneficiaries				Homeowners and businesses can subscribe to receive

				discounted energy credits. The host of the physical site is typically paid by the system owner for providing space for panels.
Cash flows	Property owner hires a solar installation company to design and build the system. Installation company collects any eligible rebates and applies them to the system. Property owner purchases or finances the net system cost and claims tax credits for themselves. Energy goes to offset the building's electricity bill.	System owner (financier/developer) funds the project. System owner pays a developer to install the project (or installs it themselves). System owner pays the host site an upfront and/or annual payment. System owner collects payments from the utility for energy delivered to the grid.	Property owner hires a solar installation company to design and build the system. Installation company collects any eligible rebates and applies them to the system. Installation company links the property owner to a solar lease provider who is able to own the system and take the tax credits. Solar lease provider charges the property owner a monthly fee for the solar panels. Energy goes to offset the property owner's electricity bill.	System owner (financier/developer) funds the project. Owner pays a developer to install the project (or installs it themselves). Owner pays the host site an upfront and/or annual payment. System owner collects payments from subscribers, typically in the form of a power purchase agreement. Owner collects tax incentives and rebates.

Typically good for	Property owner with good solar access and demand for energy at the same building. Property owner has access to capital and financing.	Property owner with good solar access but no demand for energy. Property owners with little to no tax liability.	Larger projects with higher up-front cost. Property owners that do not wish to take on the responsibility for initial development and ongoing operation and maintenance.	Property owners with a lot of roof space or large amount of property but no, or little, appetite need for energy generation.

Solar Financial Incentives and Funding Mechanisms

Mechanisms to support development of renewable energy generally focus on improving the return on investment by reducing the cost of development or increasing the value of the energy generated. Financial incentives include federal and state tax credits and reduced cost financing through public and private programs. State programs and utilities can also encourage renewable energy development through FITs and adders to the value of energy generated based on specific renewable energy or energy storage system characteristics. Below, we describe the federal, state, and utility programs available to support mid- to large-scale solar energy development (non-residential) on Long Island as of August 2019. Key features of these programs are summarized in Table 2.

Federal Programs

The **Energy Investment Tax Credit (ITC)** allows the *owner* of a solar energy system to deduct up to 30% of the cost of installing the system from their federal taxes. The ITC applies to both residential and commercial systems, and there is no cap on its value. If the owner does not have enough tax liability to claim the entire credit in one year, the remaining credits can be claimed in future years as the tax credit is in effect. Therefore, the ITC essentially reduces the cost of developing solar by 30%. Through the end of 2019, system owners can claim up to 30% of the installation costs of a solar project as a tax credit in a given year. The percentage declines to 26% in 2020, 22% in 2021, 10% in 2022 and beyond. Systems must come online by the end of 2023 to be eligible (EnergySage 2019b). This tax credit can be claimed by different entities depending on who owns the system in the solar business model applied to a project as long as that entity has enough tax liability.

The **Modified Accelerated Cost Recovery System (MACRS)** is a method of depreciating the value of real property under the US federal tax code that can be applied to solar energy systems. MACRS allows businesses to recover their investments in certain tangible property over time through annual deductions from their federal taxes. The timeframe of depreciation varies according to the type of property, and the cost recovery period for qualified solar equipment is five years. For solar equipment on which an ITC is claimed, the owner must reduce the project's depreciable cost by 15% (half the value of the 30% ITC). Therefore, solar energy system owners are able to deduct 85% of the equipment cost of a solar installation from their taxes over five years. Currently, system owners can also claim a 30% depreciation bonus, which allows them to deduct 30% of the value in the first year, while the remainder is depreciated under the normal MACRS recovery period. The depreciation bonus is set to expire in 2020 (Solar Energy Industries Association 2019). MACRS depreciation, combined with the ITC, greatly reduces development cost and increases the rate of return on investment for solar energy system owners, though these incentives must be leveraged by entities with large tax liabilities, which makes third-party ownership a very common and useful solar business model.

The **USDA's Rural Energy for America Program (REAP) Renewable Energy and Energy Efficiency Program** provides loan guarantees and grants to agricultural producers and rural small businesses to purchase or install renewable energy systems or make energy efficiency improvements. Small businesses must be in rural areas (outside of a city or town with a population of 50,000 or more), and agricultural producers may be in rural or non-rural areas. Loan guarantees are available on loans up to 75% of total project costs, and grants are available for up to 25% of total project costs. Combined, loan guarantee funding and grants can fund up to 75% of project costs (USDA Rural Development 2019).

New York State Programs

New York State also offers tax incentives for solar in the form of a property tax exemption. **New York Real Property Tax Law 487** provides a 15-year real property tax exemption for properties located in New York State with renewable energy systems for private use, including solar systems. This law only applies to the value that a solar system adds to the overall value of the property and does not exempt property owners with renewable energy system from all property tax. Governments can still benefit economically through payment-in-lieu-of-taxes (PILOT) agreements (NYSERDA 2019c). The New York Property Assessment manual provides more information about what types of equipment qualify (New York State Department of Taxation and Finance 2018). Under all four business models described above, property owners can take advantage of this incentive even if they do not own the solar system itself.

Long Island has been a leading beneficiary of NYSERDA's **NY-Sun** program and its predecessor, which have supported deployment of 88 MW solar capacity from more than 9,200 projects in Nassau county and 203 MW from more than 17,500 projects in Suffolk county. Most of these projects have been residential solar systems. The incentives through NY-Sun are no longer available on Long Island, as the residential blocks were fully subscribed in April 2016, and the commercial blocks were fully subscribed in February 2019 (NYSERDA 2019d).

For reference, the NY-Sun program provides incentives and financing options to support installation of new grid-connected solar systems as stand-alone or paired with an energy storage. For non-residential systems, including schools, only installations up to 750 kW are eligible, including community shared solar. The program is based on a megawatt (MW) block model, which allocates MW targets to specific regions of the State, breaks those targets into blocks, and assigns incentives per block. Once all blocks within a region are fully subscribed, the incentive is no longer available to that region, which is the case for Long Island. Additional incentives are provided to systems that supply energy to multifamily affordable housing properties and systems that are sited on brownfields or landfills (NYSERDA 2019e). Systems on Long Island are not eligible for solar plus energy storage or community distributed generation adders.

The **Solar for All** program is designed to help low-income communities get the benefits of solar. Under this program, households with income at or below 60% of the state median income can subscribe to community solar at no cost and receive up to $15 in credits (reductions) to their monthly electricity bill. However, the program currently does not serve Long Island, because Long Island electric utility customers do not pay into the Systems Benefits Charge to NYSERDA that funds Solar for All (NYSERDA 2019f). Long Island customers are still eligible to participate in community distributed generation projects in the service territory.

NYSERDA's **Small Commercial Energy Efficiency Program** provides two low-interest loan options to nonprofits and small businesses to finance the purchase and installation of solar systems and energy efficiency upgrades, and both options are available to Long Island electric utility customers. NYSERDA will loan up to 50% of the system costs (up to $50,000) at 2% interest and a qualified lender provides the rest of the loan at market rate. They also offer low-interest on bill recovery financing (up to $50,000 at 2.5% interest), which allows small businesses and nonprofits to use energy savings on their electricity bill to pay their loan (NYSERDA 2019e).

The **NY Green Bank** is a state-sponsored investment fund designed to increase the amount of capital available for renewable energy development through various forms of financial support such as credit enhancement, project aggregation, and securitization. NY Green Bank provides loans for renewable energy development ranging from $5 million and $50 million (NREL 2017). NY Green Bank has open solicitations to support clean energy financing arrangements, construction of ground-mounted solar projects, renewable energy and efficiency upgrades at commercial and multi-family buildings, and community shared solar (NY Green Bank 2019).

Property Assessed Clean Energy (PACE) financing, called Energize NY Open C-PACE Financing in New York, allows commercial or nonprofit property owners an innovative way to finance the cost of clean energy upgrades, including solar installations, by repaying the cost through a special charge on their property tax bill (NYSERDA 2019b; Energize NY 2019). PACE financing differs from traditional bank loans in several ways. First, financing is available for up to 100% of the project cost, loan terms are longer (up to the expected life of the improvement, generally 20-30 years), the loan automatically transfers to new owner upon sale of property, and the debt is not carried on the books of the organization and does not affect their credit (NYSERDA 2019b). Energize NY Open C-PACE brings down the cost of clean energy upgrades to under 3% for 20 year funds (Hendricks and Thielking 2016). And importantly, the savings in electricity costs provided by solar system can be used to pay for the system over time. Participation in Open C-Pace was authorized by Nassau County in May 2019 (Local Law 9-2019) and in Suffolk County in June 2019 (Local Law No. 29-2019).

Utility Programs

Utilities can encourage the development of renewable energy by issuing FITs designed to solicit proposals for new energy generation projects with specific technology, siting, size, or other characteristics. FIT programs offer a long-term contract (often 20 years) under which a utility agrees to purchase all of the electricity generated by a system at a fixed price. PSEG-LI is the only utility in New York to issue FITs to support distributed solar PV. To date, there have been three FITs issued to support the interconnection of solar, with LIPA as the purchaser to the 20-year PPA at a fixed price. Taken together, FITs have supported the interconnection of over 56 MW of nameplate capacity (DC) solar PV as of March 2019. The most recent FIT for non-residential rooftop solar and carports was fully subscribed but still open to eligible candidates to join a waitlist.

Utilities can also support renewable energy generation by compensating customers with behind-the-meter solar energy systems for the energy they deliver to the grid. There are currently two compensation mechanisms in use – net metering and value of distributed energy generation (VDER). Under net metering, solar energy producers receive volumetric credits for any energy exported to the grid--sending 1 kWh to the grid earns credit for 1 kWh to use in the future. Essentially, a kWh sent to the grid is worth the same as the cost of a kWh received from the grid--both are valued at the retail cost of electricity. With VDER, solar energy producers receive a monetary credit that can be applied to future billing cycles, and the value per kWh, called the Value Stack Tariff, is variable and largely depends on when the electricity is being sent and where it is going (Thoubboron 2018). As of August 2019, energy generated by PSEG-LI customers with demand-metered commercial accounts, demand-metered commercial participants in community distributed generation projects, and hosts for remote net metered projects that submitted interconnection applications after April 30, 2018 are compensated using VDER (PSEG Long Island 2019). All other customers are compensated using net metering.

Table 2. Summary of financial incentives and funding mechanisms currently available for solar development on Long Island.

	Type	**Description**	**Link**
Federal Programs			
Energy Investment Tax Credit (ITC)	Tax Incentive	Allows the *owner* of a solar energy system to deduct 30% of the cost of installing the system from their federal taxes	https://www.energysage.com/solar/cost-benefit/solar-investment-tax-credit/
Modified Accelerated Cost Recovery System (MACRS)	Tax Incentive	Allows depreciation of the value of solar energy system equipment under the US federal tax code.	https://www.irs.gov/publications/p946
USDA's Rural Energy for America Program (REAP) Renewable Energy and Energy Efficiency Program	Financing & Funding	Provides loan guarantees and grants to agricultural producers and rural small businesses to purchase or install	https://www.rd.usda.gov/programs-services/rural-energy-america-program-renewable-energy-systems-energy-efficiency

		renewable energy systems	
New York State Programs			
New York Real Property Tax Law 487	Tax Incentive	Provides a 15-year real property tax exemption for properties located in New York State with renewable energy systems	https://www.nyserda.ny.gov/All-Programs/Programs/NY-Sun/Communities-and-Local-Governments/Solar-Guidebook-for-Local-Governments
NYSERDA's Small Commercial Energy Efficiency Program	Financing	Provides two low-interest loan options to nonprofits and small businesses to finance the purchase and installation of solar systems	https://www.nyserda.ny.gov/All-Programs/Programs/Small-Business-Financing
NY Green Bank	Financing	Provides loans for renewable energy development and other financial support, such as credit enhancement, project aggregation, and securitization	https://greenbank.ny.gov/
Energize NY Open C-PACE Financing in New York,	Financing	Property assessed clean energy (PACE) financing that allows commercial or nonprofit property owners to pay back the cost of clean energy upgrades, including solar installations, through a special charge on their property tax bill	https://energizeny.org/
Utility Programs			
Feed-in-tariffs (FITs)	Compensation	Invites solar developers to bid on projects under an agreement to sell the energy to	https://www.psegliny.com/aboutpseglongisland/ratesandtariffs/tariffs

		the utility at a pre-specified rate. A long-term energy generation agreement that feeds the grid.	
Net metering	Compensation	Solar energy producers receive volumetric credits from the utility for any energy exported. Each kWh sent to the grid is worth the same as the cost of a kWh received from the grid--both are valued at the retail cost of electricity	https://www.psegliny.com/saveenergyandmoney/-/media/08cd6cf39bde4fbc80aa66ea7556603f.ashx
Value of distributed energy resources (VDER)	Compensation	Solar energy producers receive a monetary credit from the utility that can be applied to future billing cycles, and the value per kWh is variable based on the Value Stack	https://www.psegliny.com/businessandcontractorservices/businessandcommercialsavings/greenenergy/vder

Opportunities and Barriers for Mid- to Large-Scale Solar

Broadly speaking, mid- to large-scale solar systems can be installed on four types of property differentiated based on the type of property owner: 1) commercial, industrial, and other private properties, 2) properties owned by non-profit organizations, 3) government properties, and 4) agricultural properties. In this section, we identify the major economic considerations or barriers to solar development in each setting and discuss potential solutions.

Commercial, Industrial, and Other Private Properties

Here, we define commercial properties as buildings and/or land that are used for business activities that generate a profit, including from capital gain or rental income. Examples of this setting include office buildings, medical facilities, and retail spaces. Farms are excluded from this category and are addressed in the agricultural properties section below. It should be noted that PSEG Long Island distinguishes commercial properties based on electricity usage rather than land use. Commercial spaces can be occupied by the property owner or leased to one or more tenants. In some commercial leases, tenants secure improvement rights that allow them to alter the space to fit their business's needs, including interior and exterior spaces like rooftops. Below, we make the distinction between owner-occupied commercial settings and tenant-occupied commercial settings, as the opportunities and barriers in each are differ.

Generally, up-front installation costs present less of a barrier for commercial spaces than for some other settings, because for-profit businesses can usually take advantage of tax credits and other incentives such as PACE Financing. Here, it is important to note that federal tax credits are available to the solar system owner, which does not have to be the owner of the property on which the solar system is located. In owner-occupied spaces, the property owner can choose a business model that best suits their tax liability level and energy use. When solar energy generation potential and electricity use at a site are similar, the ownership or third-party ownership model may be most appropriate. If commercial property owners are responsible for the electricity bill at more than one property, they may even choose to use remote net metering to credit electricity generated at one site to their other utility accounts.

In tenant-occupied commercial spaces, installation of solar is often hindered by the problem of split incentives. Split incentives arise when the entity responsible for using and paying for energy is not the same as the entity responsible for paying for measures to reduce energy consumption, such as a solar adoption or efficiency upgrades. Therefore, split incentives can arise with either the owner or the tenant paying the energy bill; the latter situation is more common, in the US, where roughly 83% of commercial building occupants pay their own utilities (Jessoe et al. 2019). In this scenario, property owners may be reluctant to make energy-related capital investments, such as rooftop solar, improved heating and cooling systems, or energy efficiency upgrades, because those costs cannot be recovered when energy cost savings accrue to the tenant. However, the property owner could still accrue the tax benefits and other incentives associated with ownership of a solar system.

The Department of Energy's Better Buildings Alliance offers several potential solutions to the split incentives problem (US Department of Energy 2015). First, the property owner can invest in a behind-the-meter solar system and include electricity in the cost of the lease. Mechanisms such as a "green lease," a formal agreement between owner and tenant to partner on energy-saving mechanisms, can help formalize this arrangement (Institute for Market Transformation 2019). For some customers, electricity-inclusive leases may create their own split incentive that reduces the motivation of tenants to reduce energy use through energy-efficient behaviors. According to a study of the largest 10% of commercial electricity users in Connecticut, tenants paying for their own electricity used up to 14% less energy in the summer than tenants on electricity-inclusive leases (Jessoe et al. 2019). Alternatively, the property owner chose to provide energy from the solar system to tenants through a PPA or community shared solar arrangement.

Alternatively, rather than investing in a solar system themselves, the property owner could allow the tenant to install solar equipment as part of their improvement rights. The property owner could also lease roof space to a third-party that manages the financial arrangements of the system installation and sale of electricity to tenants or other off-takers or the grid, similar to the host business model. One major barrier to this solution is that the terms and length of the tenant's lease may not align with the payback time frame for the purchase of a solar system (under the ownership model) or a solar lease (under the third-party ownership model).

Nonprofit Properties

Property owned by nonprofit organizations, such as religious institutions, charitable organizations, advocacy groups, and community-based institutions, are another potential setting in which solar systems can be sited. Energize NY, a New York State non-profit local development corporation focused on funding clean energy projects, identified the nonprofit sector as an area of major growth for renewable energy solutions (Hendricks and Thielking 2016). Investing in renewable energy may align with the values or further the mission of the organization, however, the initial cost of development combined with a lack of access to financing and tax incentives, is a major barrier to solar installations for nonprofits.

Nonprofits primarily invest financial resources in the programs and services that further the mission of the organization, and budgets are often constrained. Further, nonprofits are underserved in debt markets, because they have unusual forms of credit or cash flows (Hendricks and Thielking 2016). Some nonprofits also have restrictions on using endowments for capital improvements (Yazdi et al. 2019). As a result, maintenance and other capital projects are often deferred and under-funded. Finally, nonprofits are ineligible for all tax-based incentive programs. We have identified several options to overcome these barriers, including group purchasing programs, property assessed clean energy (PACE) financing, serving as a host site for a solar system owned by a third-party, or third-party financing tools tailored to nonprofits.

Group purchasing programs can also help reduce initial costs. Such programs bundle multiple solar installations, develop them along the same timeline, and put them out to bid as a package. On Long Island, the PowerUp Solar program, a collaboration between the Long Island Progressive Coalition and Resonant Energy funded by US Department of Energy SunShot Initiative, is taking this approach to reduce the cost of solar installations for houses of worship and other nonprofits in the region. They are able to reduce the total system cost for each project by 15-30% through group purchasing (PowerUp Solar Long Island 2019).

Solar business models that reduce or eliminate up-front costs are also suitable in nonprofit settings, such as the host model or the third-party ownership model. Under the host model, the revenue stream to the nonprofit is in the form of lease payments from the developer, and there is no change in their cost of energy. Under the third-party ownership model, the nonprofit could negotiate a PPA in which they purchase energy from the solar system at their site at a lower rate than the retail price of electricity from the utility, reducing the overall energy costs for the nonprofit (EnergySage 2019c). PPAs are most suitable when the host's energy usage and available space for solar are compatible. When the solar energy generation potential of a setting is much greater than on-site energy use, the host business model may provide greater income for the nonprofit host (Yazdi et al. 2019). Finally, PACE financing may be used to access low-cost capital for non-profit energy efficiency and renewable energy projects through Energize NY's Open C-PACE program.

Government Properties

Government properties include those owned by federal government entities, New York State government entities, Nassau or Suffolk counties, municipal governments, and school districts. Solar systems and other renewable energy generation on government properties can reduce energy costs for the government facilities, and lease payments from solar developers can provide a predictable, sustainable source of revenue. These projects also help government entities achieve their renewable energy and greenhouse gas reduction goals.

Similar to nonprofit organizations, the initial cost of development combined with financing obstacles and a lack of access to tax incentives are major barriers to solar installations on local government properties. According to research by Lawrence Berkeley National Labs, the cost of solar development was consistently 5.5% to 15.7% higher for tax-exempt entities than similar-sized projects in the residential and commercial sectors in 2012. This higher cost was attributed to factors including prevailing wage requirements, procurement processes, a higher instance of parking structure arrays, additional permitting requirements and other issues (Barbose et al. 2013). Permitting of municipal solar projects may be easier or faster in New York and other states in which municipalities have home rule jurisdiction, where municipalities issue their own permits. County, state, and federal government projects, however, do not have home rule authority. In a 2016 survey conducted by the International City/County Management Association (ICMA) as part of the US Department of Energy's SunShot Initiative, high up-front cost was cited as the number one challenge for solar development by local governments (International City/County Management Association (ICMA) 2017).

These barriers make the ownership model least accessible for local governments, as this model bears the highest up-front costs due to their ineligibility for federal and state tax incentives. Financing renewable energy projects through tax-exempt bonds allows local governments access to low interest debt and to own of the solar system. However, many municipalities on Long Island and elsewhere are reluctant to increase debt obligations. The presence of outstanding debt can lower a government's credit rating and increase its interest rates on loans for all other projects. Elected officials may also want to keep debt and taxes low. Governments with lower credit ratings may be unable to issue bonds at an interest rate that makes a project feasible. Further, issuance of general obligation bonds for capital projects is limited by the availability of tax dollars to repay the principal and interest. New York's tax cap limits the increase in property taxes to 2% per year or the rate of inflation, whichever is higher. This cap limits the ability of local governments to use new tax revenue to fund renewable energy projects. Renewable energy projects may be eligible for revenue bonds, as the project can be structured to provide income to the municipality.

The third-party ownership models reduce the cost of development and have been widely used to finance solar on government and nonprofit properties. While PPAs are the most common third-party finance structure, additional options are available to municipalities including operating leases, sale/leaseback structures, partnership/flip agreements, and hybrid financing structures. These mechanisms, along with their benefits and challenges for local government, are described in detail in the "Guide to Implementing Solar PV for Local Governments," written by the US Department of Energy's SunShot Initiative. This resource also provides municipalities detailed information and guidance for feasibility studies, financial options, purchasing and contracting models, as well as solar system commissioning, operation, and maintenance (Dodson et al. 2013). Third-party ownership models are most viable for larger-scale projects due to the higher cost of financing.

Finally, local governments may choose to simply host a solar array by leasing land to a solar developer. In this case, the local government does not receive any of the power generated by the array and forgoes the associated energy cost savings, making this option less financially beneficial than some third-party ownership models. This may be most appropriate for properties with no to low on-site energy use, such as closed landfills or other sites without major facilities. The simplicity of this financial arrangement relative to third-party ownership and the stable revenue from lease payments make this an attractive option for local governments (Dodson et al. 2013).

Local governments also have unique opportunities to increase local renewable energy generation through community shared solar and community choice aggregation. Community shared solar is an arrangement where a single solar system provides electricity to multiple off-site customers. A local government could create a community shared solar system that provides renewable electricity to multiple municipal accounts (through remote net metering) and/or to local residents. This may be a good option for properties with no to low on-site energy use and to reduce energy costs for low to moderate income residents. If a municipality wishes to supply renewable energy to local residents but is unable to own or host large solar system, community choice aggregation (CCA) is a good option. CCA allows local governments to source renewable electricity on behalf of their residents, businesses, and municipal accounts from an alternative provider, while the local utility still provides transmission and distribution services. According to the US Environmental Protection Agency (EPA), electricity prices under CCA may be as much as 15-20% lower than retail electricity prices due to the collective buying power of communities and other market trends (US EPA 2019c). NYSERDA has created detailed information and resources for municipalities considering CCA (NYSERDA 2019b).

Agricultural Properties

Agricultural areas include land used for plant and animal production and husbandry, including food and horticulture crops as well as livestock. On Long Island, most farmland is concentrated in Suffolk County, where over 35,000 acres or 6% of total land area are in production. According to the 2017 USDA census, Suffolk County is the fourth largest agricultural county in New York State with over $225 million dollars in annual gross sales of agricultural crops, including fruits, vegetables, wine/grapes, nursery stock, greenhouse production, equine, as well as an increasing number of livestock farms, both large and small animals (National Agriculture Statistics Service 2019).

Farm operations may own or lease agricultural land, and agricultural land may be protected from development by a number of mechanisms. Long Island’s Farmland Preservation Program was created in 1974 to enable a farmer to sell only the development rights on the farmland to Suffolk county while retaining ownership of the fee simple (otherwise known as the soil and land) to continue to farm. Under this program, a deed restriction is placed on the land, specifying that it can only be used for agricultural production in perpetuity thus preserving the land from development or other land uses. Currently, almost 11,000 acres are protected under the Suffolk County Farmland Preservation Program, and an additional 10,000 acres are protected under various other programs. This limits the potential for mid- to large-scale renewable energy generation in agricultural areas on Long Island to the 14,000 acres of unprotected farmland in Suffolk county plus any unprotected farmland in Nassau County.

An additional farmland preservation program is the creation of local Agricultural districts, which offers tax incentivizes for farmers who use the land for agricultural activities. Current New York State Agriculture and Markets law offers farmland owners a favorable agricultural tax assessment in exchange for their commitment to maintain the land in agricultural production and restrict other kinds of development for five years, making it financially viable for many farms to stay in production. Under this law, installing solar on farmland is considered land conversion and carries a high penalty for farmland owners – if solar electrical output exceeds farm electrical use by more than 10%, farmers are required to pay 5 times the annual taxes avoided through the assessment plus interest (New York State Department of Agriculture and Markets 2019). This potentially limits the ability for farms to produce solar energy for off-farm use. However, conversion of farmland for wind, oil, or gas development is exempt from this payment – though these are ways to generate energy that do not carry as large a land footprint as solar.

Solar and other renewable energy generation can provide a stable, year-round source of income to farmers, which can be especially important as farm economics become more challenging and volatile. On Long Island and elsewhere around the state, farmers face a multitude of challenges that can increase operation costs and reduce profits, threatening the ability of farms to persist into the future. When combined with the high land values of Long Island, the pressure to convert farmland to other land uses is high. Further, transitioning farms between generations can lead to conversion of farms to other land uses. In instances where children of farmers have devoted themselves to other careers and/or have no interest in operating a farm, farms are often sold for development. Ideally, solar installations can be located on a less productive portion of farmland while the remainder stays in production, potentially increasing income from marginal lands or lands that cannot be farmed for other reasons, such as the presence of crop pests or diseases. Additionally, certain types of solar on “full rights farmland,” that is, farmland with no deed or other restrictions, presents an opportunity for lower-impact development rather than more permanent types of development like housing or commercial projects. Solar development, especially the ownership, host, and third-party ownership models, can be a mechanism to preserve the soils and openness of a farm on a short term basis at no cost to the taxpayers if certain protections are put in place requiring developers to construct, operate, and decommission projects to protect the agricultural use of that property, and if the right of first refusal at the end of the lease goes to the farmer or another public entity who could decide to put the land back into production if the economics are favorable. By allowing a farm to be leased by a farmer to a solar company, panels can be installed on land with minimal disturbance to the soils and for a term of 20-30 years could be maintained for solar production with the inherent possibility of the land being restored to farming with little to no effect after decommissioning if developers are required to follow New York State Department of Agriculture and Markets (NYSDAM) guidelines for construction, operation, and decommissioning, which are designed to protect the agricultural soils throughout the life of the project.

There are also opportunities for co-location (also called “co-utilization” or “agrivoltaics”) of ground-mounted solar panels and agricultural crops, grazing, and ranching, avoiding agricultural displacement for renewable energy development. In this case, a solar project can be structured so that a farmland owner receives energy from the installation, lowering their energy costs, as well as income from leasing space for the solar panels and the value of the crops planted or grazed below the panels. Research by the National Renewable Energy Laboratory (NREL) as part of the Innovative Site Preparation and Impact Reductions on the Environment (InSPIRE) project shows that co-location of agriculture and solar has the potential benefits for farmers, the environment, and solar developers (Dreves 2019). In addition to the direct economic benefits to farmers, in some cases co-location with solar can improve the yield of some crops, reduce water use and nutrient loss, help control erosion, and provide habitat for pollinator species. Co-location can also reduce the construction and operation costs for solar developers, potential increase energy production, and therefore lower costs for energy off-takers (Mow 2018).

Direct Costs of Solar Development

Cost Change Over Time

This section describes overall trends in the cost of solar development for installations of different sizes and characterizes and compares the costs of development for each type of solar installation (rooftop, parking lot, and ground-mounted) as of mid-2019. Every quarter, NREL publishes the U.S. Solar Photovoltaic System Cost Benchmark report. The report from the last quarter of 2018 (“Benchmark, Q42018”) shows that for years, PV panels accounted for the largest portion of solar system installation costs for commercial and utility-scale systems (Fu, Feldman, and Margolis 2018). This changed in 2012, because the cost of both panels and soft costs (benefits, permits, and other administrative costs not including salaries) dropped dramatically, sharply reducing the overall cost of solar development. Labor costs, however, have remained nearly constant over time. As shown in Figure 3, the 2010 average cost of a 200 kW commercial solar PV installation in the US was $5.43/W, with just under $3 of that going to panels and ~$1 to soft costs. In 2011, installation costs were incrementally smaller. Then in 2012, installation costs dropped to $3.47/W, with just over $1 of that going to panels. In 2018, installation of a commercial system (10 kW–2 MW) cost an average of $1.83/W nationally (Fu, Feldman, and Margolis 2018) and $2.92/W in New York (NYSERDA 2019g). Price variations for commercial installations are usually due to changes in the prices of modules and labor (wages). Steel prices may also become a cost factor, especially for vaulted systems in parking lots.

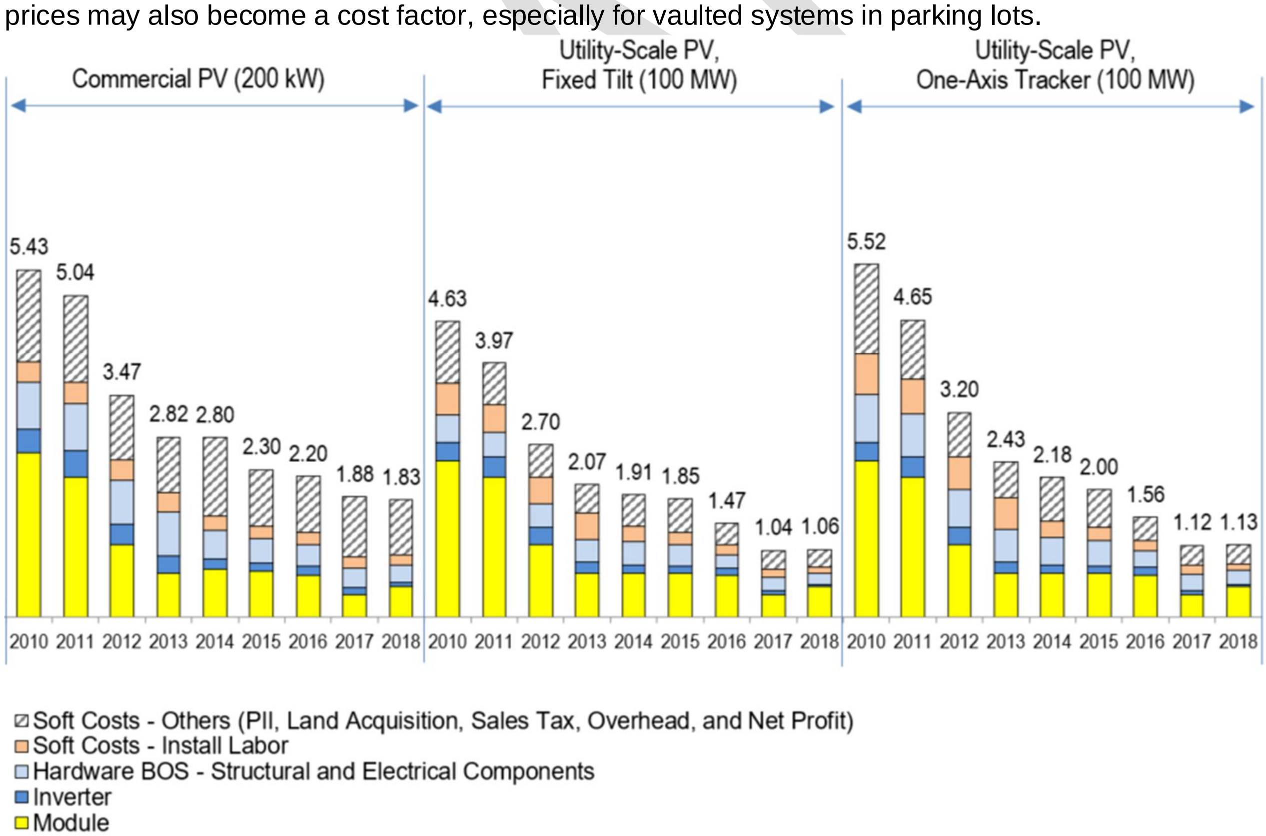

Figure 3. NREL solar PV system cost benchmark summary, 2010-2018, adjusted for inflation (Fu, Feldman, and Margolis 2018).

We see the same trends for utility-scale PV larger than 2 MW that often deliver power directly to the grid (Figure 3), with utility scale solar costing $1.06-1.13/W nationally and $2.11/W in New York (NYSERDA 2019g). Benchmark, Q42018 provides the rule of thumb that installation cost decrease $.07/W DC when the size of a system increase from 50 to 100 MW (Fu, Feldman, and Margolis 2018). The factors identified as responsible for driving down the costs of large solar installations are lower inverter prices, higher module efficiency, and economies of scale in management, labor, permitting and interconnection costs.

Not captured in Figure 3 is the cost of interconnection. The interconnection of front-of-the-meter solar systems to the electrical grid often requires upgrades to the distribution system to control voltages and minimize adverse impacts. Typical upgrade requirements include grounding banks, voltage regulators, capacitors, reclosers, fault detectors, or capacitor control changes. The costs for these additions are usually borne by the developer and can have a negative impact on the economic viability of a project. Data from Maryland shows that upgrade requirements are typically ~$300,000 or less and can add up to $0.017/kWh to the cost of power generated for a 2 MW solar project. Larger projects might require transformer or line upgrades. Costs for these additions are also usually born by the developer. Substation or distribution upgrades typically cost ~$1,000,000 or more and can add $0.017 to $0.023/kWh (Daymark Energy Advisors, RLC Engineering, and ESS Group 2018). Therefore, only large, front-of-the-meter projects can usually absorb the cost of such upgrades.

In addition to development costs, the viability of a solar project from a developer's perspective often hinges on the ability to sell power to an off-taker, usually the local utility, at a competitive rate. According to a September 2018 Bloomberg New Energy Finance Report, New York City and Long Island are the most profitable locations in the US to develop solar energy due to the high wholesale power prices in New York City and the isolation of Long Island's electrical grid. These conditions result in a premium for solar developers in these areas. The report shows that solar in New York City and Long Island earned ~$45 per MWh, while solar in Southern California earned as little as ~$15 per MWh. The lower price in California is due, in part, to the greater amount of installed solar capacity. However, overall profitability for IPPs on Long Island is mitigated by expensive real estate, high construction costs, and complicated permitting processes that increase soft costs (Martin 2018).

Comparison of Installation Types

There are three primary types of mid- to large-scale solar installations--panels mounted on rooftops, panels on raised canopy structures in parking lots (also called carports), and ground-mounted systems, which can be located on a variety of site types. Here, we describe and compare the direct cost of development for each type of solar system. For simplicity, we compare the cost of 1 MW sized projects for each of three installation types. We also provide added cost implications for clearing vegetation and for using brownfield or capped landfill sites for ground-mounted installations compared to uncontaminated and previously cleared land (Table 3). The cost of interconnection to the electrical grid is a large variable. For comparison purposes, we consider a new electrical service added to a roof, ground, or carport site with a new electric meter.

For 1 MW commercial rooftop systems, buildings must have flat roof membrane (the majority of buildings at this scale) or metal seam roof types. Installation costs are similar for both roof types, slightly less on a metal seam roof. In both cases, a full structural analysis must be performed by a third-party Professional Engineer (PE) to ensure the roof can support the added load (weight) of the solar-related equipment. The roof area required for a 1MW solar system is about 100,000 ft^2 with minimal roof equipment and obstructions.

Solar canopy structures on parking lots consist of an elevated racking system installed over parked car areas. When cars are parked ‘nose to nose’ in a double bay scenario, the solar canopy overhangs both vehicles, and the vertical support usually resides in the space between cars. Typically, 1,200 linear feet of double bay parking area is needed for a 1 MW solar project. Solar systems on parking lots are usually more expensive than rooftop or ground-mounted installations of the same size, because additional steel is needed for the elevated racking system.

Ground-mounted solar systems require about 5 acres of generally flat land per 1 MW of installed capacity where solar panels will be installed on a racking system low to the ground. There are three primary site types for ground-mounted installations based on previous land use. Uncontaminated sites are areas that have not been previously used as a landfill, waste site, or for any other use that resulted in substances that pose a hazard to health or the environment being on or below the surface of the soil. Uncontaminated sites may be wooded, where existing brush, trees, and other natural landscape elements are present, or may have been previously cleared of significant tree cover and natural vegetation for some other land use. According to the US EPA, brownfield sites are properties for which use may be restricted or “complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant” (US EPA 2019d). Finally, former brownfield, landfill and waste disposal sites that have completed a full environmental review and remediation process, with approval by appropriate governmental organization, are also potentially suitable sites for ground-mounted solar installations.

A key cost factor for ground-mounted systems is the racking system for the panels, which can be installed in one of two ways – ground-penetrating or ballasted. Ground-penetrating racking systems consist of steel beams driven into the ground to anchor and support the solar panels. This is the typical racking system used in uncontaminated areas and most Brownfield sites. A ballasted racking system rests on the surface and is weighed down using concrete or another material. This system is often used for capped landfills and at some formerly contaminated sites that have been fully and legally remediated and documented where ground penetration must be avoided. Ballasted systems can also be used for rooftops solar systems when penetrating the roof is not an option. Typically, ballasted systems are more expensive for both ground-mounted and rooftop systems compared to fixed racking systems.

Several other factors can add to the overall cost of a solar system, including permitting, site preparation and restoration, and payments in lieu of taxes (PILOTs). Permitting costs include the cost of the permit itself as well as the staff time necessary to obtain the permit. The process and time necessary to obtain a permit for mid- to large-scale solar projects is variable across Long Island, which can add to the overall soft costs and delay development of a solar installations. Site preparation and restoration vary with the type of installation and setting and includes roof replacement, land clearing and grading, and parking lot trenching and resurfacing. Finally, taxing jurisdictions in New York can require a solar developer to submit an annual PILOT as a replacement for the real property taxes for which renewable energy projects are exempt under Real Property Tax Law § 487 (New York State Energy Research and Development Authority (NYSERDA) 2019k). As a result, PILOTs increase the cost of solar development and are usually only applied to large, front-of-the-meter solar systems.

Table 3. Estimated direct costs of developing 1 MW of solar for each of three installation types – rooftop, ground-mounted on previously cleared land, and solar canopy structures in parking lots – and added cost implications for clearing vegetation, using of brownfield sites, and using capped landfill sites for ground-mounted installations. Estimates provided by EnterSolar in 2019.

	Roofmount	Groundmount (Previously Cleared/Uncontaminated Land)	Parking Canopy
Estimated Size (kWdc)	1000	1000	1000
Physical Space Required	100,000 sq ft	5 acres	1,200 ft
IC app & CESIR Study fees	$3,250	$3,250	$3,250
IC document prep cost	$1,500	$1,500	$1,500
Estimated Cost ($)	$1,895,000	$1,985,000	$3,475,000
Utility Required IC Work	$60,000	$60,000	$60,000
Developer required IC work	$20,000	$20,000	$20,000
Easement Cost			
Building permitting cost			
Site Prep	roof replacement	land grading	resurfacing
Estimated VDER ($)	$0.113	$0.113	$0.113
MW Block	*$0*	*$0*	*$0*
Simple Payback (years)	7.11	7.79	12.51
IRR (after- tax)	8%	7%	3%
NPV	$246,218	$143,578	-$505,152
Site Lease			

	Nassau	Suffolk
Sales Tax (%) materials only	4.25	-

	Clearing Wooded Land	Using Remediated Brownfields	Use of Closed / Capped Landfill Sites
Adder	$20k/acre	no upcharge from regular groundmount assuming remediation	at least 50% more for racking/fencing because it will be ballasted

Battery Storage

Energy storage has the potential to help balance generation with load in time and space. Storage will be increasingly important as population, energy demand, and the use of intermittent renewable resources continue to grow and transmission and distribution systems age and become congested. According to energy analysis firm Wood Mackenzie, 310.5 MW of energy storage were deployed in the U.S. in 2018 – 53% was behind-the-meter. Despite a shortage of lithium-ion batteries in Q2 2018, battery rack prices declined from $275/kWh in 2016 to $225/kWh in 2018. The firm forecasts that prices will continue to decline and will reach $150/kWh by 2023. Further, they predict that annual deployments will increase ten-fold by 2024, reaching 4.4 gigawatts (GW) per year with an annual market value of $4.7 billion (Wood Mackenzie 2019).

The primary benefit of integrating storage with a solar system is to balance energy supply with demand by storing energy that may not be needed when the PV panels are generating electricity (daytime) and using the stored power to meet demand when the PV panels do not generate electricity (nighttime) or are not producing enough electricity to meet demand. However, this is only one of many benefits. To evaluate the economics of how solar might integrate with storage, it is important to understand the various ways that energy storage technologies can contribute services that may be of financial value. A 2015 report by the Rocky Mountain Institute (RMI) titled, “The Economics of Battery Storage,” describes 13 types of battery services and their applicability to behind-the-meter, customer-sited applications as well as front-of-the-meter or more “upstream” functions as part of the distribution or transmission system (Appendix 1). The report categorizes these benefits from the perspective of electric utility customers, IPPs and regional independent system operators (ISOs), and utility services. According to the report, the economic value of a battery system may be improved by “stacking” the services it can provide (Fitzgerald et al. 2015).

The New York Energy Storage Roadmap[2] concludes that “many customer-sited and distribution system use cases and paired solar [plus] storage projects are, or will soon become, viable in downstate New York between now and 2025” (NYSDPS and NYSERDA 2018). They found that solar plus storage projects are attractive due to their ability to overcome intermittency of solar energy production, eligibility for federal tax credits, and their potential to reduce interconnection costs by modulating power output. The value stream under this use case included capacity, short-duration frequency regulation, and peaker-plant efficiency improvement or replacement. The RMI report posits that the number and value of services provided by battery storage is higher the further ‘downstream’ the system is located in the electricity system (Fitzgerald et al. 2015). That is, storage installed behind-the-meter at the site of power usage can potentially provide all 13 types of service at all levels, whereas upstream distribution- and transmission-level services cannot provide services to end users further downstream.

The New York Energy Storage Roadmap includes one modeling exercise for a 350kW solar installation paired with a 90 kW, 4-hour duration battery at a school on Long Island. The Energy Storage Roadmap found that, “while the PV system adds significant costs to the project,” the project was still financially viable due to eligibility for the Investment Tax Credit and the ability to use more of the solar energy on site. Furthermore, such systems could potentially provide backup power, allowing community members to use the facility as a refuge in an outage. In another use case, the Energy Storage Roadmap modeled a 4 MW community distributed generation solar system with batteries sized at 1 MW and 4 MW in the Hudson Valley and found that both had much higher value than that for unpaired storage. The Energy Storage Roadmap’s modeled VDER calculation includes assumptions for storage that cover several production and value parameters. Their use case for the LIPA service territory found that, “The paired solar + storage use cases perform significantly better than do stand-alone bulk system storage” and that avoided interconnection upgrades were a major source of value for paired solar and storage on Long Island” (NYSDPS and NYSERDA 2018).

For the most up-to-date resource for calculating VDER value stack for a specific solar plus storage project, see NY-Sun’s Solar Value Stack Calculator,[3] an Excel-based tool which is updated periodically to reflect policy changes (PSEG Long Island 2019).

[2] The New York Energy Storage Roadmap was developed by NYSERDA and NYDPS in 2019 to meet the state’s goal of installing1500 MW of energy storage in New York by 2025.
[3] Available at https://www.nyserda.ny.gov/all-programs/programs/ny-sun/contractors/value-of-distributed-energy-resources/solar-value-stack-calculator.

Indirect Benefits and Costs of Mid- to Large-Scale Solar and Battery Storage

Jobs and Economic Development Impacts

In addition to the direct economic costs and benefits of solar development for landowners, solar developers, and solar energy users (off-takers), there are indirect economic impacts that can have a substantial effect on the economy. The jobs created as part of mid- to large- scale solar development extend from construction of the array through continued operations, ranging from crane operation and manufacturing to sales and ongoing maintenance work. The wages earned through these jobs create additional spending in a region that ripples into other sectors of goods and services, from grocery stores and restaurants to retail and auto sales. In this section, we provide additional context on solar jobs creation in New York, explain the most common methodologies to capture these indirect benefits (jobs plus additional economic impacts) and share some examples.

As of 2018, New York State ranks fourth in the United States for solar job creation within the state, but only twenty-eighth in jobs per capita. The New York City metro area ranks first in solar jobs, followed by smaller metro areas of Albany-Schenectady-Troy and Buffalo-Niagara (The Solar Foundation 2019a; Envronmental Entrepreneurs et al. 2016). Table 4 provides a snapshot of job numbers in Nassau and Suffolk, including New York State for perspective and comparison. These numbers represent an annual snapshot of *all* solar jobs, and these figures are not cumulative. Some job types (such as construction) are temporary, and that is why the figures oscillate between years. The distribution of jobs is dominated by installation (7,182) with operations and maintenance holding the smallest share (477) (Table 5). The labor intensity of the installation phase results in spikes of temporary jobs rather than full time, permanent positions. This may be important as differently trained professionals may seek temporary employment opportunities in various locations (perhaps other counties in New York) if solar installation ramps up.

Table 4. Number of jobs in the solar industry sector 2015-2018 in Nassau county, Suffolk county, and New York State (The Solar Foundation 2019b).

SOLAR JOBS	Nassau	Suffolk	New York State
2015	812	913	8,250
2016	712	986	8,135
2017	818	1,221	9,012
2018	1,019	1,219	9,729

Table 5. Number of jobs in the solar industry sector by category in 2018 (The Solar Foundation 2019a).

Job Category	# of jobs	% of state total*

Installation	7,182*	74%
Wholesale trade and distribution	1,049	11%
Other	514	5%
Manufacturing	508	5%
Operations and Maintenance	477	5%

**Percentages rounded to whole numbers*

Estimating Jobs and Related Economic Development Impacts

As noted above, new jobs create economic activity beyond just the job itself. The broader impacts on goods and services can have significant impacts on a local or regional economy, thus, an input-output (I-O) model is an appropriate model to provide a broad understanding of the economic activity, including job creation. An input-output model is a quantitative economic approach, developed by Wassily Leontif (the 1973 Nobel laureate in economics), to represent the interdependencies between different economic sectors or the inter-industry relationships of the economy. The I-O model can capture the scope of economic activity related to, in this case, the solar industry in Nassau and Suffolk counties, as well as their links to the rest of the economy, thus showing how the solar industry is interdependent with all the others in the economy both as a supplier of inputs and customer of outputs. In short, an I-O model captures the economic ripple effect within a state or region.

I-O models provide a snapshot for a single point in time and are useful for estimating potential impacts of a policy or business decision on the surrounding economy. The output of these (I-O) models include three markers of economic impacts:

1. Jobs (or full-time employees, FTEs) – reported as the number of people working the equivalent of 40hr/week, 52 weeks/yr.

2. Earnings (or Income) – includes wages, salaries and employer provided supplements (such as retirement or health benefits)

3. Total economic activity – value of production plus inputs.

IMPLAN and JEDI

The two approaches most often used to analyze job and related economic development impacts of renewables are Impact Analysis for Planning (IMPLAN 2019) and the Jobs and Economic Development Impact (JEDI) model (NREL 2019). These approaches are similar in that they both use an I-O model yet have different elements that may make one vs the other more appealing for the user. Research done in Arizona comparing the impacts of IMPLAN versus JEDI indicate that results largely overlap (Bae and Dall'erba 2015). In particular, the estimates from both models predict approximately the same number of jobs and total economic activity, with the income output showing the greatest disparity between the two different models.

IMPLAN is a long-standing and widely used model for I-O analysis across various industries and sectors. One strength of the IMPLAN approach is the robust data and number of economic sectors included in the model (~440). We note that despite the abundance of sectors, IMPLAN does not have a sector that is specific to solar facilities (Bae and Dall'erba 2015). This model is often adopted because of the flexibility to define industries and economic relationships across various geographies (from town to county to bi-county analysis), as it is highly customizable. For example, PSEG Long Island used IMPLAN's I-O modelling approach to evaluate the economic impacts associated with their Energy Efficiency Portfolio in 2017. This portfolio includes multiple types of energy projects and programs. The $77.2 million investment resulted in 557 full time jobs and $73.7 million in total economic benefits to the region. Looking out 10 years, the expectation is for 1,211 full time jobs and $154.2 million in total economic benefits (2017 dollars; Opinion Dynamics 2018).

The Jobs and Economic Development (JEDI) model was developed by the National Renewable Energy Laboratory (NREL) specifically to estimate economic impacts of new power generation (solar, wind, biofuel, coal, natural gas, etc.). The Solar Photovoltaic JEDI model is specific to solar. This free I-O model uses economic data from IMPLAN across a limited but focused number of aggregate industries (twenty-two) to understand the economic impacts of solar development and the impacts throughout the economy that we expect from I-O models (NREL 2019). JEDI model results use two different time periods, construction (short term) and operations (long term, or life of the project). Flexibility is built into the model set up; the user can use default settings (minimal input for model run and default settings are based on existing projects, with input from developers and industry experts) or the settings can be highly customized, yielding more precise results.

The JEDI model has yet to be used to estimate the jobs and economic impacts of solar development in New York, but it has been used in other states recently, to estimate potential employment, earnings and economic impacts from the construction and operation of community solar facilities/proposals. A few examples:

> Connecticut. Vote Solar used the JEDI model to analyze potential impacts of a pilot program for community solar, assuming legislation in 2017 and construction in 2018. The proposal included 200 MW of new community solar. Estimated impacts for the state include 2,580 full time jobs during construction and an additional 104,000 hours of work with ongoing operations and maintenance. In addition, local earnings are estimated at $192 million with $374 million in local economic benefits for the state. A property tax revenue forecast includes approximately $81 million across the lifespan of the technology (25 years) from increased assessments (Garren and Tomic 2017).

> New Mexico. A coalition of supporters of the 2019 Community Solar Act (HB210), aimed at providing equitable access to clean energy and lower electricity costs to multiple stakeholder groups, used the JEDI model to understand the benefits of the proposed bill. The proposal included 375 MW of new community solar development by 2025. Estimated impacts for the state include the addition of more than 800 full time jobs (a 33% increase in solar employment), $219.6 million in earnings for those employed, and $453.5 million in local economic benefits for the state (Coalition for Community Solar Access 2019).

> New Jersey. Vote Solar used the JEDI model to analyze potential impacts of a pilot program for community solar in New Jersey. The proposal included 450 MW of new community solar, serving 32,000 customers. Estimated impacts include 1,778 full time jobs during construction,

an additional 41 full time jobs in operations and maintenance, and $797.9 million in local economic benefits for the state (Kasotia and Tomic 2018).

Monetized Environmental and Health Benefits

AVERT and COBRA

The indirect economic benefits of solar development extend beyond jobs and economic growth. Electricity generated from renewable resources like wind and solar avoids emissions of greenhouse gases (GHGs) and other harmful pollutants, including carbon dioxide (CO_2), particulate matter (PM2.5), nitrogen oxides (NO_X), and sulfur dioxide (SO_2), all of which have negative impacts to human health and result in healthcare expenditures. Reducing emissions of GHG and other air pollution through renewable energy generation, therefore, reduces impacts to human health and healthcare costs. The US EPA's AVoided Emissions and geneRation Tool (AVERT) quantifies the amount of emissions from fossil fuel power plants avoided through renewable energy generation or energy efficiency improvements based on regionally specific electricity generation data, capacity factors, and emissions information (US EPA 2019a). AVERT is often coupled with EPA's CO–Benefits Risk Assessment (COBRA) model to estimate and monetize air quality, human health, and related economic benefits that result from emissions reductions (US EPA 2019b).

For this project, the Nature Conservancy used the AVERT model with 2017 emissions data to estimate the fossil fuel generation and emissions avoided by installing utility-scale (front-of-the-meter) and distributed (behind-the-meter) solar in the Northeast region, which includes New York. In this context, utility-scale solar delivers energy directly to the grid and region-specific transmission and distribution losses are factored in by the model, while distributed solar delivers energy directly to end users and does not suffer from these losses. Therefore, avoided fossil fuel generation and emissions will be higher for utility-scale solar than distributed solar PV. It should be noted that AVERT does not model transmission constraints and is not sensitive to the location of new renewable energy generation within the region.

AVERT modeling results show that building 1 MW and 1 GW of utility-scale solar in New York would displace 1,560 MWh and 1,571,000 MWh of fossil fuel generation over the course of a year, respectively. Table 6 shows the total annual emissions reductions in New York State and reductions estimated to occur in Nassau and Suffolk counties from these scenarios of utility-scale solar buildout. Further, building 1 MW and 1 GW of distributed solar in New York would displace 1,320 MWh and 1,329,220 MWh of fossil fuel generation on an annual basis, respectively. Table 7 shows the total annual emissions reductions in New York State and reductions estimated to occur in Nassau and Suffolk counties from these scenarios of distributed solar buildout.

Table 6. AVERT estimates of annual displaced fossil fuel generation and avoided emissions from increased utility-scale (front-of-the-meter) solar deployment in the Northeast Region.

	Annual displaced fossil fuel generation (MWh)	**CO_2 (tons)**	**SO_2 (lbs)**	**NO_X (lbs)**	**PM 2.5 (lbs)**

Total regional 1 MW	1,560	830	460	710	50
Nassau 1MW	60	40	20	60	<10
Suffolk 1MW	100	60	40	80	10
Total regional 1000 MW	1,571,060	846,193	462,000	713,820	71,650
Nassau 1000 MW	60,080	37,410	20,720	59,960	4,340
Suffolk 1000 MW	101,300	63,160	39,210	74,550	12,700

Table 7. AVERT estimates of annual displaced fossil fuel generation and avoided emissions from increased distributed (behind-the-meter) solar deployment in the Northeast Region.

	Annual displaced fossil fuel generation (MWh)	**CO_2 (tons)**	**SO_2 (lbs)**	**NO_X (lbs)**	**PM 2.5 (lbs)**
Total regional 1 MW	1,320	700	390	600	40
Nassau 1MW	50	30	20	50	<10
Suffolk 1MW	90	50	40	60	10
Total regional 1000 MW	1,329,220	714,280	393,820	601,550	60,580
Nassau 1000 MW	50,830	31,650	17,870	50,540	3,690
Suffolk 1000 MW	86,040	53,690	34,770	63,550	10,760

Greenhouse gases and other air pollutants produced by fossil fuel-based energy generation have real and lasting impacts on human health, including increased instances, severity, and mortality of respiratory illnesses, such as asthma and bronchitis, cardiovascular disease and heart attacks, and diabetes, among others (Wolf et al. 2016). In addition to health impacts, illnesses related to air pollution lead to financial costs for individuals affected, including medical expenses, lost wages, outdoor activity restrictions, and others (US EPA 2019b). According to the U.S. Global Change Research Program (USGCRP) report, “The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment,” climate change is expected to worsen the impacts of air pollution on human health by increasing heat stress, levels of ground-level ozone, particulate matter, and aeroallergens (such as pollen), all of which exacerbate respiratory and cardiovascular illnesses (Crimmins et al. 2016). Further, the health impacts of air pollution and climate change are disproportionately experienced by vulnerable populations, including “low income communities, some communities of color, immigrant groups (including those with limited English proficiency), indigenous peoples, children and pregnant women, older adults, vulnerable occupational groups, persons with disabilities, and persons with pre-existing or chronic medical conditions” (D’Amato, Liccardi, and D’Amato 2000).

COBRA provides high and low estimates of avoided health impacts from exposure to air pollution over 20 years, including infant and adult mortality; non-fatal heart attacks; acute bronchitis; episodes of acute bronchitis; episodes of upper respiratory symptoms and lower respiratory symptoms; hospital admissions for all respiratory-related hospitalizations, asthma, chronic lung disease, cardiovascular conditions (excluding heart attacks); asthma-related emergency room visits; and number of work days lost due to illness. All impacts are monetized to show the associated cost savings of avoiding adverse health effects.

The Nature Conservancy used COBRA to estimate the human health benefits of building 1 GW of utility-scale solar in the Northeast Region, based on the above AVERT estimates of emissions reductions. Because of air circulation patterns, air pollution can impact human health far from the source of emissions. Table 8 summarizes the total human health benefits and health-related economic benefits across the whole US, the total benefits realized across all of New York, and the benefits that would occur in Nassau and Suffolk counties. This analysis shows that installing 1 GW of utility-scale solar PV would result in 3-7 lives saved and up to $67 million in avoided health harms over 20 years.

Table 8. COBRA estimates of the avoided human health impacts and associated monetary savings from increased utility scale solar PV deployment by 1GW in the Northeast Region. These results assume a 3% discount rate.

	Grand Total	New York Total	Nassau County	Suffolk County
$ Total Health Benefits (low estimate)	29,651,327.56	18,255,977.35	2,868,886.69	2,691,449.03
$ Total Health Benefits (high estimate)	66,965,153.2	41,204,833.49	6,469,862.89	6,084,818.28
Mortality (low estimate)	3.08	1.8946	0.30	0.28
$ Mortality (low estimate)	29,161,773.74	17,938,472.12	2,826,561.83	2,650,649.54
Mortality (high estimate)	6.9752	4.2916	0.67	0.63
$ Mortality (high estimate)	66,042,347.67	40,633,879.11	6,386,137.23	5,998,579.80
Infant Mortality	0.0054	0.0037	0.00	0.00
$ Infant Mortality	57,239.99	39,441.68	3,889.07	2,712.86
Nonfatal Heart Attacks (low estimate)	0.3816	0.2228	0.04	0.04

$ Nonfatal Heart Attacks (low estimate)	52,251.41	30,567.15	4,993.18	5,480.17
Nonfatal Heart Attacks (high estimate)	3.5457	2.07	0.34	0.37
$ Nonfatal Heart Attacks (high estimate)	485,503.13	284,016.31	46,393.98	50,919.16
Hospital Admits, All Respiratory	0.9538	0.5939	0.07	0.07
Hospital Admits All Respiratory Direct	0.5695	0.3362	0.05	0.05
Hospital Admits, Asthma	0.1466	0.1075	0.01	0.01
Hospital Admits, Chronic Lung Disease	0.2376	0.1501	0.01	0.02
$ Hospital Admits, All Respiratory	27,960.56	17,076.17	2,272.94	2,204.86
Hospital Admits, Cardiovascular (except heart attacks)	1.243	0.795	0.12	0.12
$ Hospital Admits, Cardiovascular (except heart attacks)	54,186.74	34,690.79	5,305.43	5,265.28
Acute Bronchitis	4.7717	3.1089	0.44	0.43
$ Acute Bronchitis	2,552.7	1,663.16	234.33	227.88
Upper Respiratory Symptoms	86.862	56.5259	8.02	7.81
$ Upper Respiratory Symptoms	3,217.59	2,093.86	297.04	289.26
Lower Respiratory Symptoms	60.8169	39.6063	5.59	5.44
$ Lower Respiratory Symptoms	1,424.05	927.4	131.00	127.46
Emergency Room Visits, Asthma	2.4869	1.7624	0.13	0.14
$ Emergency Room Visits, Asthma	1,189.57	842.98	61.93	67.60
Minor Restricted Activity Days	2672.8335	1754.4651	232.84	225.98
$ Minor Restricted Activity Days	203,147.3	133,347.20	17,697.13	17,175.43
Work Loss Days	449.6745	296.2548	38.54	37.53
$ Work Loss Days	80,610.11	53,107.59	6,908.04	6,727.66

Asthma Exacerbation	89.7523	58.2498	8.31	8.10
$ Asthma Exacerbation	20.3793	3,747.24	534.77	521.03

Social Cost of Carbon

There are many approaches to help illuminate the impacts of GHG reduction. While EPA's AVERT model captures reductions in GHGs and pollutants associated with the conversion from fossil fuels to renewable energy sources, it focuses predominantly on the human health costs avoided. The benefits (or avoided costs) of clean energy are much broader, and this section provides a brief discussion of another approach that is focused only on carbon reduction yet provides a more comprehensive picture of impacts.

GHG emissions writ large are considered a classic market failure in economics, where the costs are experienced by society as a whole but the benefits accrue only to the emitter. The results (extreme temperatures, increased flooding, public health impacts, property value loss, etc) are damaging and, in some cases, catastrophic. To correct this market failure, there needs to be an understanding of the costs borne by society from these emissions. The Social Cost of Carbon (SC-CO_2 or simply SCC) was developed to understand the myriad of impacts and used for better policy-making (Office of Management and Budget 2003).

Understanding social costs to correct market failures is in no way new, but a uniform U.S. Social Cost of Carbon was developed in 2009 and mandated for usage by EPA and other federal agencies (Shelanski 2013). The SCC was in part developed for federal agencies to compare the benefits of emission reductions with the cost of implementation in a cost-benefit analysis. The SCC enables agencies to place a marginal value on the climate impacts of rulemakings, quantifying the costs and benefits of emitting one additional ton of CO_2. It also helps answer the question, "how much are we willing to pay to avert the damages from climate change?"

As noted above, the SCC is intended to capture a range of impacts from a ton of carbon emissions. The EPA explains, "The SC-CO_2 is meant to be a comprehensive estimate of climate change damages and includes changes in net agricultural productivity, human health, property damages from increased flood risk, and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning" (US EPA 2017).

The SCC is driven by a somewhat cumbersome equation, summed up by a single numeric that changes through time. The single metric(s) is presented below in Table 10, but first we explain the key elements of the approach. It is important to note that the SCC is not a static value and a discount rate is used (Shelanski 2013). In short, there are three integrated assessment models (IAM's) that are combined to understand the fuller picture, including the interactions across the components. The stream of values is estimated until 2300.

These three IAM's are the Dynamic Integrated Climate-Economy model (DICE), Policy Analysis of the Greenhouse Effect model (PAGE) and Framework for Uncertainty, Negotiation and Distribution model (FUND), and they capture multiple physical, ecological, and economic impacts of carbon emissions through time. Though they operate differently in their calculations of climate changes and their effects, all three incorporate three modules into the model (Evans, Pidcock, and Yeo 2017):[4]

1. Socioeconomic: Includes components such as how many people will be alive during a future period and how much CO_2 will they emit.

2. Climate: Includes components such as future rainfall patterns and extreme weather events and how the climate will adapt to changing CO_2 emissions.

3. Benefits/Damages: Includes components such as future impacts on crop yields and costs to adapt to sea level rise.

The discount rate is another critical but complicated component. Since damages from emissions are static in time (i.e. damages do not only occur when emission occurs), any calculation about costs or benefits must include a future time horizon. The SCC estimates for any given time period include the present value of the damage plus all the future damages, discounted into today's money. Most U.S. government guidance uses two discount rates, 3% and 7%, to value costs and benefits within a single generation. For intergenerational costs and benefits, such as those present in this case, a lower rate is most often used (Office of Management and Budget 2003). In Table 9 below, the SCC estimates increase through time because future emissions are expected to produce larger incremental damages (US EPA 2017).

Table 9. Annual social cost of carbon values in 2007 dollars per metric ton of CO_2 (Interagency Working Group on Social Cost of Greenhouse Gases 2016). The four columns for each year, representing the average SCC values for three discount rates and a high impact figure (95th percentile) for the 3% discount rate.

Year	5% Average Discount Rate	3% Average Discount Rate	2.5% Average Discount Rate	High Impact -95th percentile, 3%
2015	$11	$36	$56	$105
2020	$12	$42	$62	$123
2025	$14	$46	$68	$138
2030	$16	$50	$73	$152
2035	$18	$55	$78	$168
2040	$21	$60	$84	$183
2045	$23	$64	$89	$197
2050	$26	$69	$95	$212

[4] A more comprehensive discussion of the IAMS can be found in Evans, Pidcock, and Yeo 2017.

While the SCC is a complicated and imperfect metric, it provides a baseline value to help understand trade-offs between the short and long-term costs and benefits of climate change. The metric is complicated, because it is based on an equation that uses multiple variables, through the IAM's. It is imperfect, because there is uncertainty about what climate change will look like and how it will impact our economy in the future. Additionally, the models that drive the SCC need to be updated regularly and there is often a lag between the most up to date science and the models.

For further thought, a recent study led by Katharine Ricke to evaluate the global social cost of carbon elucidates why the current U.S. metric may be significantly undervalued (Ricke et al. 2018). Finally, for those looking for a fuller discussion and analysis of the costs, benefits and impacts associated with renewable energy standards, a recent retrospective report offers a comprehensive picture (Wiser et al. 2016).

Potential Reduction of Energy Cost Burden for LMI Communities

Solar energy generation has the potential to improve access to the clean energy economy for low- and moderate-income (LMI) households[5] and improve energy affordability. A household's energy burden is defined as the percentage of gross household income spent on energy costs (Office of Energy Efficiency and Renewable Energy 2019). Energy is considered "affordable" when the energy burden is less than 6% of household income, and New York's Energy Affordability Policy, established as part of REV, set a goal of limiting energy costs for LMI households to this level (New York State Office of the Governor 2016). Currently, 82% of LMI households (approximately 3.5 million) in New York have an energy burden greater than 6% (Carroll 2017).

LMI households spend a disproportionate amount of income on energy compared to wealthy households. Nationally, LMI households spend 8.2% of their income on energy bills, about three times more than high income households (Gallucci 2019). In New York, the disparity is even greater--the average energy burden for low-income households is 12.6%, while the average energy burden is 6.4% for moderate-income, and 2.4% for non-LMI households. The most recent results from the Energy Information Administration's 2015 Residential Energy Consumption Survey (RECS) show that one-third of American households struggled to pay their energy bills, about one in five reported reducing or forgoing food and medicine to pay an energy bill, 14% reported receiving a disconnection notice for energy service, and 11% of households reported keeping their home at an unhealthy or unsafe temperature. These results also show that African American and Latinx households experience greater energy burdens and energy insecurity than their white counterparts (U.S. Energy Information Administration 2018).

LMI households face a high energy burden due to the legacies of structural discrimination in the housing market, which drives low-income households and people of color into older, less efficient buildings (Shahyd 2016). Much of this housing stock is functionally obsolete and lacks energy efficient heating systems. In many cases, rehabilitation and modernization costs nearly equal the sales price of homes, making these cost-saving measures impractical. Furthermore, in the case of rental properties,

[5] New York defines LMI households as those with incomes 0-80% of area median income or state median income, whichever is greater.

property owners do not pay the utility bills, so have less of an incentive to invest in these types of energy-saving measures, similar to the split incentive described in tenant-occupied commercial spaces.

A powerful solution to address energy burdens for LMI households is the adoption of solar energy. Solar panels can be installed on or near LMI households and provide clean, local energy that significantly reduces electricity costs. In addition, some systems can supply backup power if the grid is damaged during a storm or natural disaster. The high potential for solar installations to result in electricity cost savings for consumers is not only based on the number of sunny days in an area but also on building stock and energy consumption patterns. Taking this into account, New York State and Long Island in particular are places where access to solar energy can reduce energy bills for LMI households by hundreds of dollars a month (Daniel 2019). The average annual electricity use for a Long Island household is 9,060 kWh (PSEG LI 2018). Multiply this by $0.196 per kWh, the average PSEG LI residential electricity rate (as of July 2019), and add $131.40 for the annual service charge, and Long Island households are spending an average of $1,907 a year on electricity.

Solar is an up-front investment, with the only costs being the system installation and any added electricity costs in the event that the household's panels do not completely offset 100% of electricity use. This up-front cost can be avoided, however, by a third-party owner or community solar business model, which will be expanded upon below. Considering a household in New York State that owns a 6 kWh solar system (the national average) with 98% of the needs met by the solar panels and an annual electricity increase rate of 2.2% (based on the past decade), the estimate of savings in 20 years is $26,637 (Richardson 2019). Based on these figures, we can see that solar power can virtually eliminate electricity costs for households, providing a crucial relief for LMI communities and substantially reducing energy burden.

Despite all the benefits of solar, the financial barriers for LMI households can be very high, leaving those who could benefit the most from this energy resource out of the rise in solar. Almost half of U.S. households (more than 154 million people) are not able to host their own solar systems, either because they lack suitable rooftop space, rent their homes, or cannot afford to lease a solar system (Gallucci 2019). With little to no up-front costs, and the elimination of siting barriers, community solar can provide access to low-cost renewable electricity for LMI households and help reduce their electricity bills.

Community solar is already in use in New York State and other parts of the country through innovative programs that will be instructive as we develop our own on Long Island. In New York, NY-Sun's new Solar for All initiative will cover the enrollment fees and other costs for 7,000 low-income households to join community solar projects, though this program is not available Long Island (NYSERDA 2018). NYSERDA recently awarded contracts for nine community solar projects with a combined capacity of 26.4 MW, one-third of which will be reserved for cost-free subscriptions (Gallucci 2019). In 2018, PUSH (People United for Sustainable Housing) Buffalo completed the installation of a 64kW community solar facility on the roof of the former Buffalo Public School #77 as part of converting the former school into a mixed-use affordable housing project. A portion of the community solar project was financed with tax equity investment, and the remainder funded by a grant from NYSERDA. As the system goes live in early 2019, PUSH will offer deeply discounted subscription rates to the low-income seniors residing at School 77. PUSH will ensure community control over the allocation of revenue generated through the sale of subscriptions by engaging the community in participatory budgeting (New York State Office of the Governor 2018). This type of community-focused model is being undertaken on Long Island with campaigns like PowerUp Solar Long Island run by the Long Island Progressive Coalition (Chinese 2018). Efforts to deploy more affordable solar will require supporting initiatives like these.

Programs outside of New York, like Washington, D.C.'s new Solar for All program aims to help 100,000 low-income households slash their energy bills in half by 2032. It was recently awarded $13 million in grants for community solar and similar projects (Christian 2017). New Jersey is moving ahead with a pilot program to build roughly 75 MW of community solar projects a year – 40% of which will be dedicated to serving low- or moderate-income customers. In Illinois, a $30 million Solar for All program waives low-income participants' up-front costs to join community solar projects and limits monthly fees (Tomich 2018). Colorado's 2010 shared solar law, one of the first in the country, requires developers to reserve at least 5 percent of a project's subscriber pool for low-income participants. The state also awarded $1.2 million in grants to build eight low-income community solar projects (Gallucci 2019). Across the country, stakeholders are coming together to meet the energy needs of low-income communities to address issues of energy burden and affordability. Long Island can do the same.

Potential Impacts to the Utility and Utility Customers

Bringing new mid- to large-scale solar installations online impacts the electric system, and therefore has costs and benefits for the electric utility and its customers (Daymark Energy Advisors, RLC Engineering, and ESS Group 2018). Potential impacts somewhat differ for behind-the-meter systems and front-of-the-meter systems.

In the case of behind-the-meter solar systems, any excess energy generated is sent back to the grid to power other homes and businesses, and the utility purchases the energy. This reduces the total amount of energy that the utility must purchase from the NYISO market to satisfy customer demand, thereby reducing energy costs for the utility. The cost of purchasing renewable energy from these solar systems is passed on to utility customers. When the rate paid for energy delivered to the grid by behind-the-meter systems is greater than the avoided power supply market costs, the utility loses revenue from the sales of electricity and delivery charges. Revenue shifts from the utility to behind the meter solar system owners. The purchase price of energy sold to the grid from behind-the-meter systems depends on which pricing policy is applied – net metering or value of distributed energy resources (VDER). Recent analysis of small rooftop systems prepared for LIPA and PSEG LI shows that, under the current net metering policy, the rate of compensation is greater than the value of the energy to the system, and therefore the utility loses revenue to behind-the-meter solar system owners under net metering (Huber 2019).

Renewable advocates point out that while distributed solar and other energy efficiency measures do pose a challenge to electric utilities' existing business model, the benefits of distributed generation outweigh the costs, and those benefits are shared by all ratepayers. Economic benefits of behind-the-meter solar systems include avoided or reduced need for investment in transmission and distribution; avoided purchases of energy, renewable energy credits (RECs), and new capacity purchases; reduced exposure to volatile fuel prices; and more (Savage 2013).

In the case of front-of-the-meter projects, the solar energy produced is purchased by the utility at a fixed rate determined in the purchase agreement between the IPP and the utility. Here, renewable energy purchased by the utility displaces generation that would have been purchased from other sources. Often, front-of-the-meter solar energy systems are developed in response to the issuance of a FIT from the utility. The Long Island Power Authority's proposal for a solar FIT in 2013 serves as a good example of the savings front-of-the-meter solar can provide to utilities (LIPA 2016). LIPA estimated that purchasing energy from 100 MW of solar generation, approximately 157.7 million kWh per year, at a 22¢ per kWh price would cost LIPA approximately $34.7 million per year. They estimated a cost savings of 7.65¢ per kWh from avoided purchase of electricity from other sources, or $12.1 million per year, for a net cost of $22.6 million per year. Further, LIPA anticipated a net present value savings of more than $60 million from deferred or avoid expenditures over 20 years by bringing solar generation online in areas where the distribution system was constrained and in need of expensive capacity upgrades. LIPA concluded that, "These cost savings represent incremental savings to LIPA customers and make the strategic deployment of solar generation even more beneficial for economic reasons, in addition to environmental reasons" (LIPA 2016).

Both behind-the-meter and front-of-the-meter solar systems also create a host of societal benefits for all ratepayers that are generally not accounted for by utility analyses, including: public health benefits, employment and downstream economic effects, market price impacts, grid security benefits, and water savings, some of which are discussed further in this report.

Potential Impacts on Neighboring Property Values

To our knowledge, there is currently little peer-reviewed research that quantitatively evaluates the impacts of mid- to large-scale solar facilities on neighboring property values. Importantly, only matched paired property analyses, hedonic regression, and other methods using assessed home value or sales data can provide quantitative evidence of an effect on home or property values. We can, however, use research on the impacts of other renewable energy generation like land-based wind turbines on property values, examine matched paired property analyses performed by assessors and other professionals, and learn from surveys of property assessors. Here, we discuss both *perceived* impacts to property or home values by both assessors and property owners as well as *realized* impacts revealed through match paired property analysis performed for specific areas.

A recent national survey of people living near wind turbines by researchers at the Lawrence Berkeley National Laboratory found that respondents who lived within half a mile of a wind project preferred living near wind turbines than fossil fueled or nuclear energy infrastructure and had similar preferences for living near wind or solar facilities (Hoen et al. 2018). Therefore, dis-amenity research on the impacts of utility-scale wind turbines on property values might serve as a reasonable proxy for the impacts of mid- to large-scale solar installations (Al-Hamoodah et al. 2018). Research to date has found no consistent evidence that utility-scale wind projects impact sales price of homes (Hoen and Atkinson-Palombo 2016; Hoen et al. 2013; Lang and Opaluch 2013). On the other hand, researchers have found positive impacts of wind installations on property tax revenues to local school districts and local taxing entities, which may be related to increased property values in the district (Loomis and Aldeman 2011).

Public opinion research and surveys of public assessors about mid- to large-scale solar installations shows a high instance of *perceived* impacts to property values, even among those who support solar energy development. In a 2015 public opinion survey, Carlisle and colleagues found that 80% percent of U.S. survey respondents supported large-scale solar facilities generally and locally, while 70% of respondents believed these installations would reduce property values. While solar energy facilities cause very little traffic and do not generate noise, dust, or other harmful effects, support for and perceived impacts of solar facilities often hinge on visual impacts and buffer distances (Carlisle et al. 2016).

In a nation-wide survey of public assessors, the majority of respondents indicated that proximity to a large (1 MW or larger) solar installation has either no impact or a positive impact on residential home values. When indicated, negative impacts were only associated with homes very close (within 1,000 feet for a 1.5 MW array and a half mile for a 20 MW array), and geospatial analysis of utility-scale solar installations across the US showed that very few homes were actually located in such close proximity to solar systems of these sizes. Assessors with experience assessing homes near solar systems provided much more conservative (smaller) estimates of property value impacts compared to their counterparts with no experience, indicating that a lack of experience and training may impact assessment of home values near solar systems. Assessor estimates of solar installations impacts to property value were more negative at closer proximity to the installation, with greater installation size, and when provided by assessors that had not previously assessed a home near a utility-scale solar facility (Al-Hamoodah et al. 2018).

However, there is little quantitative evidence that these concerns are realized. A 2018 study of impacts of solar farms (ranging in size from 13 to 160 ac) on adjacent property values in rural and suburban areas of Illinois and Indiana found *"no measurable and consistent difference in property values"* for residential or farm properties adjacent to solar farms compared to similar properties not in proximity to solar farms, called a matched pair analysis. Proximity to solar farms had no impact on range of sales price, differences in unit sale prices, conditions of sale or overall marketability for residential single family homes or farmland, and no impact was seen on the development of new homes (McGarr 2018). Similarly, matched pair analysis in North Carolina also found no impact on the value of homes, vacant residential land, or agricultural land for properties adjacent to solar farms (Kirkland 2018).

Potential Financial Indirect Costs and Benefits in Agricultural Settings

As discussed above, solar energy generation on farms can provide both additional income and financial stability to farmers, improving farm economics, protecting against volatile commodity prices, and improving farmers' access to financing. Other indirect benefits include potential reductions in nutrient loss, erosion, and water usage as well as increased production of some crops and improved soil health. But the realization of these indirect benefits requires up-front planning and investment (Dreves 2019).

However, solar energy development has the potential to negatively impact agricultural areas as well. Some concerns include the conversion of highly productive or prime farmland for solar development, effectively taking land out of production and reducing the output of food and other crops. Cumulatively, such conversion can negatively impact the economic viability of communities or regions where farming is a major part of the economy. Further, poor construction and operation practices can lead to reductions in soil health, increased runoff, and increased inputs of herbicide. Best practices, guidance, and requirements have been utilized in other states, like New Jersey, to ensure that solar installations on farmland are sited, designed, constructed, and operated in ways that minimize negative impacts to farm operations and the environment (State of New Jersey Department of Agriculture n.d.)

Conclusions and Options for Improving Economic Feasibility

This research reveals several major economic barriers to development of mid- to large-scale solar energy systems in low-impact locations on Long Island. The first barrier is high up-front cost of development, driven primarily by soft costs, including permitting, and labor. Additionally, the cost of interconnection and grid modifications or grid upgrades are expensive and can significantly impact the overall feasibility of a project. Primarily due to differences in the cost of site preparation and restoration and racking, development on low-impact sites like parking lots is more expensive than development of ground-mounted systems. Therefore, the market drives solar development to the least expensive sites, which are often undeveloped natural areas. Targeted strategies or mechanisms are needed to encourage development on low-impact sites.

A second major barrier is the lack of access to incentives, financing, and funding in non-profit and government settings as well as for projects serving LMI households. Non-profit and government settings are unable to take advantage of tax incentives, which are the main mechanisms for reducing the up-front cost of solar. Further, most New York State programs to support solar energy development are not currently available on Long Island, including NYSERDA's Solar for All and NY-Sun programs. No programs aimed at supporting community solar, access to solar energy for LMI households, or development of mid- to large-scale solar systems on low-impact sites currently are currently offered by New York State, PSEG LI, or LIPA. In addition, the two federal tax incentives for renewable energy development, the ITC and the Modified Accelerated Cost Recovery System (MACRS) will expire within the next 5 years.

Finally, there is a dire need for increased resources, capacity, and education available to all types of property owners, community members, decision-makers, and others. Limited capacity to pursue solar adoption is a barrier across all settings. The complexity of billing rates makes leadership and coordination of more cooperative approaches to energy distribution difficult. Commercial, nonprofit, local government, and farmland property owners and tenants may not be aware of the educational and financial assistance programs available and may need assistance with developing the accounting or administrative procedures necessary to utilize different tax or cost abatement programs. A better understanding of the direct and indirect cost and benefits of mid- to large-scale solar would help communities and others make informed choices renewable energy development on Long Island.

Below, we provide strategy and policy options for improving economic feasibility of mid- to large-scale solar on Long Island, organized by the entity that would be responsible for pursuing such changes.

Federal Government

- **Extend the Federal Energy Investment Tax Credit (ITC).** This federal incentive program will sunset beginning in 2020 and will no longer be available for renewable energy systems that come online after 2023. Extending this program would encourage solar development not only by continuing to provide federal funding to finance projects, but also by providing additional certainty in the cost of projects. A lack of certainly over the future of the program is already affecting the renewable energy market, which may result in project delays or cancellations.

State Government

- **Increase state support for local government solar projects.** New York State could increase municipal participation by providing additional grants or financing options for solar on municipal property. An example is the Alberta Municipal Solar Program. This program refunds financial support to municipalities participating in that program and who install grid-connected solar systems. For a system between 150 kW to <2 MW the costs are 0.6 $/Watt. A fixed rate enables energy security for municipalities as they are not affected by energy price changes and they take advantage of a reduced energy bill. The participating municipality gets the installation paid for by the program.

- **Create policies that support transmission via the New York State Public Service Commission (NYSPSC),** via funding, innovative business models, public/private partnerships, etc. As transmission expenses are recovered through ratemaking, policymakers can encourage transmission development with supportive policies.

- **Spread the Solar for All program to Long Island** or create a similar state-funded program for LIPA/PSEG LI customers to provide no-cost access to community solar for LMI households.

- **Make NY-Sun programs available on Long Island again.** Long Island has high potential and need for community solar generation. Focus on incentives for non-residential arrays, arrays servicing multi-family housing, and arrays sited on brownfields or landfills.

- **Create policies that ensure access to community solar and renewable energy generation to LMI households.** Potential policies include:

    - requiring developers to reserve a certain portion of residential-serving or community solar project for LMI participants;

    - establishing an Equity Planning Council that includes the Chair of the NYSPSC, the President of NYSERDA, the Governor's top energy official and environmental justice organizations, low-income organizations, solar industry representatives, and other stakeholders to create a roadmap for expanding the direct benefits of distributed renewable energy to low-income and environmental justice communities;

    - directing any agency supporting the financing of clean energy projects to facilitate subsidized loans for distributed solar for low-income and environmental justice communities, and to provide financing support for community-driven and community-owned or controlled projects for low-income and environmental justice participants.

- **Update the New York State Agriculture and Markets law to eliminate the conversion penalty for development of solar on farmland.**

- **Establish regulatory standards for construction, installation, maintenance, and operation for solar installations on farms** to minimize negative impacts to farmland and the environment and provide clarity on best practices**.**

- **Increase resources, capacity, and education available to property owners in all settings.** NYSERDA could offer at least one educational program for all settings and all commercial property categories: owner-occupiers, leaseholders, and property managers.

Local Government

- **Disseminate information on C-PACE.** Both Nassau and Suffolk counties recently authorized C-PACE and should conduct outreach to eligible entities.
- **Standardize and simplify permitting of mid- to large-scale solar energy installations on low-impact sites.** Streamlined permitting could reduce the soft costs of solar development, increase the pace of solar deployment, and incentivize development on low-impact sites.
- **Review and revise local zoning laws to enable solar energy development on low-impact areas of opportunity.**
- **Integrate renewable energy development into zoning and comprehensive planning processes.**
- **Authorize and support community choice aggregation (CCA).** Community choice aggregation has the potential to drive solar energy development on low-impact sites when siting is integrated into the procurement process, and it could reduce energy costs for community members.
- **Incentivize or mandate solar development on low-impact sites**, like rooftops and parking lots, using mechanisms such as tax incentives and increased maximum floor area ratio (FAR) allowance for properties with solar energy generation.
- **Incentivize or mandate solar development in agricultural areas meet New York State Department of Agriculture and Markets construction standards for agricultural sites** and streamline permitting for projects that meet these standards.
- **Enable installation of solar on rooftops, parking lots, and potentially other low-impact sites on farms enrolled in farmland protection programs**, including increasing the amount of energy farms are allowed to produce without penalty.

Utility

- **Provide the public up-to-date, detailed information on distributed generation injection capability at substations.**
- **Reduce interconnection costs** through innovative policies and partnerships.
- **Establish distributed renewable energy program(s) to enable participation of at least 250,000 low-income, moderate-income, and environmental justice community members on Long Island by 2025.**

- **Incentivize projects in agricultural areas meet New York State Department of Agriculture and Markets construction standards for agricultural sites.**

Solar Industry

- **Enable shorter solar lease terms to better align with commercial property lease terms.**
- **Target low-conflict sites such as brownfields and landfills for ground-mounted solar installations,** which have lower development costs.
- **Collaborate with industry and non-industry partners to create and implement educational programs** for property owners in different settings, community members, decision-makers, and others.
- **Design, construct, and operate ground-mounted solar installations to maximize benefits to the environment and farm operations**, including revegetating sites with native spaces, employing practices to improve soil health, and minimizing erosion, runoff, and herbicide inputs. Planting pollinator-friendly, native species below solar panels has been shown to reduce costs of site preparation and maintenance.

Property/Solar Installation Owners

- **Increasing project scale** may provide additional value for tax-exempt customers. In 2012, the median installation cost for systems <10kW was 5.5% more expensive per watt than for systems >100kW. In the commercial sector, the economies of scale for facilities > 2 MW can reduce per unit cost to install as much as 14%. With economies of scale, the fixed costs from solar PV development can be absorbed over more installed watts, and installers might realize volume discounts, lowering the overall price per watt for the project.
- **Commercial property owners use remote net metering to enable maximum solar generation and benefits.**
- **Deploy strategies to overcome the split incentive in leased spaces** explained in the previous section.

Others

- **Create or update professional manuals and training materials for property assessors** to provide instructions regarding residential assessments near utility-scale solar installations to standardize and reduce uncertainty about the impacts of solar installations on property values. Research shows that “Assessors with experience assessing near solar installations perceived considerably smaller impacts than those without such experience. In addition, the majority of assessors with experience assessing homes near solar installations did not adjust property values based on that proximity” (Al-Hamoodah et al. 2018).

Priorities for future research

- **Conduct independent analysis of the economic development benefits and costs of renewable energy development**, including solar, within each utility's service territory using JEDI or IMPLAN by NYSERDA or NYSDPS. These models can be particularly useful when evaluating a potential program or policy, at the county to state scale, in order to better illuminate the scope of the economic activity. Results of these analyses can also be used to further understand the trade-offs of decision-making regarding community solar infrastructure and for economic development purposes. Understanding which solar economic sectors generate larger impacts to the local economy can help decision-makers evaluate policies that will stimulate economic development.

- **Conduct a New York or Northeast regional study to quantify the realized impacts of solar development on property values.** Impacts on property values are a major concern for community members and government officials in areas where solar energy development is proposed. A better understanding of these impacts can help individuals and communities anticipate and mitigate impacts, if they are confirmed, or move past this issue when planning for renewable energy development.

- **Continue research in New York State to identify best practices, suitable crops and livestock, and potential economic costs and benefits of co-locating solar with agricultural production.** The InSPIRE project has several study sites in New York; this and further research in the state can help farmers and solar developers better understand how to structure solar installations and farm operations to maximize benefits and minimize displacement of agriculture by solar energy generation.

Acronyms

AVERT	AVoided Emissions and geneRation Tool
CCA	Community Choice Aggregation
CLCPA	Climate Leadership and Community Protection Act
CO_2	Carbon dioxide
COBRA	CO-Benefits Risk Assessment model
C-PACE	Commercial Property Assessed Clean Energy financing
DC	Direct Current
DER	Distributed Energy Resources
EPA	US Environmental Protection Agency
FIT	Feed-in-tariff
GHG	Greenhouse gas
GW	Gigawatt
ICMA	International City/County Management Association
InSPIRE	Innovative Site Preparation and Impact Reductions on the Environment
I-O	Input-Output models
IPP	Independent Power Producer
ISO	Independent System Operator
IMPLAN	Impact Analysis for Planning model
JEDI	Jobs and Economic Development Impact model
kW	Kilowatt
kWh	Kilowatt hour
LIPA	Long Island Power Authority
LMI	Low- and moderate-income households
MW	Megawatt
MWh	Megawatt hour
NO_X	Nitrogen oxides
NREL	National Renewable Energy Laboratory
NYISO	New York Independent System Operator
NYSDPS	New York State Department of Public Service
NYSPSC	New York State Public Service Commission
NYSDAM	New York State Department of Agriculture and Markets
NYSERDA	New York State Energy Research and Development Authority
PACE	Property Assessed Clean Energy financing
$PM_{2.5}$	Particulate matter 2.5 microns and smaller
PPA	Power Purchase Agreement
PSEG Long Island	Public Service Enterprise Group Long Island
PV	Photovoltaic
REC	Renewable Energy Credits
RECS	Residential Energy Consumption Survey
RGGI	Regional Greenhouse Gas Initiative
SCC	Social Cost of Carbon
SO_2	Sulphur dioxide
USDA	United States Department of Agriculture
VDER	Value of Distributed Energy Resources

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Appendices

Appendix 1. Types of services that batteries can provide (Fitzgerald et al. 2015).

	SERVICE NAME	DEFINITION
ISO / RTO SERVICES	Energy Arbitrage	The purchase of wholesale electricity while the locational marginal price (LMP) of energy is low (typically during nighttime hours) and sale of electricity back to the wholesale market when LMPs are highest. Load following, which manages the difference between day-ahead scheduled generator output, actual generator output, and actual demand, is treated as a subset of energy arbitrage in this report.
	Frequency Regulation	Frequency regulation is the immediate and automatic response of power to a change in locally sensed system frequency, either from a system or from elements of the system.[1] Regulation is required to ensure that system-wide generation is perfectly matched with system-level load on a moment-by-moment basis to avoid system-level frequency spikes or dips, which create grid instability.
	Spin/Non-Spin Reserves	Spinning reserve is the generation capacity that is online and able to serve load immediately in response to an unexpected contingency event, such as an unplanned generation outage. Non-spinning reserve is generation capacity that can respond to contingency events within a short period, typically less than ten minutes, but is not instantaneously available.
	Voltage Support	Voltage regulation ensures reliable and continuous electricity flow across the power grid. Voltage on the transmission and distribution system must be maintained within an acceptable range to ensure that both real and reactive power production are matched with demand.
	Black Start	In the event of a grid outage, black start generation assets are needed to restore operation to larger power stations in order to bring the regional grid back online. In some cases, large power stations are themselves black start capable.
UTILITY SERVICES	Resource Adequacy	Instead of investing in new natural gas combustion turbines to meet generation requirements during peak electricity-consumption hours, grid operators and utilities can pay for other assets, including energy storage, to incrementally defer or reduce the need for new generation capacity and minimize the risk of overinvestment in that area.
	Distribution Deferral	Delaying, reducing the size of, or entirely avoiding utility investments in distribution system upgrades necessary to meet projected load growth on specific regions of the grid.
	Transmission Congestion Relief	ISOs charge utilities to use congested transmission corridors during certain times of the day. Assets including energy storage can be deployed downstream of congested transmission corridors to discharge during congested periods and minimize congestion in the transmission system.
	Transmission Deferral	Delaying, reducing the size of, or entirely avoiding utility investments in transmission system upgrades necessary to meet projected load growth on specific regions of the grid.
CUSTOMER SERVICES	Time-of-Use Bill Management	By minimizing electricity purchases during peak electricity-consumption hours when time-of-use (TOU) rates are highest and shifting these purchase to periods of lower rates, behind-the-meter customers can use energy storage systems to reduce their bill.
	Increased PV Self-Consumption	Minimizing export of electricity generated by behind-the-meter photovoltaic (PV) systems to maximize the financial benefit of solar PV in areas with utility rate structures that are unfavorable to distributed PV (e.g., non-export tariffs).
	Demand Charge Reduction	In the event of grid failure, energy storage paired with a local generator can provide backup power at multiple scales, ranging from second-to-second power quality maintenance for industrial operations to daily backup for residential customers.
	Backup Power	In the event of grid failure, energy storage paired with a local generator can provide backup power at multiple scales, ranging from second-to-second power quality maintenance for industrial operations to daily backup for residential customers.